A Review of Logistics Pricing Research Based on Game Theory

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Abstract: As the scope and complexity of logistics outsourcing services expand, logistics activity has become a separate market service. It has become a critical issue to determine how to appropriately price logistics services. In this study, we systematically review the scientific literature on the pricing of logistics services based on content analysis and bibliometric methods, focusing on the application of game theory. We compare and analyze the literature in terms of three dimensions: logistics scenarios, game models, and influencing factors. This study identifies the main players and key research scenarios of logistics pricing, analyzes the most appropriate and commonly used game models, and clarifies the main influencing factors of logistics pricing. Finally, we suggest future research directions to fill gaps in existing knowledge. This study conducts a systematic review of the current state of empirical research in the field of logistics pricing, which aids in the development of new models. The results of this study help to advance logistics services from a pricing standpoint, thereby increasing the economic and environmental sustainability of logistics activities.

Keywords: logistics pricing; game theory; literature review

1. Introduction

Businesses are outsourcing their logistics operations to logistics service providers (LSPs) in order to cut costs and improve efficiency as a result of the ongoing promotion of economic globalization [1–3]. Since the 1980s, the concepts of third-party logistics (TPLs) and fourth-party logistics (FPLs) have emerged and been the subject of extensive attention and research from scholars in the field [4–7]. A large number of logistics companies have also emerged in the market to provide their customers with specialized transportation, storage, handling, and other services. According to the 2019 third-party logistics study, 53% of shippers’ transportation and 34% of their warehouse operations expenditure are related to outsourcing [8]. The growth of logistics outsourcing has made logistics activities an independent market service, and how to establish reasonable pricing has become a critical issue. The most important competitive factor in the market is price [9]. Pricing for logistics services can be conceptualized as pricing between upstream and downstream companies in the supply chain. Different from product pricing in a supply chain, logistics pricing belongs to the service industry. These two patterns have different origins and mechanisms for the generation and distribution of system benefits. A fair and reasonable pricing strategy for logistics services can improve the economic and environmental sustainability of logistics activities.

Due to the intricacy of logistics operations, academics have recently concentrated their research on increasingly narrow themes. There have been numerous review studies that focus on a specific logistics link or a particular kind of logistics activity, including logistics location [10], reverse logistics [11], cold chain logistics [12,13], urban logistics [14], and others. All of these fields have thorough literature reviews that can be used as references. By reviewing the review articles on logistics, we find that there are still gaps in the current systematic research on the pricing of logistics services. Lukassen and Wallenburg [15], based on the research on industrial service pricing, expanded to third-party logistics...
service pricing and reviewed the relevant literature. However, their study focuses on the similarities and differences between logistics service pricing and industrial service pricing. The research results show that most of the pricing studies of TPLs are descriptive and lack empirical studies.

In recent years, the pricing of logistics services has received increasing attention. A number of specific, empirical studies on logistics pricing have emerged. Despite the increasing number of papers in this area, there is still a lack of systematic and updated research. Especially in the field of empirical research on logistics pricing, there is a lack of a summary of the current research state and research methods. After reviewing the literature on logistics service pricing in recent years, game theory emerges as one of the main research methods. As a classical approach in economics, game theory is widely used in coordination and pricing problems. Multiple players are involved, especially in supply chain and logistics scenarios, and their pricing process is the result of a game between the parties over profits. The key to pricing problems lies in the participants, influencing factors and the construction of models. Employing content analysis and bibliometric methods, this paper reviews logistics pricing based on game theory. We evaluate the literature in three aspects: logistics scenarios, game models, and influencing factors. We hope to provide concrete scientific and practical contributions, through a literature review that identifies the decision making and pricing model construction for logistics pricing. The idea is that the results of this paper provide researchers in logistics pricing with scientifically and practically validated methods that can help them create new game models. Moreover, by reviewing the logistics pricing literature in recent years, this paper provides a systematic and critical review to clarify the current state of empirical research in the field, predict future research trends, and fill the gaps in systematic research in this area.

The rest of the paper is structured as follows. Section 2 provides a brief description and introduction of game theory. Section 3 defines the research methodology, including the research questions, keywords, and literature selection criteria. Section 4 classifies the literature and discusses the research in detail. Section 5 summarizes the research status and points out the research results. Conclusions and recommendations for future research are described in Section 6.

2. Game Theory

Von Neumann and O. Morgenstem published Game Theory and Economic Behavior [16] in 1944, which marked the beginning of the development of a systematic game theory. A game is a series of competitive or adversarial actions in which two or more rational individuals or organizations participate. In a game, the participants are subject to a set of environmental constraints (i.e., rules) and each has different goals or interests. To achieve their goals or maximize their interests, participants must consider all of their opponents’ possible courses of action and make decisions based on them that are most beneficial to them. Game theory can be classified into several types based on the order of the participants’ actions and the amount of information they have. In addition, it is now widely used in a variety of fields, including economics, sociology, computer science, international relations, and so on. A full game typically consists of the following components.

1. Player: the player of a game is a subject who can choose the appropriate decision to maximize its own utility, which can be an individual or a group, such as a country, an enterprise, an organization, etc. Hereinafter, it is referred to as the participant.
2. Strategy: the strategy is the rule by which the participant chooses its own action; the rule will determine what action the participant chooses in what situation.
3. Utility function: the utility function is the level of utility that the parties involved in the game can obtain from the game, reflecting the participants’ expectations of the outcome. It is stipulated in economics that utility function must be quantifiable, which can be a continuous function or discrete function. The value of utility can be positive or negative. Each party involved in the game has its own utility function, but they do not necessarily know each other’s utility functions.
3. Research Method

In order to ensure the objectivity of the research results and the reproducibility of the study, with reference to the structured literature review method [17], this paper provides a systematic review of the recent research on logistics pricing based on game theory. The research methodology of this paper consists of three main stages: (I) research planning; (II) paper identification and analysis; and (III) research evaluation and synthesis. In the first stage, the research questions and the scope of the literature review were identified, and then a literature search program was designed to determine the inclusion and exclusion criteria of the literature. In the second stage, the screened literature was initially studied quantitatively and analyzed descriptively, and the literature was evaluated and classified according to the research questions. In the third stage, a comprehensive review of the literature was conducted. Content analysis and bibliometric methods are to be used to evaluate and analyze the literature and identify gaps in past research in order to discover future research trends.

As mentioned above, the pricing of logistics services is a critical issue that affects the sustainability of logistics outsourcing. Having identified the need for such a review and the research gaps, we set three main research questions (RQ1, RQ2 and RQ3):

RQ1: What are the main players and key research scenarios in logistics service pricing?
RQ2: Which game models and approaches are the most appropriate for logistics service pricing?
RQ3: What are the main and the most important factors affecting the price of logistics services?

To answer the research questions, we conducted a comprehensive review of scientific papers in the field of logistics pricing. Clear article selection criteria minimize the inclusion and exclusion bias of researchers and increase the heterogeneity of the data [18,19]. Therefore, we designed a literature search protocol and determined the inclusion and exclusion criteria. The literature was mainly drawn from the Web of Science and SCOPUS databases, which are leading and extensive citation databases that cover most of the logistics pricing literature [20]. We used the keywords “logistics”, “game theory”, and “price” to conduct a subject search in the database and identified 397 papers. The papers were evaluated and selected in a two-step filtering process. First, we further reviewed the titles, abstracts, and keywords of the papers based on the inclusion and exclusion criteria, and a total of 121 papers were considered relevant to the topic. Second, we performed a full-text reading and then conducted a snowball search of their references, adopting the same inclusion and exclusion criteria. Ultimately, 57 papers were retained for the review of this study. The literature selection process is shown in Figure 1, and all authors were involved in the joint assessment. The inclusion and exclusion criteria of the literature is shown in Table 1. In particular, according to the purpose of the literature review, we specified that logistics price should be the decision variable in the game model and be endogenous. After a full reading, much of the literature was excluded because it did not satisfy this criterion.

A total of 57 papers were published in 47 journals from a variety of sources. In the observed sample, 9 journals have more than two papers, with Sustainability (Switzerland) ranking first with three papers. In terms of publication date, the first paper retrieved was published in the Journal of the Operational Research Society in 2006. Following that, intermittent peaks were observed. Four papers were published in 2008, with fewer studies published in the years that followed, and another peak in 2013. Overall, with 38 papers published after 2016, the number of papers published increased significantly. In 2021, there are 10 papers published, with 7 published this year (as of July). This supports the literature’s growing interest in logistics pricing. The source of article publication (TOP9) and the number of papers are shown in Figures 2 and 3, respectively.
The inclusion and exclusion criteria.

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Figure 1. Literature selection process.

Figure 2. The source of article publication (TOP9).
4. Literature Classification and Analysis

Content analysis, as an observational research method, was used to systematically evaluate the body of the literature [21]. In this section, based on the content analysis method, we conduct a comprehensive review of the selected literature, summarize the current state of research, and evaluate the contribution of the existing literature. For the research questions, we classify and evaluate the literature in three main dimensions: the logistics scenarios, the game methods, and the influencing factors.

4.1. Logistics Scenarios

Modern logistics is present through the entire production and distribution process; from enterprise production to residential consumption, there are logistics activities. Customers, participant action strategies and the influencing factors of logistics activities will differ in different scenarios, influencing the creation and analysis of pricing models. According to the research scenarios, the literature is divided into categories such as third-party logistics, freight logistics, cold chain logistics, reverse logistics, crowdsourcing logistics, and pricing of logistics platforms.

The pricing problem of third-party logistics (TPLs) is a hot research topic, with 48% of the literature investigating it. Most scholars identify the pricing problem of TPL in the supply chain system, and construct the pricing model between manufacturers and TPLs [22,23], or the pricing model between retailers and TPLs [24,25]. On this basis, some articles construct a three-tier pricing system consisting of retailers, manufacturers and TPLs [26–31]. In addition, with the expanding demand for logistics, the market has become increasingly competitive. Scholars have introduced the competition factor to consider the pricing problem of TPL under market competition [32,33]. Meanwhile, scholars propose the cooperation of logistics firms due to the strong externalities of logistics networks. Some literature explores the pricing strategies and service levels of two TPLs in independent and joint decision making [34]. The results show that the pricing equilibrium under joint decision not only increases the profit of the system, but also contributes to an improvement in the service level. Part of the literature also investigates the pricing problem of a secondary logistics-service supply chain (LSSC) consisting of a logistics service integrator (LSI) and a functional logistics service provider (FLSP) [35–44]. These studies focus on the pricing and logistics capacity sourcing of LSIs and FLSPs within the LSSC. Differently, Zhang and Song [43] studied the pricing problem of a four-level supply chain (including manufacturers and retailers) with two-level LSSC participation. This is an interesting idea, but there is a lack of similar studies. Moreover, Zhang et al. [45] discussed the pricing of logistics ser-
vices between centralized distribution centers managed by headquarters and subsidiaries. Zhong et al. [46] studied a three-tier logistics supply-chain system consisting of an e-commerce mall, a courier company and an end-delivery service provider. In the research of last-mile delivery, express companies and terminal-express service providers have also received widespread attention, but there is a lack of research on their pricing model.

The pricing of freight logistics is also a well-researched scenario. For the purpose of statistical analysis, land, air and shipping are counted here as freight logistics. Mo and Chen [47] analyzed the relationship between transport service prices and service quality within the road freight industry, with different pricing policies based on service quality. Wen, Xu et al. [48] proposed the air-cargo transport pricing problem, incorporating risk attitudes into optimal pricing decisions. Based on the concept of sustainability, cooperation among freight forwarders has received increasing attention. Several studies have studied the optimal decision for freight transportation in a two-level logistics model [49,50]. Niu et al. [51] studied a supply-chain pricing model in which differentiated logistics services are jointly provided by a short-distance logistics service providers (LSP) and a long-distance LSP. On this basis, the pricing of intermodal transport has also received attention because of its environmental friendliness [52,53]. Tamannaei et al. [54] identified the competitive freight transportation pricing problem in the presence of two intermodal service providers and one direct transport system. Furthermore, many scholars have studied the freight pricing of containers, especially in port logistics [55–57].

With the development of e-commerce and the improvement in agricultural technology, the demand for cold chain logistics has increased. Unlike other commodities, fresh agricultural products need cold chain logistics to ensure adequate freshness and a low loss rate. E-commerce companies are important players in the pricing scenario of cold chain logistics. Some scholars have studied a three-stage C2B pricing supply-chain model for agricultural producers, cold chain LSP, and e-commerce firms [58,59]. Han et al. [58] investigated the optimal logistics service price for a three-stage supply chain dominated by agricultural-products producers under centralized and decentralized decisions in a pre-sale situation. On the other hand, some scholars have studied a three-stage B2C pricing model consisting of a cold chain LSP, e-commerce firms and consumers [60,61]. In addition, a B2B fresh supply-chain pricing model consisting of suppliers, retailers, and TPLs has also been studied [62,63]. Moreover, some papers have studied a two-stage pricing model for logistics firms and retailers [64,65].

Reverse logistics (RL) is another pricing research scenario. Reverse logistics refers to the process of reverse transmission between logistics members, that is, the physical activity from the place of product consumption to the place of product production. There are different organizational models of reverse logistics. According to the participants, it can be divided into three models: manufacturer recycling, retailer recycling, and LSP recycling. In the first two recycling models, logistics activities are undertaken by manufacturers or retailers, and only logistics costs need to be considered, without the pricing of logistics services. Therefore, we only studied reverse logistics alliances for LSP recycling. Fan [66] highlighted the RL pricing problem of fourth-party logistics recycling. Hosseini et al. [67] studied the pricing of drug manufacturers and 3PLs under a drug take-back program. The dual-channel closed-loop supply-chain pricing problem consisting of manufacturers, retailers, and TPLs has received academic attention [68–70]. Among them, Zhao and Zhao argue that the manufacturer dominates in this pricing system [68], while Chen et al. argue that the retailer dominates [69]. On the other hand, Giri et al. [70] studied the pricing and return decisions in a dual-channel supply chain under various scenarios such as centralized and decentralized. In addition, some of the studies introduced the concept of recyclers, who are responsible for collecting used products from consumers [71,72].

In addition, crowdsourcing logistics also provides logistics enterprises with new ideas for sustainable development. Crowdsourcing logistics is an emerging third-party distribution model, based on an Internet platform, which outsources the work of logistics and distribution services to socially idle mass service workers. The pricing of crowdsourcing
services is critical. Scholars have conducted several studies on this issue. Wang et al. [73] proposed the optimal pricing model of crowdsourced logistics services under the condition of price competition during the peak hours of distribution, considering the uncertain distribution capacity of socialization. On this basis, Wang and Xie [74] further studied the optimal pricing strategy for crowdsourced logistics services under two scenarios: supply–demand equilibrium and cumulative delivery-order minimum under stochastic demand.

With the rapid development of the logistics industry and the enhancement of information technology, many logistics information platforms have emerged to provide logistics software and information services, which also extend the new logistics service pricing problem accordingly. Ji et al. [75] proposed the optimal pricing decision of a logistics-software customization service based on the bargaining method of game theory. Qin and Juan [76], on the other hand, studied the pricing problem of a logistics cloud-network intelligence system and constructed a three-level pricing model for logistics service providers, network platform coordinators and logistics network systems. Yu and Ji [77] established a two-step pricing strategy model for a regional logistics information platform based on game theory. Hou et al. [78] incorporated user distance preferences into the pricing decision and investigated the optimal pricing of logistics service platforms under competition.

4.2. Game Methods

The research of pricing game models is relatively mature and, after years of research and development of game theory, there are many classical game methods. The basic model is usually based on strict assumptions, and the selection of the game method will directly affect the pricing results. The appropriate game method is crucial to the study of the pricing of logistics services. In order to make the research closer to reality, some scholars have gradually started to relax some of the assumptions included in the classical models. Therefore, this section reviews the game methods used in the literature.

In the study of logistics pricing, most scholars have used the Stackelberg leadership model. The Stackelberg model is a price leadership model where the players are in an asymmetric market competition and there is a difference in the order of action. In the Stackelberg game, it is assumed that player 1 (leader) determines his pricing strategy \( v_1 \) first, and player 2 (follower) observes \( v_1 \) and then determines his pricing strategy \( v_2 \). In this case, player 1 (leader) has a first-mover advantage in that he determines his profit-maximizing output based on knowing the reaction function of player 2 (follower). Player 2 observes \( v_1 \) and then determines his pricing strategy, so player 2’s pricing strategy \( v_2 \) is determined by \( v_1 \), and there is a mapping function relationship, i.e., \( v_1 \rightarrow v_2 \). In a supply chain where LSPs are involved, LSPs usually act as price takers and do not have priority in pricing. Therefore, scholars use the Stackelberg game to study the supply-chain pricing problem with the participation of LSPs [22,25,27,30,31,46,58,66,68,69,72]. For instance, Chen et al. [69] studied the pricing decisions of a three-level closed-loop supply chain consisting of manufacturers, retailers, and TPLs, with retailers dominating. However, in the fresh supply chain, cold chain LSPs can maximize their market share by enhancing their core competencies due to market imperfections in real scenarios. Therefore, some scholars have constructed a supply-chain pricing model with cold chain LSPs as the leader [60,62,63]. In the logistics service supply chain (LSSC), LSI s are usually in the leading position, so scholars mostly use the Stackelberg game to study their pricing problem [37,39,41–43]. Liu, Wang et al. [37] discussed a two-stage LSSC pricing model with a surge in market demand in the second stage. By changing the dominant mechanism of the Stackelberg game, they eliminated the inability to meet market demand due to LSI’s overconfidence. Further, they [39] also considered the impact of logistics loss preference on pricing strategy and designed four game scenarios to obtain the highest payoff pricing decision scheme. In addition, scholars have used the Stackelberg game to study the pricing of LSPs under competitive conditions. Du et al. [32] studied the distribution decisions and optimal prices of new entrants when there is one logistics service provider in the market. Moreover, some scholars have introduced various price coordination strategies based on the Steinberg
game model, such as revenue-sharing strategies, cost-sharing strategies, unit-delivery price contracts, and combination strategies [25,46].

The Bertrand model is also commonly used in logistics service pricing. It takes price as a decision variable and is a price competition model. The Bertrand model assumes that players provide homogeneous services, i.e., equal marginal costs. The players compete by choosing prices. Wang et al. [73] investigated Bertrand price competition between two crowdsourced logistics service providers when the demand for logistics services is random. The study indicated that the more intense the competition, the lower the optimal service price of crowdsourced logistics. Liu [33] studied the competitive pricing of two express companies in the context of e-commerce, and the results showed that the price competition of homogeneous companies will eventually lead to the non-profit of the company.

In addition, some scholars have adopted bargaining theory to solve the pricing problem of logistics services. A bargaining game refers to the solution of the benefit distribution problem by two or more participants through negotiation. The players determine the minimum accepted price and the maximum paid price in advance, and, according to a certain price strategy, both parties take turns to offer until a Nash equilibrium solution is reached. Li [23] constructed a bilateral bargaining model with switching costs to analyze the outsourcing pricing decision between manufacturers and TPLs. Ji et al. [75] developed a pricing model based on a game-theoretic bargaining approach. A three-round bargaining backward regression calculation is performed for a logistics software customization service to derive its optimal pricing strategy. Qin and Juan [76] studied the pricing in the intelligent system of a logistics cloud-network using the Rubinstein bargaining model. Wang et al. [65] used the generalized Nash bargaining (GNB) framework to study the optimal logistics price of a fresh-food supply chain under different replenishment strategies. The bargaining game is applicable to negotiations under complex negotiation conditions. Among them, the Rubinstein bargaining model and Nash bargaining model can be regarded as the process of a cooperative game.

During the literature review, we found that some scholars adopted bilevel programming for pricing. Bilevel programming is a system optimization problem with a two-level recursive structure, where both the upper-level problem and the lower-level problem have their own decision variables, constraints and objective functions. Therein, the upper-level decision maker needs to consider the possible adverse effects of the strategy adopted by the lower-level decision maker when choosing the optimal decision to achieve the objective. At the same time, the lower-level decision maker needs to take the upper-level decision as a parameter and choose its optimal decision within this range. Therefore, bilevel programming can be used to describe dynamic game problems with constraints. We group the pricing problems using this approach into one category. Guo et al. [35] proposed a bilevel programming describing the game relationship between an integrated logistics service provider and a subcontracting supplier. Their upper-level objective is to minimize the total cost of the LSP, and the lower-level objective is to maximize the total service quality of the subcontracting supplier. Zhang et al. [45] studied the pricing of logistics services between a centralized distribution center managed by headquarters and a subsidiary, and constructed a Bilevel programming pricing model. The conclusion shows that bilevel programming pricing model improves the profit of the head office, but increases the logistics cost of the subsidiary to some extent. Bilevel programming studies the strategic behavior of target customers through a single optimization problem, providing a degree of flexibility and realism for expected demand, which is different from classical demand functions [79]. However, there are few papers on logistics pricing using this method, at present.

Besides the classical game methods mentioned above, scholars have used other dynamic game methods for logistics pricing according to their research scenarios. For the sake of analysis, they are grouped here into one category, which belongs to other dynamic games. After constructing a dynamic game model, some scholars used the reverse induction method to solve it [24,29,47,48,51]. In addition, Hou et al. [78] adopted the Hotelling model to study the pricing strategies of logistics service platforms with competition and
user distance preferences. Wang and Xie [74] constructed an optimal dynamic pricing model for crowdsourced logistics services by optimal control theory.

Game pricing models usually have strict constraints, so their applicable conditions are limited. To meet the complex pricing scenarios, some scholars have used multiple game approaches instead of using a single game approach. Comparative analysis of logistics decision making under centralized or decentralized conditions is a hot topic, and there are many studies in this field [34,40,43,59,61,70]. In general, centralized decision making can achieve Pareto optimality, but its strict requirements on supply-chain participants make it difficult to achieve in practice. In the decentralized condition, some research has studied the influence of different power structures on the optimal price of the supply chain system in detail [43,70]. For example, Giri et al. [70] studied the pricing and return decisions of a two-channel supply chain under centralized, decentralized (Nash game), and decentralized scenarios with vendor dominance, retailer dominance, and TPL dominance (Stackelberg game). Some studies introduce coordination contracts based on decentralized decision making to achieve Pareto improvement in supply-chain systems [59,61]. For example, Song et al. [59] proposed two coordination contracts based on the decentralized decision making of fresh agricultural products, unilateral cost-sharing and revenue-sharing contracts (CS&RS) and consolidated rebate and revenue-sharing contracts (CR&RS). In addition, scholars have used both cooperative and non-cooperative games for pricing research [26,28,31,52,64,67,77]. For example, Yu and Ji [77] proposed a pricing model based on Stackelberg’s game and bargaining theory, respectively, when performing the pricing of logistics platforms. Moreover, some scholars have discussed a variety of competitive game models according to various research scenarios [36,49,50,53]. Watada et al. [49] investigated a two-level logistics model for freight carriers and shippers, and constructed pricing models under three competing games: Stackelberg, Collusion, and Cournot. It was shown that the Stackelberg game maximizes system profit and the Collusion game maximizes shipper profit.

4.3. Influencing Factors

When constructing a game model, the selection of influencing factors is very important for the pricing of logistics service. For the literature review, we derive the explained factors according to the target of the models in each paper and then assign them to a specific category. The logistics pricing model based on game theory mainly considers the following factors: cost indicators, service indicators, risk indicators, competition indicators, sustainability indicators, and other factors.

Cost is the most important factor affecting a logistics price. Depending on the model design, scholars have considered different costs. The cost of logistics services is the most-considered cost category. Some studies further subdivide logistics-services costs into transportation costs, warehousing costs, management costs, etc. For cold chain logistics enterprises, logistics service costs also include refrigeration costs or preservation costs [59–61,64,65]. Among them, some studies introduce a continuous variable, preservation effort, and the preservation cost is a quadratic function of preservation effort [59,61,64]. Some scholars also classify logistics-service costs into fixed costs and variable costs [28,31,48,74]. For instance, Wang and Xie [74] divided logistics service costs into the fixed service expenses and unit compensation of service personnel in their research of optimal pricing for crowdsourced logistics. Further, they investigated the impact of delivery riders’ wage ratio on logistics pricing and platforms’ expected revenue. Wen et al. [48] divided logistics service cost into fixed costs and uncertain costs when they investigated aviation logistics, and the uncertain cost was affected by oil price, weather and other conditions. Some scholars introduce the investment cost undertaken by LSP to improve the level of logistics services, which vary with the logistics service efforts [24,29,30,43,46,64,73]. In addition, scholars discuss other costs according to various logistics scenarios. For crowdsourced logistics, Wang and Xie [74] stated the order loss cost, which is the loss of orders from the crowdsourced logistics service platform due to the insufficient service capacity of social delivery personnel. Due
to the existence of order loss cost, the crowdsourced logistics service platform adjusts the price of logistics services when there is insufficient demand for social delivery personnel to incentivize an increase in the supply of social delivery services. Wang et al. [73] considered the unit loss cost caused to the crowdsourced logistics service platform when social part-time delivery personnel reject orders. Moreover, Li [23] proposed switching costs, i.e., the costs that manufacturers need to spend when searching for logistics partners. Niu et al. [51] studied the delay cost caused by the failure of TPL to deliver goods within the specified time. Yu and Ji [77] considered the operating costs of the platform when they studied the pricing of logistics-information platform services. Wang and Hu [42] studied the green investment cost that TPL need to pay to reduce the adverse impact on the environment. Song et al. [59] discussed the investment cost of establishing a safety tracking system for a fresh supply chain.

Service indicator is another key factor affecting logistics pricing. Some scholars argue that the logistics service level will affect the market demand, and then affect the optimal pricing decision of LSPs [30,34,37,47,58]. Mo and Chen’s study [47] reveals that different pricing policies for different service qualities are not only beneficial to the profitability of freight companies, but also to the improvement in service quality. Wang et al. [73] also considered the service quality of crowdsourced logistics service providers. The difference is that they take service quality as a factor that affects the cost of logistics services. A higher logistics service level also means more logistics service efforts by enterprises, and service efforts will generate service costs. Therefore, some scholars believe that logistics service level will not only affect the market demand, but also the cost of logistics services [24,25,29,30,34,43,46,63,64]. When conducting research on service quality, some scholars have focused on a single indicator. For example, Du et al. [32] used delivery speed to measure the service quality of logistics companies. Jiang and Mou [64] used freshness level to evaluate the service quality of cold chain logistics enterprises. In fact, there are many factors affecting logistics service quality, and the multifaceted nature of service indicators makes the service quality level value a multidimensional vector. Therefore, evaluation methods such as hierarchical analysis, gray analysis, and fuzzy analysis can be used for calculation. Guo et al. [35] proposed the synthetically expressive degree (SED) to measure the service quality of subcontracted logistics service providers. Since SED is affected by several factors and there may be redundancy of indicators, they first used a fuzzy rough set to reduce the indicator system to obtain important indicators and their weights, and then calculated the service quality of each subcontracted logistics service provider. In addition, Du and Han [44] introduced the logistics service quality defect rate in the study, describing the possibility that the logistics service quality provided by FLSP is lower than the customer’s expectation. It is noteworthy that some studies regard logistics service level as one of the decision variables in the pricing model [43,62–64].

Part of the literature studies the impact of competitive indicators on logistics pricing. Some scholars introduce competition-based indicators in their studies. The mainstream view is that the degree of competition affects the optimal pricing decision of enterprises by adjusting market demand. Wen et al. [48] introduced competition-level parameters in a logistics pricing model for air cargo. The competitive-level parameter reflects the impact of an airline’s price adjustment on the demand of its competitors. When Niu et al. [51] studied a two-level logistics supply chain that provides differentiated logistics services, the substitution coefficient of two different logistics services was used to measure the competition intensity. Liu [33] and Wang et al. [73] considered the price competition coefficient when constructing the pricing model. Interestingly, although some studies do not introduce competition indicators, they do consider the impact of market competition. For example, De and Singh [62] believed that the core competitiveness of LSP comes from logistics service level and logistics service price. They studied the optimal price under pessimistic or optimistic competitive strategies of TPL. Overall, the degree of market competition is influenced by many factors, including the number of potential entrants, the
number of real competitors, price competition, quantity competition, and the degree of product differentiation, etc.

Usually, the risk preference of each player in the game model is neutral if not specifically stated. Some scholars considered risk when making pricing decisions. Chen et al. [29] considered risk preference when studying the pricing of TPL. They concluded that the risk preference of supply-chain members depends not only on retailer pricing but also on the market demand. Wen et al. [48] discussed the optimal pricing decisions of two risk-averse air cargo companies when they exist in the market. They applied mean-variance theory to characterize the risk-averse behavior of decision makers. The results show that risk preference has a direct as well as an indirect effect on optimal prices. Therefore, it is important to incorporate risk factors into optimal pricing decisions. Wang and Hu [42] investigated the decision-making attitude of LSSC when dealing with the system risk of a green supply chain, and constructed a game model between LSI and LSP under three different risk preferences (optimistic, pessimistic, neutral).

Moreover, we also studied the impact of sustainability indicators in logistics pricing decisions. Sustainability indicators refer to indicators that help to promote the sustainable development of logistics activities in the three aspects of environment, economy and society, and reduce the negative externalities of logistics activities. The negative externalities of logistics are mainly reflected in the damage to the environment in the process of cargo transportation, warehousing, and packaging, such as noise pollution and increased carbon emissions. In recent years, more and more studies have considered sustainability indicators in pricing models. For example, some scholars have considered the green level of logistics services in their research [25, 41, 42]. Among them, Wang and Hu [42] assumed that the green level of logistics services not only affects the market demand, but also affects the logistics cost. Wang et al. [41] considered the optimal level of LSP-design green innovation and the optimal level of LSP-delivery green innovation in LSSC. In order to promote environmental sustainability and improve the energy efficiency of transportation, some scholars have considered the impact of carbon emissions [40, 53, 65]. Wang et al. [65] studied the fresh-food supply chain under carbon cap-and-trade policies, considering the trading price of carbon emission permits. Tamannaei et al. [53] considered government intervention to introduce fuel taxes in the freight pricing system. Xu and Han [40] investigated the impact of corporate social responsibility (CSR) performance, CSR demand coefficient and low-carbon demand coefficient on LSSC. In addition, for reverse logistics pricing, some scholars considered government subsidies [57] or government penalties [67]. Chen et al. [69] discussed the environmental awareness of consumers. As the environmental awareness of consumers increases, the recycling of second-hand products will increase.

In addition to the above factors, scholars have also investigated some other indicators. For example, Hou et al. [78] discussed consumers’ spatial-distance preferences for logistics service platforms. They argued that consumers are also sensitive to the spatial distance between each other because the longer the distance, the longer the service waiting time. Zhao et al. [36] considered reputation and time of LSP. They believed that consumers are willing to choose LSP with a better reputation or who had been established longer. Liu et al. [39] proposed the loss aversion preference of LSSC members. Hosseini et al. [67] also stated the degree of product defects, which is a random variable with probability density function $f(.)$ and a cumulative distribution function $F(.)$. When studying the pricing decisions of TPL with financing services, Zhang et al. [30] considered the influence of financing interest rate.

5. Review Results

The research on the pricing of logistics services based on game theory can be reviewed from the above three perspectives. With reference to the bibliometric research, this section applies statistical methods to discuss the research results and research trends.

Figure 4 shows the percentage of literature for each logistics scenario. The hot research scenarios for logistics pricing are TPLs (46%), freight logistics (18%), cold chain logistics
(14%) and reverse logistics (12%), in that order. The research on the pricing decisions of TPLs is mainly focused on the two-tier or three-tier supply-chain system consisting of suppliers, TPLs and manufacturers. In addition, the pricing problem of a logistics service supply chain (LSSC) composed of LSI and FLSP is also a hot topic, especially the internal pricing decisions of LSI and FLSP. Special emphasis in the future research should be placed on the analysis of LSSC’s pricing in multilevel supply chains composed of manufacturers and suppliers, as well as the pricing strategy of 3PL in competitive markets. In the freight logistics scenario, scholars are more concerned with the cooperative pricing of road freight forwarders and the pricing problem of multimodal transportation. In the future, we can continue to focus on the pricing strategy of multimodal transport, especially some innovative intermodal transport methods, and the comparative of intermodal participants operating independently and jointly. In addition, with the development of economic globalization, the pricing strategy of air transportation also deserves more attention. The participants in the pricing scenarios of cold chain logistics and reverse logistics are relatively fixed. Among them, the key to pricing in cold chain logistics is to coordinate the prices of cold chain logistics service providers under the condition of ensuring the freshness of products. On the other hand, the pricing strategy of reverse logistics is related to the characteristics of the product itself. Companies aim to increase the product recovery rate through the pricing strategies. The pricing of crowdsourcing logistics and logistics information platforms is less studied at present, constituting a research gap.

Figure 4 illustrates the proportion of literature for each game method. The literature review reveals that existing studies have adopted dynamic game methods to create logistics pricing models. They consider the price strategy of logistics as the result of a multi-stage game. Although one study from 2008 discussed the static game [80], the results were only to illustrate the pricing advantage of TPLs and presented the logistics pricing results in the study with repeated games (dynamic games). A total of 42% of the literature uses the Stackelberg game to construct the pricing model. This indicates that most scholars believe that LSPs are in an asymmetric market competition under the pricing scenarios. Among them, most of the studies argue that TPL have no priority in supply chain pricing, which is the price taker. The next most adopted approach is to integrate multiple game methods (32%). Logistics service pricing involves many interested subjects and the decision-making process is complicated. Comparing and analyzing various types of game models is helpful to find a more suitable pricing method. There are usually three ideas for the construction of multiple game models: (I) to study pricing strategy under centralized and decentralized situations; (II) to study pricing strategy under cooperative and non-cooperative games;
and (III) to study pricing strategy under different competitive patterns. For decentralized decision making, the pricing-strategy research of supply chains under different power structures is a hot topic. In addition, it is also important to study price-coordination strategy based on decentralized decision making in order to achieve Pareto optimality. This area has already been studied by scholars. We believe that these two perspectives are the focus of future research. In addition, some scholars have adopted bilevel programming to construct the pricing model, where the upper-level decision maker and the lower-level decision maker set their own decision objectives separately. At present, few studies have used this approach, but we believe it is a direction to focus on.

The frequency percentages of the influencing factors is shown in Figure 6. The most considered factor is the cost indicator, which accounts for 58%. In fact, all studies introduced cost indicators, except for one study that assumed zero platform-operating costs in its study for ease of analysis [78]. The next most important factor is service indicators. Scholars state that logistics service level affects pricing by influencing market demand or the cost of logistics services. Typically, studies use quadratic functions to represent the nonlinear relationship between service costs and service levels [24, 29, 30, 43, 62, 64, 73]. Service indicators currently appear in the group with a frequency of 20% and need more attention. In addition, some models considered sustainability indicators (10%), risk indicators (3%), competition indicators (4%), and other factors (6%). As can be seen, with the emphasis on the negative externalities of logistics activities, sustainability indicators have received more research attention. Appropriate logistics pricing strategies can push the sustainability of logistics activities. For in-depth study, bubble plots of the impact factors are drawn. Figure 7 shows the cross-frequency of the influencing factors. The bubble size indicates the number of times that the impact factors corresponding to the horizontal and vertical coordinates co-occur in the pricing models. It can be seen that 18 papers consider both cost and service indicators, accounting for 32% of the total literature reviewed. This indicates that the significance of service and cost indicators for logistics pricing is being acknowledged in an increasing number of studies. Moreover, the empty spaces might spark new ideas for future research. For example, we can investigate pricing decisions under the combined effect of service and sustainability metrics in the future. Figure 8 illustrates the number of factors included in the papers. Most of the literature considers the influence of only one or two types of factors when constructing pricing models. In the study of logistics service pricing, the more factors discussed, the fewer papers found. The results show that it is quite difficult to model in this field.
In the case of pricing studies in TPLs, the most considered factor is cost indicators, followed by service, sustainability, other factors, risk and competition indicators. There is only one study that introduces risk indicators in the study of TPLs pricing. However, this does not mean that scholars have not studied market competition in TPLs. For instance, Du et al. [32] used the Stackelberg game to simulate competition between two LSPs without introducing the competition indicator in the pricing model. Overall, the cross-analysis of pricing research scenarios and influencing factors provides some research directions. For example, pricing models for TPLs should consider cost and sustainability indicators. On the other hand, as mentioned earlier, logistics needs to focus on cost and sustainability indicators. On the one hand, a larger bubble indicates stronger correlation between the two, and the number of papers decreases as the number of factors increases.

**Figure 6.** Frequency of the influencing factors.

**Figure 7.** Cross-frequency of the influencing factors.

**Figure 8.** Number of factors included in the paper.
Figure 9 provides a cross-frequency of the logistics scenarios and influencing factors. In the case of pricing studies in TPLs, the most considered factor is cost indicators, followed by service, sustainability, other factors, risk and competition indicators. There is only one study that introduces risk indicators in the study of TPLs pricing. However, this does not mean that scholars have not studied market competition in TPLs. For instance, Du et al. [32] used the Stackelberg game to simulate competition between two LSPs without introducing the competition indicator in the pricing model. Overall, the cross-analysis of pricing research scenarios and influencing factors provides some research directions. On the one hand, a larger bubble indicates stronger correlation between the two, and scholars should consider both factors in subsequent research. For example, pricing models for TPLs should consider cost and service indicators. The pricing model of reverse logistics needs to focus on cost and sustainability indicators. On the other hand, as mentioned above, the blank area may offer future research directions. In the future, we should pay more attention to the competitive pricing issues of TPLs, cold chain logistics and reverse logistics. Meanwhile, the influence of risk attitude on the pricing strategy of cold chain logistics and reverse logistics should be studied.

Figure 9. Cross-frequency of the logistics scenarios and influencing factors.

Figure 10 shows the cross-frequency of the logistics scenarios and game method. The pricing scenario for TPLs is so complex that various game models can be applied. We can see that the most used approach is the Stackelberg game, followed by a combination of multiple game methods. In particular, bilevel programming is currently used only to study the pricing problem of TPLs. For the pricing of cold chain logistics, all existing studies have adopted the Stackelberg game (including the literature that adopts multiple game methods). On the one hand, it may be that there are few studies on this area so the sample size is small. On the other hand, it also indicates that the Stackelberg game is most suitable for the pricing study of cold chain logistics. After determining the research scenario of logistics pricing, the bubble plot results in Figure 10 can provide a reference for the selection of future game methods.
As logistics requirements become more complicated, more and more interesting subjects price coordination strategy that can promote a Pareto better is also an important future pricing in cold chain logistics is to coordinate the prices on the basis of preserving product

6. Conclusions and Research Implications

Logistics is critical in today’s social and economic system. Appropriate logistics pricing strategies can help LSPs compete in the market and promote the sustainable development of logistics operations. A large number of logistics pricing studies based on game theory have emerged in recent years. As we can see, numerous game strategies have been employed to address logistics pricing issues in various scenarios and under various influencing factors. Based on content analysis and bibliometric methods, we examine the pertinent literature in terms of three dimensions: logistics scenarios, game models, and influence factors. In order to address the vacuum caused by the absence of empirical studies in logistics pricing, this paper intends to clarify pricing strategies in logistical situations, identify gaps and problems in prior studies, and contribute to the development of new scientific methodologies and models. The following research trajectories, in our opinion, should also receive consideration in the future.

First, there is a need for more thorough research on logistics scenarios. TPLs and freight logistics are the main subjects of pricing research in logistics. Scholars concentrate on the pricing of secondary or tertiary supply chains, which include suppliers, TPLs and retailers. Future research on TPLs should focus on the pricing of LSSC in the multi-level supply chain composed of suppliers and retailers, as well as the pricing of TPLs in the competitive market. In the freight logistics scenario, future attention should be paid to the pricing of multimodal transportation and air transportation. In addition, the key to pricing in cold chain logistics is to coordinate the prices on the basis of preserving product freshness. As reverse logistics pricing is determined by the characteristics of the product, it is necessary to develop a pricing strategy to improve the product recovery rate. Unlike other situations, crowdsourcing logistics pricing needs to give more consideration to the service capability and bargaining power of the delivery workers. The literature on crowdsourcing logistics pricing is scant.

Secondly, game pricing methods that are multi-objective and multi-type should be developed. The dynamic game methodology is used in all of the pricing logistics game models. In addition, the key to pricing model research is asymmetry in logistics partners. As logistics requirements become more complicated, more and more interesting subjects are included in logistics activities. Pricing logistics services has become a challenging issue because it requires balancing everyone’s wants and interests. This need is nearly impossible to meet with the traditional single-game pricing scheme. Using multiple-game approaches for pricing research and constructing multi-objective game-pricing models are the trends in future pricing research. Since logistics pricing is mostly in asymmetric market competition, future research can concentrate on the changes in pricing strategies under different power structures of supply chains. Additionally, based on decentralized decision making, the price coordination strategy that can promote a Pareto better is also an important future research direction.
Thirdly, pricing strategies considering the role of multiple factors such as service, competition, risk, and sustainability indicators should be studied. Most of the current pricing models are constructed based on single influencing factors. Among them, cost indicators and service indicators are the most important factors affecting logistics pricing. However, the risk attitude of LSPs and the participation of market competitors can affect the logistics pricing too. Especially, with the increase in society’s concern about the sustainability of logistics activities, sustainability indicators that can reduce the negative externalities of logistics environments are also taken into consideration when making pricing decisions. Therefore, it is important and necessary to pay attention to the influence of multiple factors on pricing strategies. Although it is difficult to study multiple factors in model construction, scholars should make full consideration when conducting research.

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References

15. Lukassen, P.J.; Wallenburg, C.M. Pricing third-party logistics services: Integrating insights from the logistics and industrial services literature. *Transp. J.* 2010, 49, 24–43. [CrossRef]
24. Tu, J.; Sun, Z.; Huang, M. Supply Chain Coordination Considering E-Tailer’s Promotion Effort and Logistics Provider’s Service Effort. J. Ind. Manag. Optim. 2022, 18, 2191–2220. [CrossRef]
34. Li, W.; He, X.; Nie, K. Pricing decision research for TPL considering different logistics service level influencing the market demand. J. Ind. Eng. Manag. 2013, 1, 267–275. [CrossRef]
42. Wang, S.; Hu, Z.H. Green logistics service supply chain games considering risk preference in fuzzy environments. Sustainability 2021, 13, 8024. [CrossRef]


70. Giri, B.C.; Chakraborty, A.; Maiti, T. Pricing and return product collection decisions in a closed-loop supply chain with dual-channel in both forward and reverse logistics. *J. Manuf. Syst.* **2017**, *42*, 104–123. [CrossRef]


