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RESEARCH PAPER

Directing Future Studies on Contract Optimization in Supply Chain Management: A Review Study

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ABSTRACT

As efficient instruments, there have been increasing studies on contract optimization in the supply chain field over the recent two decades. The lack of review papers is one of the gaps in contract optimization studies. Hence, the extent study aimed to provide researchers with an attitude to direct future studies on this topic. Therefore, the collected studies on contract optimization were reviewed and analyzed primarily. Then, papers were classified based on the selected categories and themes. Finally, evaluation and results were presented based on the classified topics. They conducted studies, then achievements and limitations of the literature and future research opportunities were introduced to pave the way for researchers' further studies.

KEYWORDS: *Supply Chain management; Contract optimization; Game theory; Bullwhip effect.*

1. Introduction

A supply chain refers to a network of agents and members that are independent of each other, but cooperate to fulfill the needs of an end customer. Therefore, the total profit of the supply chain approaches the global optimality if chain members perform coordinately. In this case, contracts are one incentive means for the supply chain to match different functions and maximize profit. Contracts have an extensive theory base [1]. Supply management, timely customer lead, minimizing hazards caused by variations between supply and demand, and forecasting production and inventory are important factors within a supply chain that require signing contracts between suppliers and buyers.

Optimizing supply chain contracts in a wide range of applications have different types such as revenue-sharing contracts, wholesale price contracts, option contracts, cost-sharing contracts, buyback contracts, smart contracts, capacity reservation contracts, etc. Also, various techniques are used in this field for optimization, including game theory, probabilistic models, and other optimization methods. Also, the presence of phenomena such as risk, uncertainty, bullwhip effect, and strategic alliances such as 3PL gives a special attraction to this area of the supply chain. In addition, the ability to define new contracts such as smart contracts in the field of blockchain adds to its attractiveness. Therefore, in this article, we will explore the field of contract optimization, related to the stated cases in a regular manner. Also, Table 1 shows some articles in different fields:

Tab. 1. Applications of contract optimization

Row	Scope of application	Articles
1	Agricultural	[2]; [3]; [4]; [5]; [6].
2	Maritime Transportation	[7]
3	Biofuel	[8]
4	Education	[9]
5	Energy	[10]
6	car and aviation industries	[11]

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7	New energies	[12]; [13]; [12].
8	Foodstuffs	[14].
9	High-tech industry	[15]; [16].
10	Assembly systems	[17]
11	Communication industry	[18]
12	health sector	[19]
13	Electricity supply chain	[20]; [21]; [22]; [10].
14	fashion industry	[23].
15	Digital industry	[24]
16	Chemicals	[25].
17	transportation industry	[26].
18	integrating building information modeling (BIM) system	[27].
19	Industry 4.0 and emerging DSCP-technologies, cybersecurity, and sustainability relationships with DCSP-technologies	[28].

Considering the essential role of supply chain contracts in the coordination between its different levels, in the optimal state of contracts, it reduces costs of inventory, production, distribution, suppliers, retailers, and customers. Another role of contracts is to create confidence in production, supply, and maintenance for the parties of the supply chain because the parties to the contract will have a lot of information on the demand for goods, the amount of production, the amount of inventory, etc. based on the content of their contract.

Contracts have the ability to accurately determine the amount of product production, the quality of the product, the amount and volume of the periodic order, the price of the product, and in some cases and special conditions, such as the method of sending the product, etc. Contract reduces the risks in supply chains. Therefore, it is one of the important research areas in the supply chain. Also, contracts can be relied upon as a legal document for each of the parties.

Our reviews in section 2.2 indicate an increasing number of studies on this topic. However, we found only five review studies that are reported in Table 2 briefly. Accordingly, there is a gap in the holistic study on supply chain contract optimization, implying the importance of reviewing former studies to provide researchers with an accurate attitude toward the roadmap of future studies.

Tab. 2. The area studied in previous review papers

Row	Title	Ref.	Studied area
1	Overview of Coordination Contracts within forwarding and Reverse Supply Chains	[1]	1. This paper aims to coordinate forward and reverse supply chain contracts
2	Review on Supply Chain Contracts in Reverse Logistics: Supply Chain Structures and Channel Leaderships	[29]	1. Study the effect of contracts on the performance of logistics systems with a focus on environmental sustainability and reverse logistics 2. Classify and examine supply chain structures and channel leadership
3	Revenue-sharing contracts in a supply chain: a literature review	[28]	1. Investigate the revenue-sharing contract within supply chain management for two formats: (1) a wholesale price contract with an added revenue-sharing mechanism, and (2) a consignment contract with revenue-sharing.

The present paper is structured as follows: Section 2 describes the methodology used in literature search, content analysis, and literature classification. Section 3 presents a detailed analysis of the papers. Section 4 discusses the main findings and how to direct future studies.

2. Methodology

The literature review should follow a systematic and clear plan to ensure the validity of the findings. The objective is to identify, evaluate, and classify works in the literature to illustrate the available knowledge in this area and discover gaps

and opportunities for future studies [30] Our review process includes the steps in Figure 1.

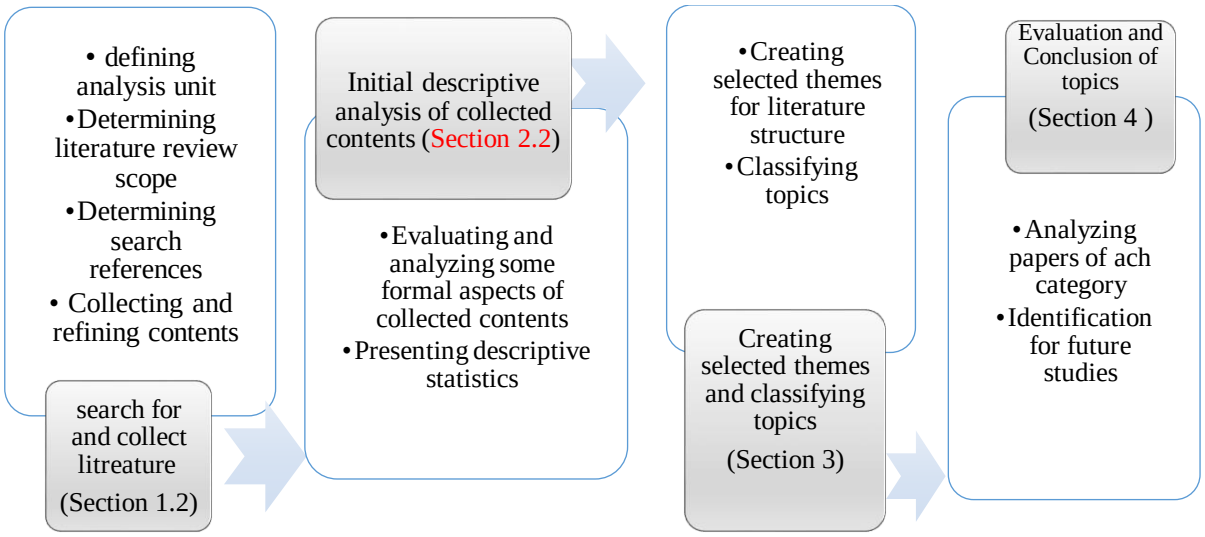

Fig. 1. Steps in the research process

The research steps have been explained herein:

2.1. Search for and collect literature

Setting the searched literature border is an important step in the literature review. Although there are many articles in the field of contract optimization and related topics, such as supply chain management, etc., we are only satisfied with the articles that are within the scope of the research search. We searched relevant literature on contract optimization in the English language published in authoritative scientific journals. We considered papers published in journals and removed books. We searched the structured keywords through the Elsevier database (www.sciencedirect.com) to collect and find relevant works. The following keywords were used: "Supply Chain", "Optimization", "Game", "Coordination", "Contract", and a combination of these terms searched through titles, abstracts, and keywords of papers. Overall, five mixed words were used to search "Supply Chain" besides "Contract" and one of these terms: "Game", "Optimization", or "Coordination". Therefore, the following mixed words were used in the search: Supply Chain + Contract + Game, Supply Chain + Contract + Optimization, and Supply Chain + Coordination + Contract.

2.2. Initial descriptive analysis of collected contents

This part of the study presents the statistical distribution of papers published in each journal during the studied years. According to Figure 2, the identified literature included 373 papers selected is considered research interval. The first and last reviewed papers were published in 2004 and March 2022, respectively. Figure 2 indicates the ascending trend of published papers from 2004 to 2022. However, it should be noted that the extent study was written in the first quarter of 2022, and 52 papers were then identified. This considerable increase in the number of papers compared to previous years implies a higher interest in contract optimization over recent years.

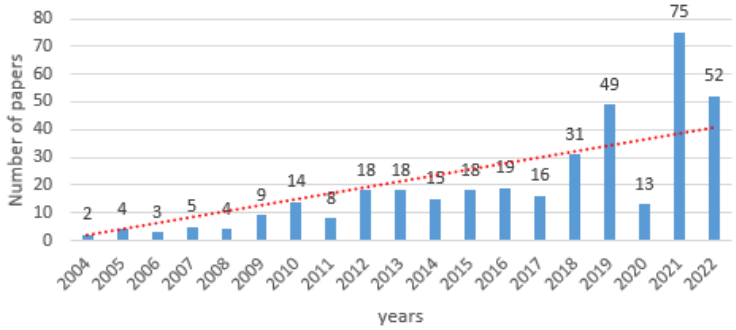

Fig. 2. Distribution of publications per year during the studied period

2.3. Aspects innovations of research

The innovative aspects of this research are related to the extraction of new study gaps in contract optimization research. These new gaps in categories:

1. Examining types of contracts,
2. Symmetry and asymmetry of information,
3. Bullwhip effect in terms of contract optimization,
4. Types of games used,
5. Smart contracts,
6. Combined contracts,
7. Types of non-deterministic methods and used algorithms,
8. Levels of chains used in research,
9. Strategic alliances and issues such as 3PL, VMI, and transportation will be examined.

To achieve this goal, we will follow the methodology suggested in Figure 1.

3. Classification of Research Subjects

This study is one of the first comprehensive reviewing papers about contract optimization in the supply chain, holistically examining all contracts in the supply chain in brief. The papers should be classified due to the dispersion of papers in terms of various aspects. This study attempts to classify subjects, so readers and researchers can find future research directions in each category. Figure 3 illustrates the structure of mentioned points to clarify the topic.

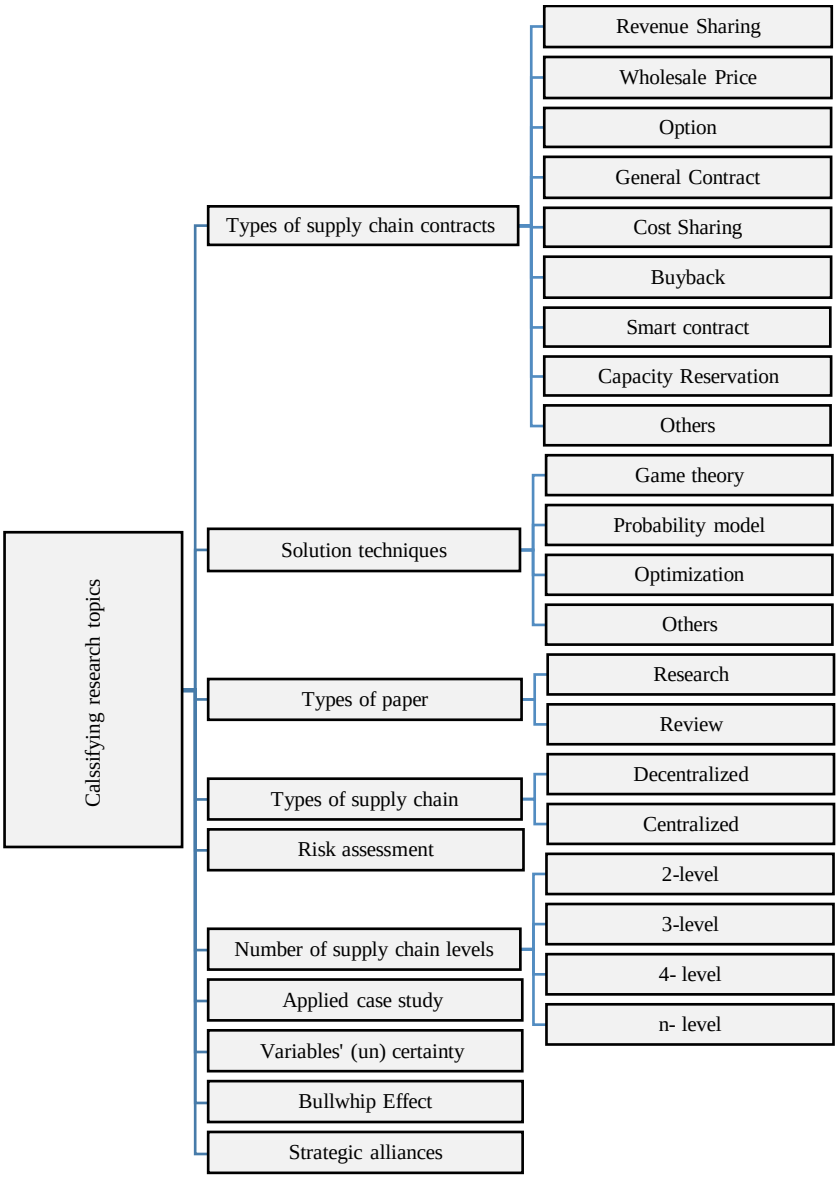

Fig. 3. Selected themes and classification of research topics

3.1. Types of supply chain contracts

According to reviewed studies, 170 papers examined contracts and their effect on supply chain, such as contract design, comparison between contracts, and effect of contracts on supply chain management, transportation, logistics, etc. Table 3 defines some available contracts to clarify the subject. It is worth noting that among the reviewed papers, 67 studies examined other contracts that are fewer than the contracts introduced in Table 3.

Tab. 3. Definition of some popular contracts in the supply chain

Contract name	Contract subject	The regular technique or formula of contract
Revenue-Sharing Contract	This is a coordination mechanism that the distributor provides for the retailer to change the retailer's profit (and the distributor's profit) to encourage the retailer to make a centralized decision for optimizing the total performance of the supply chain. Assume that β represents the distribution of total profit between supplier and retailer. This contract is described with two parameters (α, β) in which the supplier receives wholesale price α that is less than the final cost of entity (c) from the retailer in exchange for 1-β% of the retailer's revenue. Constraint α<c sets channel coordination[31]. $T_r(q,\alpha,\beta)=\alpha q+(1-\beta)CS(q).$ Supply chain profit Suppose that $\alpha=\beta C$, then $\pi_r(q,\alpha,\beta)=\alpha q+(1-\beta)CS(q)=\beta\pi(q).$ Retailer profit $\pi_s(q,\alpha,\beta)=\alpha q+(1-\beta)CS(q)=(1-\beta)\pi(q).$ Supplier profit	Stackelberg
Repurchase Contract	Assume q as the purchase amount in the given period and B (q) as the purchase return at the end of the period. Under a repurchase contract, the supplier receives an amount of money from the retailer (ω) in exchange for per purchased unit but spends (b) a unit to the retailer in exchange for each unit remaining at the end of the period. In this contract $b\le\omega$[32]. $T_b(q,\omega,b)=\omega q-bB(q).$	Stackelberg
Wholesale Price Contracts	In a wholesale price contract, the seller supplies the product (or service) under the wholesale price ω for purchasers, and sellers and buyers negotiate on wholesale price value [11].	Game
Option Contract	In an option contract, the purchaser reserves a product or service under the fixed price or option price over the contract period, and the rest of the demand is determined based on the stock price and dividend [11]	Stackelberg
Discount Contract	Under this contract, the higher the purchase volume, the higher the discount rate [33].	
Capacity Reservation Contract	A Capacity Reservation Contract includes parameters $(\alpha,\beta,\gamma,\lambda)$ λ that represent reservation cost γ and indicates product price during the period; β is the fine paid by the producer if it cannot supply the retailer's order. A shows the purchase price that retailers should pay for partial order that exceeds the reservation volume. In this contract, the retailer reserves Q after paying $\lambda.Q$ [34]. $\pi_R(Q,K)=\mu_p E(D\Lambda K)-p.Q$ Retailer's profit $-E_D\left\{p_e(D\Lambda K\Lambda Q)+\lambda_c\left((D\Lambda K)-Q\right)^+\right\}$ $\pi_M(Q,K)=p.Q$ Supplier profit $+E_D\left\{p_e(D\Lambda K\Lambda Q)+\lambda_c\left((D\Lambda K)-Q\right)^+\right\}-cK$	Stackelberg
Quantity Flexibility Contract	The retailer performs as a leader, and the producer is a follower under this contract. Following steps are taken in this contract: 1) a contract comprising parameters $(\alpha,\beta,\gamma,\lambda)$ (w, αq, βq, d) is proposed. The α represents wholesale price after demand fulfillment. Moreover, the producer must pay a fine (β) if it cannot supply the retailer's order within the allowed interval., In addition, the retailer must pay the	Stackelberg

	fine (γ) if the final order is out of the allowed interval., Parameter $\lambda \epsilon [0,1]$ measures flexibility and allowed range or interval., 2) under this contract, the retailer reserves Q; therefore, the allowed interval equals [34] $\pi_R(Q,K) = \mu_p E(D\Lambda K) - T(Q,K)$ Retailer's profit $\pi_M(Q,K) = T(Q,K) - cK$ Supplier's profit	
Smart Contract	The smart contract is used for online transactions. It is designed to facilitate, confirm or implement negotiations and execute terms of a joint legal contract, including payment, liabilities, and execution without a third party [21].	Qualitative/ Stackelberg
Cost-sharing Contract	Under a cost-sharing contract, suppliers and producers share the cost shortage. In this contract, all supply chain members share the cost of missed sales and the fine of shortage imposed on the producer at the end of the period [35].	Stackelberg
Hybrid Contract	This contract combines two or more contracts considering the problem conditions to achieve better coordination compared to the case of using only one contract.	Expected profit

Table 4 reports the distribution of papers based on the contract type. The first row of this table is titled General Contract. Many papers under the General Contract category in supply chain contracts analyze contracts within the supply chain [36]. The mentioned papers examine the effect of risk and associated factors on contracts, cooperation between members, and the effect of contracts on transportation, inventory, project management, and sustainability. Other papers have addressed some topics, including contract selection, competition, design of contracts under information asymmetry, quantification of contracts' efficiency, etc. This Table includes other contracts that comprise some contracts, such as the combination of several contracts, an agreement under specific supply chain conditions like green conditions, cooperation in investment trajectory, financial contracts, and so forth.

Tab. 4. Key observations of papers based on the contract type

Contract type	percentage	Key observations
General Contract	45%	Topics in this category review the following items: 1. The effect of risk and its related factors on optimal decisions in supply contracts 2. Cooperation between members, examining the impact of contracts on the issue of transportation 3. Cooperation of members through transportation, the role of contracts in inventory control 4. Project contract management for coordination 5. Coordination for sustainability 6. Implementation of coordination contracts 7. Choosing a contract 8. Competition 9. Designing contracts under information asymmetry 10. Quantifying the effectiveness of contracts 11. Coordination and the effect of price supply chains.
Revenue-Sharing Contract	15%	In the articles of this category following items are studied: 1. Income sharing agreement with a joint investment 2. Revenue-sharing contract through bargaining 3. Revenue and cost-sharing contract for pricing policies and services in a two-channel closed-loop supply chain. 4. Monopoly in franchise revenue-sharing contracts 5. The value of information 6. Pricing based on behavior 7. The optimal time to announce the purchase price 8. Social group purchase 9. Competition and coordination, 10. 3PL 11. Circular economy 12. Uncertainty 13. Combination with other contracts 14. Hierarchical subscription contract

		15. Application in the field of improving quality and services 16. Reducing carbon 17. Uncertain supply and demand conditions.
Option Contract	9%	In this type of contract, the following items can be seen: 1. Bilateral option contract 2. Relief resources 3. Risk-adverse suppliers 4. Information asymmetry 5. Prepurchase.
Wholesale Price Contract	9%	This type of contract along with topics like: 1. Incentive mechanisms 2. Constructive advertising and store brand introduction 3. RFID adoption strategy 4. Bank credit financing 5. Two-channel supply chain 6. Market uncertainty, Pareto and Caldor-Hicks improvements 7. Direct fines 8. Mixed contracts 9. Collaborative games 10. Bargaining in asymmetric conditions 11. Innovation in the chain 12. Fixed wholesale contract.
Cost-Sharing Contract	3%	This type of contract along with topics like: 1. Leakage of information 2. Block supply chain 3. Standard and customized products 4. The effect of government subsidies 5. Research and development and advertising 6. Interchangeable products 7. Multilateral coordination 8. Environmental costs 9. Different government intervention policies 10. Cooperative advertising.
Buyback Contract	2%	This type of contract along with topics like: 1. Information sharing 2. Combination with other contracts 3. Random demand, inventory managed by the seller 4. Fuzzy random variable demand.
Smart Contract	2%	This type of contract along with topics like: 1. Recovery strategies 2. Smart contracts based on blockchain 3. Purchase 4. Traceability and payment transactions 5. Smart contracts 6. Game models 7. Intelligent supply chain.
Capacity Reservation Contract	1%	This type of contract along with topics like: 1. Combination with other contracts 2. Bilateral fines 3. Uncertainty in supply 4. Possibility of deduction.
Others	14%	It can be said about the articles on contracts of this group: 1. Some of these contracts of this group are composed of several contracts 2. The contracts of this group are defined in the specific conditions of the supply chain, such as being green, cooperation in the way of investment, financial contracts, etc.

Six reviewed studies on supply chain contracts addressed smart contracts that are based on the newly emerged blockchain technology. Smart contracts aim to reduce transaction costs by actualizing traceable and irreversible transactions using blockchain technology for databases. However, smart contracts' potential is beyond the cost reduction because it facilitates entrepreneurial

cooperation of inter-organizational business processes characteristic of a smart supply chain [21]. Table 5 reports the subjects addressed in papers included in this category.

Tab. 5. Studies on blockchain contracts

Paper	Description
[21]	The effect of smart contracts and blockchain technology to implement joint business projects in entrepreneurial activities
[37]	Investigating how much smart contracts can facilitate blockchain programs economically and operationally
[38]	Effect of contracts on sharing information between smart supply chain members
[39]	Effect of blockchain on supply chain balance using game theory
[40]	Blockchain optimization approach provided for greenhouse system. The proposed approach performs in three steps: forecast, optimization, and control
[41]	Using smart contracts based on blockchain technology to overcome disorders in complicated supply chain

3.2. Solution techniques

Contract parties interact with each other to gain higher profits. Game theory can be used to model contracts. Contract optimization includes issues such as assessment of equilibrium point, optimization of overall profit, etc. In total, 203 papers used game theory to solve the considered problem. Most reviewed papers (n=105) used non-cooperative games, Stackelberg, and Nash equilibrium concepts. The mentioned papers studied issues related to coordination and cooperation through contracts. Table 6 reports the number of techniques used to solve contract optimization problems. However, few studies used cooperative game solution concepts, such as core value and Shapley value [42]. However, these notions are powerful instruments used to analyze the high number of potential contract conditions in which supply chain members can achieve better results through cooperation and collective action. Like cooperative games, dynamic games and games with asymmetric information have also been used to analyze problems pertained to supply chain contracts. The mentioned games can be widely used in this field. Some studies have used other methods, including nonlinear programming, integer programming, simulation, and risk analysis.

Tab. 6. Key observations of contracts' problem solution

Technique		No.	Percentage	Key observations
Game theory	Nash-bargaining	24	55%	In the articles of this topic category: 1- A simple supply chain including a supplier and a retailer, 2- Information symmetry, 3- risk taking, 4- Carbon emissions, 5- Leader and follower of the game, 6- Cooperation and competition, 7- Innovative supplier, 8- Justice and fairness in the decision making of the parties, 9- Disruption in the supply chain (disturbance in the channel, etc.), 10- Green and sustainable supply chain, 11- Nash's asymmetric bargaining, and 12- Combined contracts have been studied
	Stackelberg game	81		This technique in the topic of contract optimization along with topics such as: 1- Collaborative advertising, 2- Two-channel supply chain (online-offline), 3- Financial risk coverage, 4- Risk taking and risk aversion, 5- Discount policy, 6- Product life cycle approach, 7- Symmetric and asymmetric information, 8- Dynamic supply chain,

				9- Carbon reduction policies, 10- Mean-variance analysis, 11- Uncertainty, 12- Social responsibility, and 13- Participation of the third party have been investigated.
	Others	98		1- This group includes dynamic, competitive, evolutionary, and cooperative games, 2- Strategic game, 3- Playing in the presence of a combination of contracts, 4- Delegation strategy, 5- market segmentation, 6- Cloud networking, 7- Advertisements that create a monopoly in the contract, 8- Hidden and open information, 9- Radio frequency identification technology, 10- Uncertainty in supplying resources, 11- Different methods of ordering goods, and 12- Crowd-sourcing production along with the optimization of contracts, have been investigated in this category.
	Probability model	18	5%	1- Contract farming, 2- Price only contracts, 3- Markov model, 4- Coordination of capacity decisions, 5- Supply chain with multiple suppliers, and 6- Few discount contracts, have been investigated in this group.
Optimization	Expected profit	80	35%	In this section, topics such as: 1- Asymmetric information, 2- Social responsibility, 3- Carbon responsibility, 4- Delay in payment, 5- Service contract in the platform era, 6- Standard and customized products with delay, 7- Direct versus indirect fines, 8- Gathering information, 9- Advance purchase and random demand, 10- Bilateral information asymmetry, 11- Currency exchange rate, 12- Under the subsidy contract, 13- Random returns and overconfidence, financing, 14- Improving the quality and maintenance services, 15- Choosing a vertical contract under competition, 16- Carbon emission tax regulations, 17- Performance-based contracts, and 18- endogenous demand information are examined.
	Stochastic programming	14		In this section, topics such as the following items are investigated: 1- Designing a contract for the purchase of humanitarian aid goods considering severe disasters, 2- Optimum inventory allocation for clinical trial supply chains, 3- multi-purpose supply chain, 4- Risk sensitivity analysis, 5- Long-term supply chain partnerships, 6- Delay in payment, 7- Repair contracts, 8- The contract with asymmetric demand information.
	Other methods	39		1- Perishable items 2- Food waste recycling 3- Financing strategies 4- Information asymmetry 5- Uncertainty of the market 6- Result-based contracts 7- Pricing and refilling policy 8- Swelling

			9- Two-part tariff contracts.
Simulation	2		It has been used to simulate a dynamic strategy in the field of income management for perishable items.
P-graph	1		This approach has been used for two-stage decision making in transportation contracts.
Cash flow	1		Purchasing, traceability and cash advance credit payment transactions in the supply chain using blockchain smart contracts.
Non-Technique	15	5%	In this section, topics such as the following items have been examined: 1- Optimal smart contract 2- Digitization of the supply chain 3- Competitive market 4- Commercial credit financing versus bank credit financing 5- Smart contracts for smart supply chain 6- Resale market 7- A review of the contracts.

3.3. Types of papers

The searched papers comprised five review papers. These papers have examined agricultural issues, closed-loop supply chains, supply chain contracts in reverse logistics, revenue-sharing contracts in the supply chain, and digitalization of the construction and procurement supply chain. The rest of the papers verified and addressed different topics related to supply chain contracts.

3.4. Centralized and decentralized supply chain

In a centralized supply chain, suppliers and retailers belong to a single owner; therefore, an entity makes all decisions. In the decentralized type, however, suppliers and retailers have their ownership and make decentralized decisions. In a decentralized system, the retailer usually sends orders to respond to the supplier's contract plan [43]. Of reviewed papers, 69 cases examined centralized and decentralized supply chains simultaneously and evaluated the role of contracts in these two systems. However, the majority of studies considered decentralized supply chains. Figure 4 illustrates this topic.

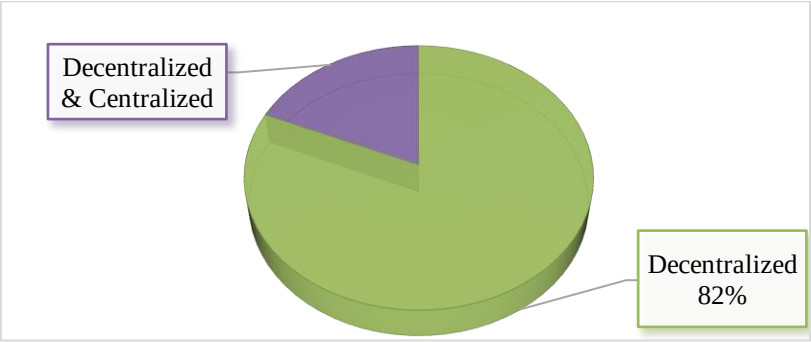

Fig. 4. Distribution of centralized and decentralized supply chains

3.5. Risk assessment

Risks existing in supply chains cause complexity in making investment decisions; therefore, risk assessment is important for supply chain contract parties. Hence, detecting risk factors and evaluating and analyzing risk reduction factors are significant issues that should be considered in supply chain contracts. Figure 5 shows the percentage of papers that used risk assessment in the contracts. It should be noted that some papers used quantification methods (e.g., risk function, statistical variance, etc.) for risk assessment while other papers used qualitative techniques.

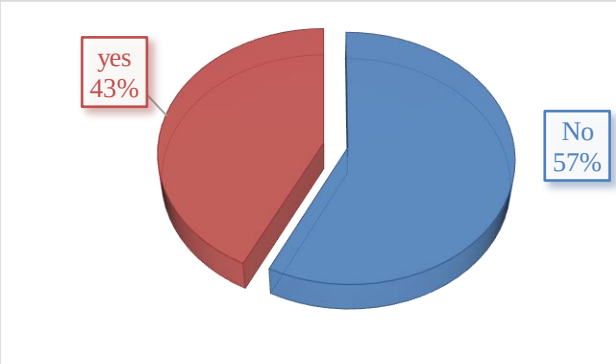

Fig. 5. Risk assessment through searched papers

3.6. Papers' case studies

Among identified papers, 245 studied the problem only using examples and numerical analyses, while the rest investigated case studies. Table 7 reports the papers with case studies. The row of "Others" in this table mainly consists of qualitative studies, the general topic of the supply chain, and other areas such as education, chemicals, store brand, montage system, fashion industry, life, construction industry, and other areas with frequencies less than 4.

Tab. 7. Number of studies based on their examined issues

Scope of study	Papers	No.
Agriculture, food and biofuel sector	[44];[45] ;[46]; [47]; [48]; [49]; [50]; [51]; [13]; [52]; [8]; [14]; [53]; [54] [55].	15
Health field	[56]; [19]; [57].	3
Digital technology	[58]; [20]; [15]; [21]; [24]; [22]; [59].	7
Transportation Industry	[26]; [11]; [60]; [61].	5
Department of energy and electricity industry	[62]; [18]; [12]; [63]; [64];[65].	10
Others	[66]; [67];[68]; [59]; [69]; [70]; ; [43]; [71], [25]; [72];[73], [74], [17]; [58], [40]; [75]; [76].	87

Figure 6 depicts the frequency (%) of papers based on the examined case studies.

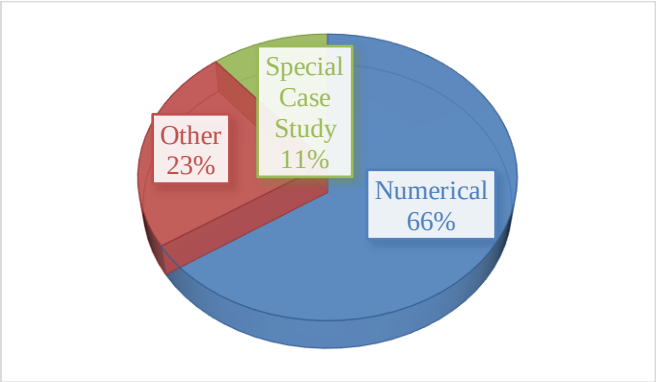

Fig. 6. Number of papers based on the studied issues

3.7. Certainty and uncertainty

Uncertain variables and parameters in a supply chain make the contract more complicated. Determining available parameters and variables allows for discussing contracts' results more simply. Of identified papers, 215 comprised uncertain parameters, such as demand, price, and so forth; Table 8 indicates the distribution of techniques used to examine the behavior of these variables. Topics in 11 cases (None) of the papers were qualitative, so the certainty and uncertainty of variables could not be identified.

Tab. 8. Key observations related to certainty or uncertainty

Row	percentage	Key observation

Certain	41%	1- In the works of this category, a limit is usually considered to face things like risk, uncertain demand, etc. 2- In their article [77] note that competition and coordination in the supply chain of contract organic agricultural products have been investigated. 3- In their article note that the supply contract and process innovation in a dynamic supply chain with information asymmetry has been investigated, which has been modeled in an appropriate way according to the variable conditions of the problem.
Uncertain	59%	1- In their article [41] mentioned that the performance of a multi-layer supply chain network including multiple suppliers, manufacturers, and distributors in the use of blockchain before and after disruption, under different conditions, is studied and expanded the previous works in this field 2- [78] note that the subject of the bilateral agreement of relief resources under the uncertainty of demand, it is particularly attractive in the discussion related to crisis management. 3- Many articles in this section have addressed the modeling of information asymmetry in the chain using the capability of non-deterministic models. 4- In their article, [79] note that one of the new issues of production under the title of crowdsourcing in production is discussed, considering a subcontract.

In 11 cases (None) of the articles, the relevant topics were qualitative and there was no talk about the certainty or uncertainty of the variables of the problem.

Of 224 papers with uncertainty, 6, 142, and 62 used fuzzy, probability, and stochastic techniques, respectively. Table 9 reports some papers that used techniques to eliminate the uncertainty.

Tab. 9. Key observations of techniques that used under uncertainty

Tech.	percentage	Key observation
Fuzzy	3%	1- Competition in the chain in the case of random returns 2- Examining chain contracts in an uncertain mixed environment 3-Examining contracts in stochastic fuzzy supply chain
Stochastic	31%	1- Examining contracts in case of uncertainty in investment 2- Examining the medical care chain 3- Checking the contract in case of random demand 4- Checking the contract in the case of information asymmetry 5- Review of sales discount contracts
Probability	66%	1- Examining factors of risk aversion and risk-taking 2- Debt financing 3- Examining the manufacturers' discount policy 4- Examining contracts in the presence of fines for producers and consumers 5- Examining energy performance contracts 6- Examining contracts in the case of information asymmetry 7- Checking the contract in a random environment 8- Examining multilateral coordination 9- Special capacity investment 10- Decision making and coordination in dynamic mode 11- It is necessary to explain that supply chain contracts are mechanisms that are usually designed to coordinate against various risks in the supply chain environment. Considering probabilistic methods are one of the most efficient methods for modeling these phenomena, it has always attracted the attention of researchers.

3.8. Number of supply chain levels

The number of supply chain levels affects contracts' efficiency. In other words, an increased number of supply chain levels and conflicting objectives lead to the complexity of contracts. According to conducted studies, 333 papers, 19 papers, and two papers used 2-level, 3-level, and 4-level supply chains, respectively. Two studies considered the n-level supply chain. Table 10 shows these details.

Tab. 10: Key observations of supply chain levels

No. of levels	Percentage	Observation key
2-level	93.5%	1- Usually, this type of structure consists of one retailer-one supplier, one retailer-several suppliers, or several retailers-several suppliers. 2- Creates a suitable initial platform for designing contracts in a supply chain. 3- The game theory approach of the leader-follower type has been used in this structure.
3-level	5.5%	1- The three-level game model is used in contract design for this type of chain 2- For this structure, in the state of information asymmetry, has been studied in three very few levels. 3- The topics related to the sub-chain in this structure can be interesting from the point of view of studies.
4-level	0.5%	1- The multi-product, multi-period, and multi-objective model has been studied in this structure. 2- A revenue-sharing agreement is used for this type of structure.
n-level	0.5%	1- The revenue-sharing contract has been studied in this type of structure 2- Studying other types of contracts in this type of structure can be interesting.

3.9. Bullwhip effect

Supply chains use contracts to reduce or remove the bullwhip effect. Contract clarifies the interaction between supply chain members allowing them to share their information and eliminate the bullwhip effect. Of reviewed studies, only three papers examined the bullwhip effect and its role in optimizing supply chain contracts. Table 11 reports these studies briefly.

Tab. 11. Bullwhip effect in searched papers

Paper	Description
[80]	This study examines production rate variance with output sales and producer inventory variance. The research concluded that higher sale in output means higher income, and output sales in the manufacturer site may reduce order fluctuations and production inventories, which improves replenishment. On the other hand, output sales may cause a bullwhip effect.
[81]	This study examined the case in which a supplier's capacity is booked, and a shortage has occurred. The results indicated a weak view of actual customer demand that led to surplus supply or shortage, which characterizes bullwhip effect.
[82]	This study explained the nonlinear theory and dynamic behavior of bullwhip to analyze customer behavior in a competitive economy, expressing that bullwhip cannot completely explain the complicated dynamic behavior of the supply chain system. Moreover, this study pointed to the carbon tax mechanism as a new approach to analyzing supply chain complexity.

3.10. Strategic alliances in contract optimization

Four papers examined strategic alliances and their effects on supply chain contracts. These papers mainly used the Stackelberg type of game theory. Table 12 reports a brief explanation of these papers.

Tab. 12. Strategic alliances in searched topics

Paper	Description
[83]	This paper examined two finance sources (bank and 3PL finance) in which a retailer or 3PL firm determines customized services.
[84]	This study used game theory to analyze the business model to indicate the optimal strategy of participants in the healthcare supply chain, constituting one producer, one 3PL provider, and one retailer.
[38]	In this study, the product provider uses 3PL logistics services for the purchaser. This study suggests a blockchain-based contract for supply chain transactions.
[85]	This study considers an e-channel where an e-retailer has a limited in-house shipping fleet and can hire additional shipping services from a 3PL to encounter demand volatility.

4. Conclusion and Recommendations

4.1. Conclusion

This study provides a systematic review of literature that use contracts to optimize supply chain performance. This paper is the first comprehensive review study on research that has been conducted on contract optimization in the supply chain. Our analysis confirms the rapid expansion of such studies over recent years. The studied literature covers a wide range of SC-related issues. Literature classification allowed us

to find the most frequent issues rather than others and research gaps in supply chain aspects.

Our study shows there are only four articles on capacity reservation contracts with asymmetric information. Furthermore, in a manufacturing supply chain, the capacity reservation contract is used to prevent supply disruptions in a multi-level mode for several products and periods in information symmetry and asymmetry situations under multi-supplier-one-retailer-one-supplier scenarios that multi-retailer can be attractive in a dynamic environment. Moreover, one of the appropriate methods to obtain the optimal state in the capacity reservation contract is parameter adjustment.

Most of the issue of information asymmetry refers to asymmetry in demand and other categories related to the supply chain, such as retail prices, and characteristics of end customers have not been examined yet which in the presence of supply chain contracts can be very attractive, which can be modeled and studied using game theory.

Among all the articles, only three papers have investigated the impact of the contract on the bullwhip effect in the supply chain. Considering the coordination mechanism of contracts in a decentralized supply chain such as the supply chain of food, medicine, and especially perishable items, it is suggested to study the effect of contracts on the phenomenon of bullwhip effect in the state of information symmetry and asymmetry. Also, the following methods are suggested for this type of study 1- methods based on simulation 2- Using appropriate statistical distributions to model the bullwhip effect phenomenon in the presence of contracts 3- Using innovative and meta-heuristic methods to model and study the bullwhip effect and compare the results in two cases with and without a contract. 4- Using data mining methods.

Collaborative games and games with asymmetric information are rare in the existing literature, and only five articles deal with cooperative games. However, one of the reasons for this lies in the dynamic nature of the supply chain variables, which makes the atmosphere governing the supply chain more competitive, and the issue of cooperation is less addressed.

Considering the role of coordination of contracts, cooperation in the chain can be adopted as one of the approaches to achieving coordination in the chain. Therefore, by using this approach and with the capabilities of contracts, design optimal contracts in cooperative approaches in the payment chain. In this regard, we can mention the following:

1- The topic of cooperative games in discussions related to strategic alliances such as contracts in the field of 3PL in the supply chain can have a good appeal, which is trying to achieve win-win results by using game theory.

2- It is suggested to model cooperative advertising contracts using cooperative games.

3- The issue of information cooperation and information leakage in research and development cooperation can be investigated using contracts.

4- Designing partnership contracts in the field of cooperation in forecasting demand, supply, etc.

4.2. Future recommendations

Finally, this study assisted us to emphasize on research gaps and providing some insights for future studies in the following scopes that shown in Table 13:

Tab. 13. Suggestions for directing future studies

	RESEARCH GAP	SUGGESTIONS FOR DIRECTING FUTURE STUDIES
1	UPDATED INFORMATION DURING MULTIPLE TIME PERIODS Very few articles have investigated the issue of updating information in time periods.	The impact of updating information on supply chain contracts can be studied from the following perspectives: 1- The effect of contracts in reducing the bullwhip effect in updating information related to demand and etc. 2- Designing optimal contracts to update the information of the parties in the supply chain. 3-Determining the appropriate times to update the information to reduce phenomena such as the bullwhip effect by using the capabilities of contracts.
2	BLOCKCHAIN EFFECTS ON CONTRACTS Considering the existence of six articles in the field of blockchain technology, which makes it possible to create smart contracts in the context of supply chains, it is interesting that out of this number, 4 are	1- Studying the impact of blockchain technology on all types of supply chain contracts 2- Studying the issue of contracts in the context of this technology at the horizontal and vertical levels of the chain, considering the possibility of non-leakage of information in blockchain technology.

	related to the current year, which shows the attention. researchers in this field.	3-Studying the effects of increasing information asymmetry in the use of blockchain technology and the effect of contracts in reducing its negative effects
3	COMBINED CONTRACTS According to Table 3, the number of articles in the field of combined contracts is less compared to other contracts.	1- The combination of contracts in order to design optimal contracts compared to each and every component of construction contracts 2- Designing subcontracts at different levels of the chain
4	NON-DETERMINISTIC METHODS IN CONTRACT OPTIMIZATION According to the investigations carried out in this article, among the non-deterministic methods of stochastic programming and probabilistic methods, less attention has been paid than other methods, which can be seen in Table 6.	In order to study the uncertainty of information in the amount of inventory, demand, supply, product quality, production, etc., it can be studied.
5	SIMULATION METHOD AND META-HEURISTIC ALGORITHMS The simulation method and meta-heuristic algorithms to face uncertainty have received less attention than other methods, so only one case [41] has been discussed for meta-heuristic algorithms. Therefore, future research in this field can be interesting.	1- In non-deterministic models, these types of algorithms can be used to simulate the results 2- These algorithms can be used in cases related to combining the subject of contracts with other subjects in case of difficult problems.
6	REVIEW ARTICLES IN THE FIELD OF CONTRACT According to Section 3-3, the number of review articles in the field of contracts is very small, so to guide future studies, we can pay attention to these types of articles in future research.	A review of each type of contract with different approaches
7	CENTRALIZED AND DECENTRALIZED SUPPLY CHAINS The simultaneous examination of the supply chain in the centralized and the decentralized mode in the articles in the field of contract optimization can be useful for future research.	Simultaneous examination of concentration or lack of concentration regarding information, inventory, production, etc. in the supply chain along with the issue of contracts in the field of agriculture, arbitration, etc.
8	MULTI-LEVEL SUPPLY CHAINS Examining the supply chain in a multi-level mode in articles can be particularly attractive.	Examining different contracts in the multi-level supply chain and between members of different levels can compare the efficiency of the contracts.
9	STRATEGIC ALLIANCES IN THE SUPPLY CHAIN The introduction of topics such as strategic alliances in the supply chain can be useful for future studies because our review shows that only four articles have addressed the topic of 3PL.	Investigating the issue of strategic alliances in a multi-level supply chain and between different levels is suggested.
10	DUAL-CHANNEL SUPPLY CHAINS Only six articles have investigated the supply chain in dual channel mode, so considering the importance of this issue in the real world, it can be useful for future research.	Considering the expansion of the online channel in exchanges and the need to facilitate network communication and communication security, it is suggested to evaluate the impact of this issue on supply chain contracts and various supply chain phenomena.
11	VMI POLICIES IN SUPPLY CHAINS Very few VMI policies have been used in the reviewed articles, so combining this topic with other topics in contract optimization can be attractive.	Investigating the issue of inventory managed by the manufacturer or supplier in the presence of various supply chain contracts is attractive for studies.
12	PARETO IMPROVEMENT	This approach can be used to conduct qualitative studies, such as:

	In the reviewed cases, a small number of articles (only six articles) have addressed the topic of Pareto improvement.	1- Checking the credit risk of the parties using contracts 2- Examining the behavioral issues of the decision maker in the design of contracts 3- Examining incentive issues, time, and financial discounts in contracts using the Pareto approach 4- Checking the level of satisfaction in the parties of the contracts 5- Designing intellectual property sharing agreements in an innovative supply chain
13	R&D INVESTMENT Optimizing contracts in the field of R&D investment can be useful for future research because few articles have addressed this issue in the reviewed articles.	The design of R&D contracts in innovative supply chains and topics related to open innovation and crowdsourcing is attractive.
14	DYNAMIC AND REPETITIVE GAMES According to Table 5, although the use of game theory in the field of contract optimization has spread well, in the meantime, very few articles have used dynamic games and repetitive games.	The use of dynamic games in dynamic supply chains with flexible structures is attractive 1- Designing optimal contracts for dynamic risk management in supply, demand, inventory, quality, and modeling orders using dynamic games 2- Optimizing contracts in dynamic supply chains 3- Modeling contracts in the field of dynamic chains such as application supply, fashion industry, digital industry, and communication
15	INTELLIGENT TRANSPORTATION SYSTEMS The use of intelligent transportation systems has received little attention in past studies, due to the progress of such systems in recent decades, therefore the urgent need for these types of systems in the real world, can be of great interest in future research.	Topics related to the intelligentization of the supply chain in the presence of various types of supply chain contracts in the field of electronic businesses.
16	MULTI-PRODUCT SUPPLY CHAINS Multi-product supply chains have received little attention in recent research, which of course can be due to the complexity of the issue of optimization in the case of multiple products.	Designing optimal contracts for multi-product supply chains can be attractive for studies.

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Appendix:

Tab. 14. Distribution of papers based on the contract type

Contract type	Papers
General Contract	[86]; [87]; [88]; [89]; [36]; [90]; [91]; [92]; [93] ; [87]; [94]; [95] ;[12]; [96]; [97]; [98]; [99] [1]; [100]; [100];[69]; [101]; [102]; [103]; [104]; [105]; [106]; [107]; [108]; [109]; [110]; [111]; [112]; [29]; [113]; [114]; [115]; [116]; [117]; [118]; [119]; [120]; [121]; [122]; [14]; [123]; [124]; [125]; [126]; [127]; [128] ; [129]; [8]; [9]; [130]; [52] [13]; [131]; [132]; [133]; [25]; ; [134]; [51]; [135]; [136]; [137]; [59]; [138]; [71]; [139]; [64]; [140]; [141]; [142]; [143]; [10]; [144]; [145]; [20]; [19]; [57]; [146]; [147]; [148]; [77]; [84]; [149]; [150]; [151]; [57]; [152]; [49]; [153] [154]; [155]; [57] [156]; [63]; [56]; [157] [34]; [150]; [158]; [159]; [160]; [161]; [75]; [62] [47]; [46]; [162]; [58]; [44]; [163], [164]; [165]; [147].
Revenue-Sharing Contract	[166]; [26]; [18]; [44]; [10]; [167];[168]; [83]; [27]; [10]; [73]; [22]; [50];[169] [28]; [170]; [171]; [172]; [173]; [107]; [174]; [65]; [175]; [176]; [177]; [178]; [179]; [180]; [163]; [181]; [182]; [70]; [183]; [184].
Option Contract	[185]; [53]; [24]; [186]; [187]; [188]; [189]; [27]; [85]; [190]; [191]; [192]; [193]; [61]; [194]; [195]; [196]; [197].
Wholesale Price Contract	[198]; [199]; [67]; [27]; [200];[201]; [11]; [202]; [24]; [186]; [117]; [203]; [204]; [205]; [206]; [207].
Cost-Sharing Contract	[208]; [12]; [209]; [72];[74]; [210]; [211] [212]; [35].
Buyback Contract	[69];[213]; [214]; [43].
Smart Contract	[41]; [40]; [39]; [38]; [37]; [21].
Capacity Reservation Contract	[34]; [215];[216]; [15].

Others	Penalty ([66]; [217]), Quantity Flexibility [45], Carbon reducing ([218]), Consignment ([18]; [219]), Debt-shared Contract ([220]), Long-term ([48];[221];[222]), Delay-in-payments ([223]; [224]), Guarantee ([225]), Service contract ([226]; [76]), Price Contract ([227] [68]; [55]), Price discount Contract ([228]), Insurance ([229]), Financial ([230]), Profit sharing Contract([231]), Side-payment self-executing Contract ([82]), Hybrid contract ([232]), Rebate Contract ([233]; [234]; [33]),Index-based price Contract ([235]), Quantity discount Contract ([236]; [237]), Flexible Contract ([238]), Risk sharing Contract ([239], Flexible trade credit ([240]), Range contract ([241]), Semiconductor supply chain ([81]), Bonus([242]), Markdown contract ([23]), Farming contract ([243]), Incentive ([244]), Ship-to-order contract ([80]), Side-payment ([245]).

Tab. 15. Techniques used in contracts' problem solution

Technique		No.	Papers
Game theory	Nash-bargaining	24	[246]; [182]; [70]; [86]; [247]; [113]; [173]; [118]; [131]; [248] ; [230]; [44].
	Stackelberg game	81	[198]; [199]; [58]; [85]; [220]; [12]; [228];[201]; [63] ; [74]; [232]; [149]; [83]; [77]; [34];[144]; [235]; [142]; [249]; [137]; [136]; [219] ;[249];[73]; [125]; [119]; [115]; [233]; [100]; [99]; [98];[182]; [193]; .
	Others	98	[66]; [44]; [18]; [67]; [26]; [250]; [251]; [160]; [225]; [39] ; [34];[231];[209]; [72]; [11]; [200]; [161];[82]; [154]; [48];[49]; [57]; [150]; [84];[147];[37]; [204]; [189]; [22]; [186]; [122]; [186]; [24]; [111]; [110]; [211] ;[212]; [176]; [96]; [80]; [87]; [91]; [15]; [222]; [245].
Probability model		18	[46]; [47]; [140]; ; [105].
Optimization	Expected profit	80	[62]; [223]; [76];[148];[19]; [10]; [71]; [236]; [50] ; [203]; [51]; [252]; [13]; [52]; [9]; [126];[186]; [114]; [238]; [173]; [24]; [53]; [174]; [241]; [104]; [23]; [185]; [179]; [178]; [253]; [69]; [175]; [243]; [244]; [227]; [92]; [234]; [90]; [214]; [54]; [217].
	Stochastic programming	14	[197]; [57]; [65]; [224]; [93];[229];[61]; [191].
	Other methods	39	[44]; [45]; [158]; [157]; [20]; [64]; [59]; [25]; [8]; [254]; [239]; [112]; [69]; [215]; [221]; [216]; [36]; [255]; [164]; [180]; [43].
Simulation		2	[48]; .
P-graph		1	
Cash flow		1	[38].
Non-Technique		15	[40]; [75]; [150]; [200]; [155]; [28]; [21]; [29]; [1]; [110]

Tab. 16. Techniques used under uncertainty

Tech.	Papers
Fuzzy	[254]; [122];[69].
Stochastic	[206]; [84]; [19]; [71]; [189];[136];[169];[25]; [13]; [141]; [125]; [247];[107]; [241]; [65];[176]; [253]; [224]; [196]; [243]; [226]; [110]; [256];[90]; [257]; [214]; [195]; [217]; [194];[183]; [55]; [61]; [182]; [182]; [193]; [215]; [221]; [216]; [89]; [191]; [180]; [43].
Probability	[41]; [45]; [40]; [46]; [47] [18]; [85]; [250]; [258]; [197]; [48]; [159]; [200]; [220]; [209]; [201]; [56][11]; [161]; ; [57]; [27]; [82];[150] [148]; [218]; [20]; [145]; [10]; [37]; [64]; [204]; [73]; [22]; [50]; [203]; [51]; [132]; [52]; [129]; [259]; [186]; [260]; [237]; [24]; [53]; [111]; [110]; [202];[105]; [242]; [104]; [133]; [80]; [244]; [93]; [227]; [213]; [234]; [91].

Tab. 17. Number of supply chain levels in reviewed papers

	Papers
2-level	[166]; [26]; [250]; [44]; [167]; [48]; [83]; [34]; [27];[73]; [249]; [22]; [50]; [169]; [28];[170]; [171]; [172]; [107]; [174]; [65]; [176]; [177]; [178]; [179]; [181]; [182]; [70]; [183] [184]; [185]; [53]; [24]; [186]; [188]; [189]; [85]; [192]; [193]; [182]; [194]; [195] ; [196];[197]; ; [198]; [199]; [67]; ;[27]; [200]; [148]; [11]; ; [202]; [24]; [259]; [186]; [203]; [204]; [205]; [44]; [12]; [209]; [72]; [74]; [210]; [211]; [212]; [35];[252];[69]; [213]; [214]; [43].
3-level	[261] ;[262]
4-level	[44]; [175].
n-level	[178]; [184].