

Dual-Channel Agricultural Product Supply Chains: Coordination Mechanisms, Pricing Strategies, and Sustainable Practices

Yaohui Wang

School of Economics and Management, Chongqing Jiaotong University, Chongqing 400074, China

ABSTRACT

Dual-channel supply chains have become an important research topic in modern supply chain management. By integrating traditional retail channels with e-commerce channels, this supply chain structure enables firms to coordinate online and offline operations, optimize resource allocation, reduce operating costs, and respond to heterogeneous consumer demand. Based on the existing literature, this paper reviews dual-channel supply chain research from the perspectives of basic concepts, current research topics, research progress, and future trends. The review shows that substantial progress has been made in channel coordination, pricing strategies, cross-channel services, and low-carbon supply chain management. In particular, revenue-sharing contracts and cost-sharing mechanisms can alleviate channel conflict, cross-channel service design can improve supply chain efficiency, and low-carbon policies can promote sustainable supply chain development. However, several issues remain insufficiently addressed, including dynamic changes in consumer behavior, supply chain resilience, and the application of intelligent technologies. Future research should further explore intelligent optimization methods under multi-channel collaboration, green supply chain strategies in low-carbon contexts, and long-term models of consumer behavior, thereby providing stronger theoretical and practical support for dual-channel supply chain management.

KEYWORDS

Dual-Channel Supply Chain; Channel Coordination; Pricing Strategy; Cross-Channel Service; Low-Carbon Supply Chain.

1. BASIC THEORIES AND CONCEPTS

A dual-channel supply chain refers to a supply chain structure in which a manufacturer sells products through both online and offline channels. This model integrates the advantages of traditional retailing and e-commerce, provides consumers with more flexible purchasing options, and at the same time generates challenges such as channel conflict and channel competition^[1]. Dual-channel supply chains are generally characterized by online-offline integration, the coexistence of competition and cooperation, and the ability to meet diversified demand. Online channels attract consumers through price transparency and convenience, whereas offline channels emphasize physical experience and after-sales services. Together, these channels create a more flexible consumption environment. Although online and offline channels compete in terms of market share, prices, and service levels, coordination mechanisms such as unified pricing and revenue-sharing contracts can improve overall supply chain performance^[2]. Moreover, dual-channel strategies can cover different consumer segments more effectively. Price-sensitive consumers tend to prefer online purchasing, whereas consumers who value service and experience are more likely to choose offline channels^[3]. From a

theoretical perspective, this supply chain model helps firms respond to market changes and maintain competitive advantage through resource integration and operational optimization.

2. CURRENT RESEARCH STATUS

2.1. Channel Conflict and Coordination

Channel conflict between online and offline channels is one of the central issues in dual-channel supply chain research. Owing to lower operating costs, online channels often compete through lower prices, which may reduce the profits of offline retailers and weaken overall supply chain efficiency. To address this problem, researchers have proposed coordination mechanisms such as revenue-sharing contracts, cost-sharing mechanisms, and dynamic pricing strategies. Comparative analyses of centralized and decentralized decision-making suggest that centralized decision-making can maximize overall supply chain profits, whereas decentralized decision-making often requires cooperative contracts to improve system efficiency^[4].

2.2. Pricing Strategies and Consumer Behavior

Consumer behavior has a significant influence on pricing strategies in dual-channel supply chains. Consumers usually exhibit higher price sensitivity in online channels, while offline channels rely more heavily on service experience and brand loyalty. Accordingly, an appropriate price differentiation strategy can help reduce channel conflict and improve the overall returns of supply chain members. In addition, studies on consumer utility and channel preference suggest that pricing decisions should not be considered independently from service quality, channel trust, and consumer switching behavior .

2.3. Cross-Channel Returns and Services

Cross-channel returns are an important service strategy for improving consumer experience. This mechanism allows consumers to return products through a channel different from the original purchase channel^[5]. While cross-channel returns can enhance consumer satisfaction and purchasing convenience, they may also increase reverse logistics costs and create operational conflicts among channels. Existing studies indicate that the design of return policies should balance service level and cost control. Optimized return policies and compensation mechanisms can improve supply chain performance while maintaining consumer service quality.

2.4. Dual-Channel Supply Chains in a Low-Carbon Context

With the advancement of carbon-reduction policies, carbon cap-and-trade mechanisms have become a growing focus in supply chain research. Studies show that carbon trading prices, emission-reduction cost sharing, and government subsidies can influence pricing decisions and cooperation strategies among supply chain members^[6]. For example, collaboration between manufacturers and retailers can reduce the overall carbon footprint of the supply chain through shared investment in emission-reduction technologies. Low-carbon dual-channel supply chain research therefore connects operational coordination with environmental sustainability.

2.5. Specific Characteristics of Fresh Agricultural Products

In dual-channel supply chains for fresh agricultural products, high loss rates and preservation requirements represent major challenges. Existing research mainly focuses on preservation effort, brand promotion, pre-sale decisions, and freshness-sensitive demand. For instance, the combination of preservation cost-sharing contracts and brand promotion strategies can reduce product

deterioration and improve consumer recognition of freshness and brand value ^[7]. These studies show that dual-channel coordination for fresh products should account for product perishability, freshness investment, and consumer trust.

3. RESEARCH PROGRESS

3.1. Application of Game-Theoretic Models

Game theory has been widely applied to strategic research on dual-channel supply chains. Stackelberg game models are frequently used to examine optimal pricing and profit allocation under different market structures. In such models, manufacturers and retailers make pricing decisions according to leader-follower relationships, and existing studies often find that manufacturer-led structures can be beneficial for overall profit maximization under certain conditions. Dynamic game models are also used to analyze long-term optimization strategies, particularly in low-carbon supply chains. Research indicates that carbon trading prices affect emission-reduction investment decisions and the overall returns of supply chain members. The introduction of dynamic cooperation mechanisms, such as carbon cost-sharing contracts, can further improve green supply chain efficiency ^[6]. In addition, incorporating risk aversion into game models makes pricing strategies more sensitive to external uncertainty and provides a more realistic perspective for studying complex supply chain environments .

3.2. Optimization of Cross-Channel Services

Cross-channel services, including cross-channel returns, unified pricing, and order fulfillment, have become important topics in dual-channel supply chain research. Simulation-based studies suggest that the design of cross-channel services should consider consumer preferences, return costs, and operational efficiency. Return convenience may improve consumer satisfaction but may also increase operational costs. Therefore, combining dynamic pricing with return compensation mechanisms can help balance service costs and operational performance ^[8]. Unified pricing is also regarded as an effective means of reducing cross-channel conflict. When online and offline channels adopt unified pricing, overall supply chain benefits may improve because consumers can choose more flexibly between channels ^[9]. With the development of intelligent technologies, order fulfillment efficiency has become another important research direction, particularly in relation to how intelligent logistics systems can reduce delivery delays and improve consumer experience.

3.3. Development of Low-Carbon Supply Chains

As environmental policies continue to advance, carbon cap-and-trade mechanisms have been increasingly incorporated into supply chain management research. Researchers have developed dynamic modeling frameworks for low-carbon supply chains and proposed various green development strategies. Investment in emission-reduction technologies can directly reduce carbon emissions and may also generate additional economic benefits through carbon trading markets ^[10]. Studies also suggest that collaborative emission-reduction behavior among supply chain members, such as technology sharing and joint investment, can improve overall efficiency while reducing the profit pressure caused by carbon-reduction targets ^[6]. At the policy level, dynamic carbon caps and fluctuations in carbon trading prices are considered key factors affecting low-carbon supply chain decisions. Further research is needed to clarify how these factors influence the long-term stability and economic performance of dual-channel supply chains .

4. FUTURE RESEARCH TRENDS

4.1. Intelligent and Digital Management

Future research should further integrate digital technologies and intelligent systems into supply chain decision-making. Big data analytics and artificial intelligence can be used to predict consumer behavior, support precision marketing, and improve dynamic pricing. Machine-learning-based forecasting models may improve demand prediction accuracy, thereby optimizing inventory management and order fulfillment. Blockchain technology also has potential for improving supply chain transparency by enabling real-time data sharing and cross-channel collaboration, thereby reducing information asymmetry ^[11]. The further development of intelligent technologies, such as unmanned warehousing and automated logistics, may also reduce operating costs and improve overall efficiency.

4.2. Dynamic Research on Consumer Behavior

Consumer behavior is an important factor in dual-channel supply chain management. However, many existing studies remain based on relatively static assumptions. Future research should pay greater attention to the dynamic evolution of consumer behavior and its influence on long-term channel strategies. With the popularization of multi-channel shopping habits, consumer decisions are increasingly affected by online promotions, offline experiences, service quality, and low-carbon preferences. Dynamic modeling methods, such as system dynamics and stochastic control, can be used to analyze behavioral changes in multi-channel environments. Further research on long-term preferences for service quality, price sensitivity, and low-carbon products can provide more reliable decision support for channel optimization ^[12].

4.3. Low-Carbon Economy and Sustainable Development

Against the background of global carbon-reduction goals, further research is needed on the optimization of low-carbon supply chains, especially the long-term effects of carbon trading mechanisms on pricing, revenue allocation, and member collaboration ^[13]. Carbon market price fluctuations may directly affect the pricing decisions and profit distribution of manufacturers and retailers. By introducing dynamic emission-reduction cost-sharing mechanisms, supply chain members can achieve collaborative carbon reduction and improve overall environmental performance. Future studies should also examine the long-term influence of green technology innovation on low-carbon dual-channel supply chains and explore how economic and environmental objectives can be balanced.

4.4. Supply Chain Resilience and Risk Management

In the face of global supply chain uncertainties, such as public health emergencies, natural disasters, and demand fluctuations, supply chain resilience has become an important research direction. Flexible supply chain design and risk-sharing mechanisms can improve the ability of firms to respond to disruptions ^[14]. Multi-channel collaboration can enhance resilience, particularly when supply interruptions or demand volatility occur. Measures such as multi-channel inventory sharing and flexible logistics routing may reduce operational risks. Future research should combine game theory and network optimization methods to explore the decision-making behavior of supply chain members under risk-averse conditions and examine how these behaviors affect overall supply chain resilience ^[15].

5. CONCLUSION

Overall, dual-channel supply chain research has made considerable progress in channel coordination, pricing strategies, cross-channel services, and low-carbon development. Existing studies show that revenue-sharing contracts, dynamic pricing strategies, and cross-channel service optimization can improve overall supply chain performance and consumer satisfaction. At the same time, the development of low-carbon policies and green technologies has provided new perspectives for sustainable supply chain research. Nevertheless, several limitations remain. Many studies are based on theoretical models and lack empirical validation, which may limit the practical applicability and effectiveness of their conclusions. Research on the dynamic evolution of consumer behavior and its long-term impact on multi-channel strategies remains insufficient. The implementation effects of environmental policies and their interaction with the interests of supply chain members also require further investigation, particularly under carbon market volatility.

From a broader research perspective, future studies should strengthen the integration of theory and practice. Case studies and firm-level operational data can be used to test the applicability of theoretical models and improve their practical value. Interdisciplinary approaches involving psychology, behavioral economics, and data science may further improve consumer behavior models and intelligent optimization algorithms. In the context of green development, the implementation pathways of low-carbon policies and their long-term effects on overall supply chain performance and profit distribution should also be examined more systematically. Such research can provide scientific and operationally feasible support for firms and policymakers seeking to improve dual-channel coordination, digital transformation, and sustainable supply chain management.

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