**Frontiers in Business, Economics and Management**
ISSN: 2766-824X | Vol. 14, No. 1, 2024

# A Literature Review on Pricing Decisions for Complementary Supply Chains Considering Social Preference Behavior

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**Abstract:** In practice, many enterprises have achieved better market results through the implementation and continuous optimization of the complementary products strategy. Although complementary products can bring higher value and utility to customers' consumption experience, thus affecting the production operation and sales price decisions of enterprises, the strategic choices of complementary supply chain members will be affected when facing the different social preference behaviors of the members in the complementary supply chain and the complex supply chain structure. Based on this, this paper considers the vertical altruistic preference of the manufacturer over the retailer and the horizontal altruistic preference of the manufacturer over the manufacturer of the complementary product under different altruistic preference dimensions for a two-level supply chain system consisting of two manufacturers producing complementary products and a common retailer, and analyzes the optimal pricing strategies of supply chain members under different altruistic preference levels, which is of great significance for the stable operation of the supply chain.

**Keywords:** Altruistic preferences;Complementary products; Pricing decisions.

## 1. Introduction

Since the theoretical research related to supply chain management appeared in Harvard Business Review in the 1980s, supply chain has been the focus of research in the direction of management, which has produced rich research results after more than 40 years of development. Moreover, these researches have been widely applied in actual business operations, and have played a vital role in the rapid and efficient development of enterprises. In recent years, the quality and development of supply chain has been highly valued by the state, and the General Office of the State Council, the Ministry of Commerce and other departments have successively issued the Guiding Opinions on Actively Promoting Supply Chain Innovation and Application, Notice on Carrying out Pilot Supply Chain Innovation and Application and other relevant documents to guide and support the development of supply chain. As an important part of the supply chain, the supply chain of complementary goods is crucial to the promotion of supply chain development. Complementary goods refer to two commodities that have a consumption dependency relationship. When one of them aims to increase the market share of the product through marketing methods, this also promotes the sales of the complementary product. Thus, demand and revenue are interrelated between complementary products oriented to the same market. In practice, many companies have achieved better market results by implementing and continuously optimizing complementary product strategies. For example, Haier washing machine and Procter & Gamble jointly advertise and market their products, which has increased the sales of both products. Although complementary products can bring higher value and utility to customers' consumption experience, thus affecting the production operation and sales price decisions of enterprises, the strategic choices of complementary supply chain members will be affected in the face of the different social preference behaviors of the members in the complementary supply chain and the complex supply chain structure.

At the level of decision makers themselves, most of the previous studies are based on the assumption that decision makers themselves are completely rational. However, behavioral economists, represented by Nobel Prize winner Kahneman, have found that in reality, decision makers are not all "rational economic beings", they are concerned about their own profit level, and they also attach great importance to the interests and losses of other members of the supply chain, and in behavioral supply chains, different decision makers are always influenced by social preferences due to their market position and their own factors. In a behavioral supply chain, different decision makers, due to their market position and their own factors, always make decisions with social preferences, such as fairness concern, reciprocity and altruism preference. For example, early Wal-Mart and P&G in order to get the maximum benefit and foothold in the competitive market, both of their cooperation is based on maximizing their own interests, later, Wal-Mart and P&G invested in the development of win-win supply chain, and achieved significant results, both of their interests have been qualitatively changed. Wal-Mart began to improve the cooperative relationship with suppliers, the most important thing is to take the initiative to provide support from the price pressure on suppliers to help them reduce costs. At the same time, by virtue of its own perfect scientific management system and technical standards to allow suppliers to reduce costs and improve the quality of both sides to realize the benefits of enhancement. Wal-Mart's help to suppliers is actually a kind of altruistic preference, which is mainly reflected in Wal-Mart's desire to improve the interests of suppliers in the market through some of its own selfless support, and ultimately it will also bring about the enhancement of the interests of the entire supply chain, and play a role in optimizing and coordinating the supply chain. Regarding the altruistic preference behavior is common in the

operation and management of the actual complementary goods supply chain, the altruistic behavior of the supply chain decision-making body, that is, the decision-making body will produce positive utility due to the increase of the other party's benefit, focusing on the cooperative relationship between the supply chain enterprises. A large number of studies have shown that in the process of supply chain operation, in order to promote the increase of social welfare, members tend to embody altruistic preference to a certain extent to promote the cooperation between the two sides, which portrays that the members consider taking into account the other party's interests while taking into account the interests of their own interests, reflecting the concern of the members of altruistic behavior for social welfare. Therefore, focusing on the optimal strategies of complementary supply chains under altruistic behavior can make the obtained conclusions more consistent with reality and provide theoretical references for decision makers in the application of actual business scenarios.

At the level of complementary supply chain structure, based on the existing research, most scholars study the altruistic preference of one member and one dimension based on the supply chain model of one manufacturer and one retailer, but in the actual situation, the supply chain does not only have the preference behavior of a single member. Based on this, for the secondary supply chain system consisting of two manufacturers producing complementary products and a common retailer, it is important to consider the vertical altruistic preference of the manufacturer to the retailer and the horizontal altruistic preference of the manufacturer to the manufacturer of the complementary product under different altruistic preference dimensions, and analyze the optimal pricing strategy of the supply chain members under different levels of altruistic preference, which is important for the stable operation of the supply chain.

# 2. Relevant Theories and Research Status

## 2.1. Studies on complementarities

In terms of the definition of complementary goods, complementary goods, according to the traditional definition of economics, refer to two goods that have to be consumed together in order to satisfy the utility of the consumer, for example, a stapler and a staple, a ping-pong paddle and a ping-pong ball, a toothbrush and a toothpaste, and so on. When the price of one of these goods is reduced, consumer demand for the complementary product of that good also increases, so usually there is an interdependent and symbiotic relationship between the complementary goods. With the change of consumers' demand for products, complementary products have certain relativity with consumers [3], two products that are complementary in function, utility or consumer behavior habits are called complementary products. More generally, it is considered that if the utility generated when consumers consume two products at the same time is greater than the sum of the utility of consuming the two individually, it is a complementary product. In real life, the complementarity of complementary goods has asymmetry, based on this asymmetry can be divided into three categories of complementary goods: (1) fully complementary goods (perfect complementary goods), the two commodities are put together to consume the use of the value of the use of, such as gasoline and automobiles. (2) not strictly complementary goods (imperfect complementary goods), the two goods can be used alone to reflect the value, but also can be used together to reflect the value, such as tea and tea cups. (3) Unidirectional Complementary Goods, where one good must be used together with the other good to reflect value, and the other good can be used alone to reflect value, such as leather shoes and shoe polish.

In terms of complementary goods pricing, product pricing strategy is an effective means of regulating supply chain management and is one of the most important decisions in supply chain operations. Complementary products complement each other in function, promote each other in consumption, and influence each other in price. The ability to accurately assess the consumer's prediction of product value and thus set a reasonable product price is an important factor in the profitability of enterprises. Therefore, the academic community has conducted extensive and in-depth research on the pricing strategy of complementary products and achieved rich results. In this paper, we study the pricing strategy of complementary products from the perspective of supply chain, so the literature review on complementary products focuses on complementary product pricing in the literature review. A complementary goods supply chain consisting of one manufacturer and one retailer.Ata Allah Taleizadeh and MasoudCharmchi analyze the problem of optimal advertising inputs and optimal pricing of complementary goods for a two-tier supply chain consisting of one manufacturer and one retailer.The results show that the profit levels of both the manufacturer and the retailer move inversely with the degree of product complementarity. Xu-Jin Pu still considers a two-tier supply chain consisting of a manufacturer that produces complementary products and a retailer that sells complementary products, and studies the pricing and advertising problems of retailers who sell their products separately versus in bundles, and elucidates the conditions under which retailers adopt the bundling strategy to sell.

Based on the above literature, it can be seen that the current research on complementary goods is mainly based on the optimal decision-making under the complete rationality of the supply chain members, and it is more in line with the real situation to explore the impact of the altruistic behavior of the complementary goods supply chain members on the decision-making of the supply chain operation.

## 2.2. Research related to supply chain operation structure

At present, the research on the dynamic game within the secondary supply chain composed of a single manufacturer and a single retailer is more in-depth. Generally, the decision structure of the dynamic game within the secondary supply chain is categorized into integrated decision structure and non-integrated decision structure, therefore, in the study of the secondary supply chain, scholars will always consider the two scenarios of integrated and non-integrated decision structure of the supply chain when it comes to the decision of supply chain operation.

(1) Integrated decision structure. This kind of decision-making structure regards the manufacturer and retailer in the supply chain as a whole, there is no dynamic game in the chain, both parties share information in market decision-making, and conduct market behaviors in full accordance with the agreement of both parties. The joint decision of manufacturer and retailer under this decision structure can maximize the profit of the supply chain, and may also

increase the profit of both manufacturer and retailer at the same time. However, in reality, supply chain members will not share information completely in order to prevent data leakage and maximize profits from their own point of view, which makes integrated decision-making difficult to realize.

(2) Non-integrated decision-making structure. This kind of decision-making structure regards manufacturers and retailers in the supply chain as independent individuals, and both manufacturers and retailers make decisions with the goal of maximizing their own profits, and there is a lack of trust between supply chain members, and information is not shared. Under this kind of decision-making structure, market power is an important factor affecting the decision-making of supply chain members, and the power can be categorized into three situations through the different positions of enterprises in the supply chain:

(i) Manufacturer-dominated. In this case, the manufacturer has more market information and is in the dominant position in the supply chain, and sets the wholesale price of goods first, while the retailer is in the following position in the supply chain, and decides the retail price according to the decision-making behavior of the manufacturer. This game is also known as MS-stackelberg.

(ii) Retailer-dominated. In this case, the retailer has more market information and is in a dominant position in the supply chain, and sets the retail price first, while the manufacturer is in a trailing position in the supply chain, and decides the wholesale price according to the retailer's decision-making behavior. This game is also known as RS-stackelberg.

(iii) Retailer and manufacturer co-lead. In this case, the manufacturer and the retailer have equal market information and jointly dominate the supply chain. The manufacturer decides the wholesale price based on the principle of profit maximization without knowing the decision-making information of the retailer, while the retailer decides the selling price based on the principle of profit maximization without knowing the decision-making information of the manufacturer.

## 2.3. Studies Related to Altruistic Preferences

Altruistic preference behavior can be regarded as the decision maker's expectation of higher returns in the long run by temporarily reducing his own returns to a certain extent. At present, many domestic and foreign scholars have analyzed the research on altruistic preference behavior in supply chain management. The main studies of foreign scholars include: Shi et al. (2013) found that altruism has a significant impact on pricing strategy, and the impact on manufacturers is greater than that on retailers. du et al. (2014) studied the analysis in the case of the existence of manufacturers with altruistic preference retailers do not exist and the existence of manufacturers without the existence of the retailer with altruistic preference, and found that the manufacturer has greater profit margins by virtue of the dominant position and makes altruistic preference behaviors. space to make altruistic preference behaviors and the effect of altruistic preference behaviors is more significant compared to retailer altruistic preference behaviors.Bassi et al. (2014) found that as the degree of reciprocal altruistic preference increases, the revenue of the supply chain system is also enhanced.Xia et al. (2018) constructed an altruistic supply chain model of a single manufacturer and a single retailer, and found that both altruistic and low-carbon preferences can significantly enhance the profitability of the supply chain members and overall profit and utility, and the two preference utilities are superimposed on each other.Fan et al. (2019) incorporate the retailer's altruistic behavior into a closed-loop supply chain and explore the impact of this preference on the stability of the supply chain system.

In the research part of domestic scholars, Zhai Jia et al. (2019) from the uncertainty of the multiple effects of demand factors and decision-makers' behavioral preferences, etc., in the analysis of how to coordinate the supply chain under the altruistic preference behaviors adopted the coordination strategy of robust optimization. Fan Ruguo et al. (2019) found that both retailers' and manufacturers' altruistic behaviors incentivize manufacturers to reduce emissions and retailers to promote low carbon, and that manufacturers' altruistic behaviors have a greater impact on system stability than retailers' altruistic behaviors.Wang et al. (2020) found that the government sector improves the overall efficiency of the supply chain's operation and the total social surplus, and that altruistic preference behaviors increase the revenues of e-platforms and improve the overall efficiency of the closed-loop supply chain, but is detrimental to remanufacturers. Zhao Lin et al. (2015) used game theory to analyze the effects of altruistic and reciprocal preferences on the pricing strategies of closed-loop supply chain members, and the study showed that altruistic preferences can increase the recycling quantity of reverse recycled waste products, and the manufacturer obtains a positive correlation between the actual utility and the degree of mutual benefit between the two parties [44]. Sun Yuling (2017) constructed three models of supply chain altruism, retailer altruism and double hair altruism for the high requirements of fresh and live agricultural products for timeliness, and found that the supply chain can obtain the optimal decision when both parties' altruism is within a certain range of values, but when only the retailer exists in the altruistic preference and the degree of it is large, it will reduce the supply chain operation efficiency. Dai Ying et al. (2017) compared the newsboy model under fully self-interested and altruistic preference and found that manufacturer altruistic preference can motivate retailers to sell more quantities of new and remanufactured products, and retailers are more willing to cooperate with altruistic-preferred manufacturers compared to fully self-interested manufacturers. Lan Longhui et al. (2019) used non-cooperative game theory in a three-level closed-loop supply chain and found that the channel profit under the partial joint model is lower than the profit of the centralized decision-making model, and used the Shapley value and kernel kernel solution both schemes to coordinate the model and proposed a coordination mechanism for balancing the satisfaction on the basis of this. Shang Chunyan et al. (2020) found that government intervention in subsidies to recyclers can induce indirect returns to manufacturers, but to a certain extent, it will damage some of their own profits. Xu Peng et al. (2019) found that when the reciprocity preference of multiple game parties exists at the same time relative to the traditional two-party altruistic preference behavior is more able to show the benefits of altruistic behavior to the supply chain system. Guo Junhua et al. (2022) consider the existence of dual altruistic preferences of manufacturers and retailers to study the differential pricing decisions of a remanufacturing closed-loop supply chain and find that dual altruistic preferences are conducive to the improvement of the overall profitability and efficiency of the closed-loop supply chain. Zhou Maoshen et al. (2022) elevate altruistic preference from a psychological variable to a

strategic decision for research, which can address strategic incentives, sustainability, and Pareto improvement of SR behavior from the perspective of a supply chain with multi-stakeholder interactions. Wang Yuyan et al. (2021) consider the impact of product quality and the altruistic preference behavior of e-commerce platforms on supply chain decision making and find that the service level of e-commerce platforms, the selling price of manufacturers and product quality increase with the degree of altruistic preference. Liu et al. (2023) construct a remanufacturing supply chain consisting of a battery supplier and an automobile manufacturer, and find that an increase in the supplier's altruistic (fairness) preference leads to an increase (decrease) in the total profit of the manufacturer and the system in a two-way irrational preference scenario.

# 3. Review of the Current State of Research

According to the above literature, at the level of decision makers themselves, the current research on complementary products is mainly based on the optimal decision-making under the complete rationality of supply chain members. Behavioral economists, represented by Nobel Prize winner Kahneman, have found that in reality, decision makers are not all "rational economic beings", they are concerned about their own profit level, and they also attach great importance to the interests and losses of other members of the supply chain, and that in behavioral supply chains, the decisions of different decision makers always carry social preferences, such as fairness concern, reciprocity, and social influence, due to their market position and their own factors. In the behavioral supply chain, different decision makers, due to their market position and their own factors, always make decisions with social preferences, such as fairness concern, reciprocity and altruism preference.

At the level of complementary supply chain structure, based on the existing research, most scholars study the altruistic preference of one member and one dimension based on the supply chain model of one manufacturer and one retailer, but in reality, there is more than just a single member's preference behavior in the supply chain. Based on this, for a secondary supply chain system consisting of two manufacturers producing complementary products and a common retailer, it is important to consider the vertical altruistic preference of the manufacturer over the retailer and the horizontal altruistic preference of the manufacturer over the manufacturer of the complementary product under different altruistic preference dimensions, and analyze the optimal pricing strategy of the supply chain members under different levels of altruistic preference, which is important for the stable operation of supply chains.

# 4. Summary

Based on the shortcomings of the existing literature, the research objective of this paper mainly lies in constructing a game model of decision-making in complementary goods supply chain under different altruistic preferences by introducing altruistic preference behaviors into the decision-making of complementary goods supply chain operation, respectively. To explore the impact of different altruistic preferences of complementary supply chain members on the optimal pricing, optimal profit and utility of decision-making structure members.

(1) Establish the Stackelberg game model of complementary supply chain with different altruistic preferences, and solve the optimal pricing, optimal profit and utility of supply chain members under different models.

(2) Analyze the effects of horizontal altruistic preferences and vertical altruistic preferences on the optimal pricing decisions of supply chain members, and compare the profits of members and the overall profits of the supply chain.

(3) Demonstrate the effects of relevant parameters on the decision outcomes and the effects of altruistic parameters on decision variables and profits (utility) by means of numerical experiments to provide guidance for the pricing strategies of supply chain members under different levels of altruistic preferences.

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