

Research Article

Organic Food Labeling and Advertising: A Tripartite Game Model between One Supplier and Two Heterogeneous Manufacturers

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The development of the organic food industry is of great significance to the environment and society as consumers increasingly prefer green and healthy food. However, certain production and investment problems must be solved. A tripartite game model is established in this study to investigate the labeling and advertising investment decisions in an organic food supply chain composed of one supplier and two heterogeneous manufacturers by the biform game approach. In addition, a subsidy mechanism is introduced to alleviate underinvestment. The results show that, first, the supplier will label if labeling cost is relatively low without considering advertising investment. Second, the supplier will not label if advertising investment is considered because of the “diffusion of responsibility” mentality, and both manufacturers will invest in advertising as a result of equilibrium in dominant strategies. Third, the advertising subsidy mechanism can achieve Pareto improvement and coordinate the supply chain. Finally, manufacturer heterogeneity will lead to differentiated subsidy strategies that the supplier can claim to give additional subsidies to the weak manufacturer, thereby weakening the “diffusion of responsibility” mentality.

1. Introduction

Environmental problems attract increasing attention as the economy develops [1]. Conversely, the quality of food is declining [2], and the harmfulness of unhealthy food is gradually increasing [3]. Organic food is considered environmentally friendly [4] and can reduce harm to the environment [5]. Against this background, organic food forms a market with good development prospect in the global food industry [6–8]. On one hand, many governments attach great importance to organic food production and improve policies to promote the development of this industry [9, 10]. For example, the Russian government implements a bill that prohibits the use of pesticides and antibiotics to regulate the production of organic food in Russia. On the other hand, consumers’ low-carbon preference and environmental awareness promote green investment among enterprises

[11]. Many enterprises produce or sell organic food to improve market competitiveness. For example, Whole Foods Market is the largest organic supermarket chain and the first certified organic food retailer in the United States. Although its price is slightly higher than those of other supermarkets, it remains very popular with consumers, especially among families with children.

We study the decisions of supplier and manufacturers in the noncooperative stage and profit allocation in the cooperative stage in an organic food supply chain. In the noncooperative stage, two manufacturers decide whether or not to invest in advertising, while the supplier decides whether or not to label the goods. In the cooperative stage, profits will be allocated by the Shapley value method. The cooperative game method is generally used in the organic food supply chain. However, when considering investment, obtaining a rational decision is difficult if only the

cooperative game method is used because the investment problem should be analyzed in the noncooperative stage [12]. Fortunately, the biform game can solve such problems effectively. Based on the cooperative game, the biform game considers the noncooperative game method and divides the game process into two stages for analysis [13]. With this approach, Feess and Thun [12] distinguished two stages in the process of solving the supply chain problem. Enterprises can invest in the first stage and divide profit in the second stage. The result shows that this method can coordinate the supply chain.

In the cooperative stage, we use the Shapley value method to calculate the expected profits of the supplier and manufacturers in various scenarios and provide optimal decision suggestions by comparing and analyzing profits. The Shapley value method is commonly used to allocate profit to members. Researchers have widely used the Shapley method in the cooperative game since its introduction in 1953 because it can ensure fairness, anonymity, effectiveness, additivity, and symmetry when allocating profit [14]. Liu et al. [15] used the Shapley value method to provide a profit allocation mechanism for enterprises in a dynamic supply chain, but it requires related information from each firm at each time point. Gao et al. [16] improved the Shapley value method to ensure fair profit distribution when two collaborators cooperate under uncertain profit. However, the Shapley value method has several limitations. First, it does not take into account the effort of each enterprise. Instead, it only considers the marginal contribution of each member. Second, it supposes that all enterprises bear the same risk, but certain factors, such as ecological technology level and risk, will also affect profit allocation. In view of this context, Xu et al. [17] took into account the environmental effort level and risk to improve the Shapley value method.

Ecolabeling, which can identify the green attributes of food, has been used in the food market to attract consumers' attention. Labeling products can increase the reference price in the minds of consumers and improve the environment to a certain extent [18]. Therefore, many organic food suppliers are willing to increase the greenness and place green labels on their products to increase value and improve competitiveness [19, 20]. However, producing and processing organic products are costly [21] because improving production technology and organic certification brings additional expenses to food suppliers. Therefore, deciding if products should be labeled is an important decision for food suppliers. This study assumes that labeling can dictate a premium price [22] and generate labeling costs that will be borne by the supplier. According to the expected profits calculated using the Shapley value method, the supplier will decide whether or not to label in the noncooperative stage (Section 3.1).

Advertising is crucial in attracting consumers and increasing market demand to a certain extent [23, 24]. Many enterprises frequently invest in advertising to further build goodwill and brand reputation, thus improving competitiveness in the market [25]. Therefore, the optimal advertising investment schemes of supply chain members are widely studied. For example, Hong et al. [26] established a Stackelberg game model and found that advertising has an

important impact on market demand and profits of channel members; it can also coordinate supply chain members effectively [27]. Wu et al. [28] compared the optimal advertising strategies in decentralized and centralized scenarios by the differential game method and concluded that the scheme under centralized decision-making can increase the advertising investment of supply chain members. However, investing advertisement requires corresponding cost. Therefore, reducing advertising costs to maximize corporate profits has become a research hotspot for business operators and scholars. In the majority of cases, this problem can be solved effectively by using the cooperative advertising strategy, which can stimulate the advertising investment level and increase the performance of supply chains to help members achieve Pareto improvement. Horizontal and vertical cooperative advertising are the two common methods used in cooperative advertising. In the horizontal cooperative advertising scheme, retailers at the same sales level jointly advertise. Gou et al. [29] studied joint venture and contract alliance cooperative schemes by the differential game method and found that both schemes are superior to the noncooperative one. In the vertical cooperative advertising scheme, the manufacturer will bear part of the advertising cost to stimulate the retailer's advertising investment [30]. Lu et al. [31] studied the equilibrium strategy when the manufacturer provides the retailer with advertising subsidy and found that the negotiated advertising subsidy rate can achieve Pareto optimum. According to De Giovanni et al. [32], the retailer may no longer be willing to cooperate when the manufacturer's revenue share is too high. On the basis of these studies, other scholars further examined the comprehensive cooperative advertising scheme. Xiao et al. [33] proposed a hybrid program that involved the vertical and horizontal cooperative advertising schemes, in which manufacturers and retailers jointly make upstream and downstream decisions for the alliance. Chernonog and Avinadav [34] compared three cooperative advertising schemes where the responsibility of advertising investment is shared by the manufacturer, retailer, or both; they found that the scheme in which the manufacturer is the sole advertising investor is a complete disclosure mechanism. Li et al. [35] explored three cooperative advertising modes, namely, unilateral cooperation, bilateral cooperation, and integrated modes. The authors found that, in contrast with the unilateral cooperation mode, the bilateral cooperation mode can bring additional benefits to an entire channel. In the current work, a tripartite game model is established to investigate further the impact of manufacturer heterogeneity on investment decisions.

We assume that two manufacturers exist. One is well known in the food industry and has rich experience in organic food production, whereas the other is an emerging food manufacturer with relatively low reputation. The supplier can supply raw food materials to only one manufacturer, creating a competitive environment for the two manufacturers. Each manufacturer decides whether or not to invest in advertising and to what level (Section 3.2). We first establish the branded ingredient game model, which only considers the labeling decision of the supplier. The

advertising investment game model, which studies not only the labeling decision of the supplier but also the investment decision of manufacturers, is established to determine the influences of advertising investment on the decisions of players.

Underinvestment may occur in advertising investment because of the costs and risks. Subsidy for investment costs can alleviate the underinvestment problem [12]. This study introduces an advertising subsidy mechanism, where the supplier commits to pay a certain percentage of the manufacturers' advertising investment. In the non-cooperative stage, the supplier decides on the subsidy percentage and whether or not to label the product. In the cooperative stage, surplus is divided according to the Shapley value. The optimal subsidy percentage can be obtained via backward induction (Section 3.3). Many scholars focused on the subsidy problem in supply chains. Considering the investment problem of supply chains, Proch et al. [36] built a continuous time model and found that the supplier can encourage manufacturers to raise their investment level by subsidizing a portion of their investment costs to improve the underinvestment problem. In contrast to Proch et al. [36], Alaei and Setak [37] proposed that subsidy negotiation can further improve advertising performance by establishing and analyzing the dynamic differential game model. In addition, many scholars proposed that subsidy is not confined to one-way subsidy. In certain conditions, two-way subsidy is superior to one-way subsidy. For instance, Song et al. [23] introduced a two-way subsidy mechanism where the members of the supply chain can share investment costs with one another to coordinate the supply chain. However, the existing literature on subsidy seldom considers manufacturer heterogeneity. As such, we establish a tripartite game model with advertising subsidy to study the optimal subsidy strategy of the supplier when faced with differentiated manufacturers and to alleviate underinvestment.

This study has the following key contributions to the existing literature on competition and cooperation in organic food supply chains. First, it provides optimal strategies in labeling and advertising investment with consideration of manufacturer heterogeneity and consumer green preference. It presents interesting and unique explanations for several phenomena. Second, it verifies the existence of underinvestment and introduces a further coordination program, namely, the advertising subsidy mechanism, to alleviate the problem and achieve the Pareto improvement to coordinate organic food supply chains. Moreover, it offers reasonable suggestions on the supplier's subsidy and manufacturers' advertising investment. In fact, the optimal decisions of enterprises will enhance their competitiveness in the highly competitive market [38].

The remainder of this paper is structured as follows: Section 2 presents the notations and assumptions. Section 3 describes and analyses the tripartite game model. Section 4 provides the numerical analysis. Finally, Section 5 concludes and summarizes the management insights and future directions of this study.

2. Notations and Assumptions

First, we provide several essential notations as follows:

P_i : highest price that consumers will pay for manufacturer i 's products, where $i \in \{A, B\}$

c_0 : labeling cost incurred by the supplier's labeling strategy

c_i : advertising cost incurred by manufacturer i 's investment in advertisement, where $i \in \{A, B\}$

α_i : investment return coefficient, where $i \in \{A, B\}$

π_{ki} : profit of manufacturer i at the end of the cooperative stage, where $i \in \{A, B\}$, and k takes values of 1, 2, and 3 in the branded ingredient game model (BIGM), advertising investment game model (AIGM), and advertising subsidy mechanism (ASM), respectively

π_{kM} : profit of the supplier at the end of the cooperative game stage, where k takes values of 1, 2, and 3 in the BIGM, AIGM, and ASM, respectively

t_i : supplier's subsidy percentage for the manufacturer's advertising investment, where $i \in \{A, B\}$

Based on these notations, we propose the following assumptions to simplify the model:

- (1) The production cost of the supplier is 0
- (2) Labeling cost is entirely borne by the supplier, whereas the advertising cost is entirely borne by the manufacturers
- (3) The sales volume is 1
- (4) Labeling does not affect the product of well-known manufacturer A and increases the price of the product of manufacturer B by $\alpha_B c_0^{(1/2)}$ [12], where $P_B + \alpha_B c_0^{(1/2)} < P_A$
- (5) Advertising and labeling are the same type of investment; that is, for each manufacturer, the investment return coefficients of labeling and advertising are equal, which are expressed as α_i and $\alpha_A = \alpha_B$, respectively

For convenience, the definitions used in the following sections are listed in the following paragraphs. First, we introduce the meaning of certain symbols in the game process. In game set $N = \{1, 2, \dots, n\}$, each player j selects strategy $s_j \in S_j$, where S_j represents the strategy set of player j . Strategy vector (s_1, \dots, s_n) defines a utility transferable game, and the corresponding characteristic function is defined as $v(s_1, \dots, s_n) : 2^N \rightarrow \mathbb{R}$, where 2^N is the power set of N . In this study, $N = \{M, A, B\}$. For any set $C \in 2^N$, $v(s_1, \dots, s_n)(C)$ represents the revenue created jointly by players in set C , where $v(s_1, \dots, s_n)(\emptyset) = 0$. On this basis, we set the following definitions according to [13].

Definition 1. In game set N , a noncooperative game is defined as (S_1, \dots, S_n) , whereas (N, v) denotes cooperative game. The biform game is defined as $(S_1, \dots, S_n; N, v)$.

Definition 2. In cooperative game (N, v) , the Shapley value of each player j is

$$\phi_j(v) = \frac{1}{|N|} \sum_{C \subset N \setminus \{j\}} \binom{|N| - 1}{|C|} (v(C \cup \{j\}) - v(C)), \quad (1)$$

where $|N|$ represents the number of all members in game set N , $|C|$ denotes the number of members in any subset C in N , and $\binom{|N| - 1}{|C|}$ refers to the number of combinations of $|C|$ elements taken from $|N| - 1$ different elements.

Definition 3. If any two alliances, namely, C_1 and C_2 , satisfy $C_1 \cap C_2 = \emptyset$ and

$$v(C_1 \cup C_2) \geq v(C_1) + v(C_2), \quad (2)$$

then the cooperative game (N, v) is superadditive.

3. Model Description and Analysis

The tripartite game model proposed in this study consists of three parts, namely, BIGM, AIGM, and ASM, which are used to investigate the optimal strategy of labeling, advertising investment, and subsidy, respectively, in organic food supply chains.

First, we establish the BIGM, which only considers the labeling decision of the supplier. In this model, the supplier's strategy set is $S_M^{\text{BIGM}} = \{\text{Labeling}, \text{No labeling}\}$. The AIGM is then established to explore further the optimal decision of the supplier regarding advertising investment and its impact, the labeling decision of the supplier, and advertising investment decision of manufacturers. The AIGM involves the competitive game between manufacturers and cooperative game between the supplier and manufacturers. In this model, the strategy sets of the supplier and manufacturers are $S_M^{\text{AIGM}} = \{\text{Labeling}, \text{No labeling}\}$ and $S_i^{\text{AIGM}} = \{\text{Advertising}, \text{No advertising}\}$, respectively, where $i \in \{A, B\}$. Finally, to alleviate underinvestment and coordinate the organic food supply chain, we establish the ASM to elucidate further the influence of subsidy. In this context, the strategy sets of the supplier and manufacturers are $S_M^{\text{ASM}} = \{\text{Labeling}, \text{No labeling}\} \times \{\text{Subsidizing}, \text{No subsidizing}\}$ and $S_i^{\text{ASM}} = \{\text{Advertising}, \text{No advertising}\}$, respectively.

3.1. BIGM. We assume that manufacturers A and B produce the same kind of organic food in the supply chain, and supplier M can supply raw materials to only one manufacturer due to financial constraints. Manufacturer A is a well-known manufacturer with rich experience in organic food production, whereas manufacturer B is an emerging food manufacturer with relatively low reputation. Consumers are willing to buy manufacturer A's product at price P_A and manufacturer B's product at price P_B , where $P_B < P_A$, due to the brand effect. Figure 1 depicts the decision sequence of the players in the BIGM.

The first stage is the noncooperative stage, where supplier M decides whether or not to label the product as "organic food" at cost c_0 . According to Assumption (4) in Section 2, labeling will bring investment returns $\alpha_B c_0^{(1/2)}$ to manufacturer B, but no price premium to manufacturer A's product, as shown in Figure 2.

The optimal decision of supplier M is dependent on the comparison and analysis of its expected profits under various scenarios. Figure 3 illustrates the income range of supplier M. When supplier M opts not to label and to cooperate with manufacturer A, the total revenue is P_A , whereas manufacturer B gains zero benefit. If supplier M cooperates with manufacturer B, then the total revenue is P_B and $P_B < P_A$. Thus, the income range of supplier M in this case is $[P_B, P_A]$. Supplier M will prepay labeling cost c_0 when it decides to label the product. If supplier M cooperates with manufacturer A, then the total revenue will be $P_A - c_0$. However, if supplier M cooperates with manufacturer B, then the total revenue will be $P_B + \alpha_B c_0^{(1/2)} - c_0$. Therefore, the income range of supplier M in this case is $[P_B + \alpha_B c_0^{(1/2)} - c_0, P_A - c_0]$.

In the cooperative stage, the supplier cooperates with one manufacturer to produce and sell organic food and ultimately gain profit. At the end of the cooperative stage, the supply chain use the Shapley value method to divide profit. Notably, the manufacturer's final profit is defined as π_j , where $\pi_j = \phi_j(v)$, $j \in \{A, B\}$; the final profit of supplier M is π_M , where $\pi_M = \phi_M(v) - c_0\Gamma$. We use indicator function $\Gamma = 1$ if supplier M chooses to label and $\Gamma = 0$ otherwise. By analyzing the supplier's final profit, we can obtain its optimal decision.

Proposition 1. *Only when the labeling cost is relatively low will the supplier choose to label. Table 1 presents the supplier's optimal decision in the BIGM.*

Proof. First, we analyze the income range of supplier M. If supplier M opts not to label, then the income range is $[P_B, P_A]$; otherwise, the income range is $[P_B + \alpha_B c_0^{(1/2)} - c_0, P_A - c_0]$. Only when $P_B + \alpha_B c_0^{(1/2)} - c_0 > P_B$ will supplier M consider labeling, that is,

$$c_0 < \alpha_B^2. \quad (3)$$

Then, we use the Shapley value method to calculate the supplier's profit when choosing to label or not and use π_{1M}^L and π_{1M}^N to express both decisions, respectively, as shown in Table 2. We find that when $\pi_{1M}^N < \pi_{1M}^L$, namely,

$$c_0 < \frac{1}{36} \alpha_B^2, \quad (4)$$

supplier M will choose to label, whereas it will not label when $c_0 \geq (1/36) \alpha_B^2$. Notably, the supplier decides not to label when the profits of labeling and no labeling are the same.

In addition, after considering the price premium of manufacturer B's product when labeling, we also take the inequality in Assumption (4) in Section 2 into account as a basic condition for supplier M's decision to label, namely,

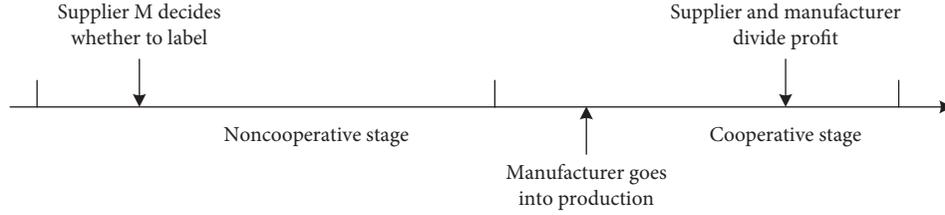


FIGURE 1: Decision sequence of players in BIGM.

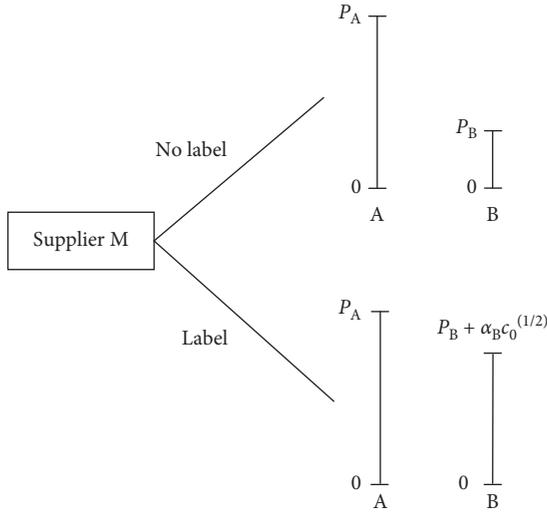


FIGURE 2: Prices of manufacturers' product in BIGM.

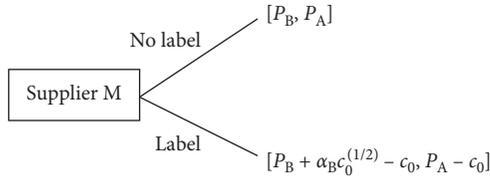


FIGURE 3: Income range of supplier M in BIGM.

TABLE 1: Supplier's optimal decision in BIGM.

Condition	Decision
$c_0 < (1/36)\alpha_B^2$ and $c_0 < ((P_A - P_B)/\alpha_B)^2$	Label
$c_0 \geq (1/36)\alpha_B^2$	No label

$$c_0 < \left(\frac{P_A - P_B}{\alpha_B} \right)^2. \quad (5)$$

When inequalities (3)–(5) are simultaneously met, supplier M will choose to label; otherwise, it will forgo labeling. \square

Referring to Proposition 1, we find that the labeling decision of the supplier is mainly dependent on labeling cost without considering advertising investment. The supplier should label to achieve higher profit given that labeling cost is relatively low. However, when the labeling cost is high,

TABLE 2: Expected profit of supplier M in BIGM.

S_M	π_{1M}
No label	$\pi_{1M}^N = (1/2)P_A + (1/6)P_B$
Label	$\pi_{1M}^L = (1/2)P_A + (1/6)(P_B + \alpha_B c_0^{(1/2)}) - c_0$

labeling investment will enter the stage of diminishing returns to scale, which will adversely affect the supplier's profit. At this point, the supplier should choose not to label.

According to Definition 3, we will verify whether cooperative game is superadditive as follows.

Proposition 2. *Cooperative game (N, v) is superadditive.*

Proof. In fact, the manufacturer will not profit if it does not take the supplier's resource. Hence, we can infer that $v(\{i\}) = v(\{j\}) = 0$, $i, j \in \{A, B\}$. If supplier M cooperates with manufacturer i , then

$$v(\{M, i\}) = v(\{M, i, j\}) > 0; \quad (6)$$

hence, $v(\{j\}) + v(\{M, i\}) \leq v(\{M, i, j\})$. Thus, we derive the following:

$$v(C_1) + v(C_2) \leq v(C_1 \cup C_2). \quad (7)$$

As a result, cooperative game (N, v) is superadditive. \square

The superadditivity of the cooperative game shows that all players in the game are willing to cooperate because the total revenue from cooperation is always no less than the sum of the revenue from their respective operations. This notion also proves the feasibility and rationality of the model.

In this subsection, we dissect the supplier's labeling decision without considering the manufacturers' advertising investment and verify the superadditivity of the cooperative alliance. Next, we will establish the AIGM to further study the investment decisions of the supplier and manufacturers when considering advertising investment.

3.2. AIGM. To increase competitiveness, the manufacturers will advertise their products. On the basis of the BIGM, we establish the AIGM to further study the impact of advertising investment on the decision of supply chain members. We assume that manufacturers A and B have the ability to advertise their products. Figure 4 shows the prices of the manufacturers' products in the BIGM and AIGM.

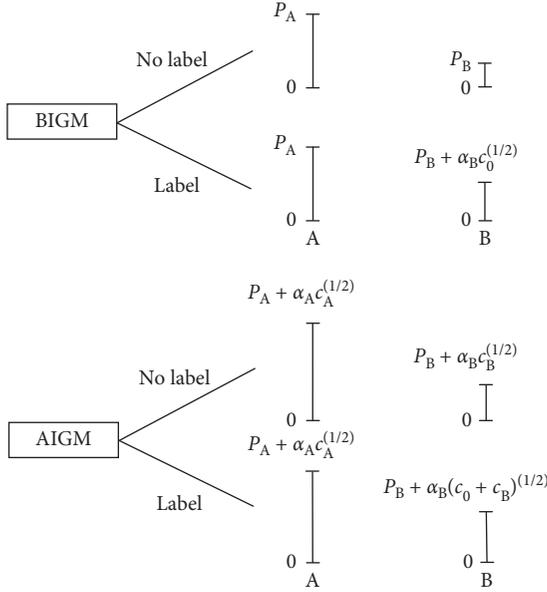


FIGURE 4: Prices of manufacturers' products in BIGM and AIGM.

In the noncooperative stage (S_1, \dots, S_n) , supplier M decides whether to label, whereas manufacturers A and B decide whether to invest in advertising and how much to invest. In the cooperative stage (N, v) , the supplier and manufacturers divide the profit. Figure 5 illustrates the decision sequence in the AIGM.

In the analysis of the biform game $(S_A, S_B, S_M; N, v)$, we adopt the backwards induction, which is contrary to the decision order. First, profit set (π_A, π_B, π_M) under strategy set (S_A, S_B, S_M) is calculated using the Shapley value method. Then, the optimal decision of the manufacturer on advertising investment is obtained by analyzing these profits. Finally, we obtain the labeling decision of the supplier.

Figure 6 provides the income ranges of supplier M. In the case of manufacturers A and B investing in advertising, if supplier M chooses not to label and cooperates with manufacturer A, then the total revenue is $P_A + \alpha_A c_A^{(1/2)} - c_A$, and manufacturer B gains no benefit. However, if supplier M cooperates with manufacturer B, then the total revenue is $P_B + \alpha_B c_B^{(1/2)} - c_B$. Thus, the income range of supplier M in this case is $[P_B + \alpha_B c_B^{(1/2)} - c_B, P_A + \alpha_A c_A^{(1/2)} - c_A]$. If supplier M chooses to label and cooperates with manufacturer A, then the total revenue will be $P_A + \alpha_A c_A^{(1/2)} - c_0 - c_A$. If supplier M cooperates with manufacturer B, then the total revenue will be $P_B + \alpha_B (c_0 + c_B)^{(1/2)} - c_0 - c_B$. In this case, the income range of supplier M is $[P_B + \alpha_B (c_0 + c_B)^{(1/2)} - c_0 - c_B, P_A + \alpha_A c_A^{(1/2)} - c_0 - c_A]$.

Notably, however, if one or both manufacturers do not invest in advertising, the supplier's income range will become more complex. Consequently, we will analyze the investment decisions of the manufacturers.

Proposition 3. *Manufacturers A and B choose to invest in advertising in AIGM.*

Proof. When supplier M chooses not to label, we can obtain the profit of manufacturer B using the formula in Definition 2 as follows:

$$\pi_{2B}^N = \frac{1}{6} (P_B + \alpha_B c_B^{(1/2)}) - c_B. \quad (8)$$

Understanding that manufacturer B's profit is only related to its investment is easy; that is advertising investment can bring positive net income to B. Thus, manufacturer B will choose to invest in advertising. Then, we analyze A's investment decision as follows:

$$\pi_{2A}^N = \frac{1}{2} (P_A + \alpha_A c_A^{(1/2)}) - \frac{1}{3} (P_B + \alpha_B c_B^{(1/2)}) - c_A. \quad (9)$$

Under the premise that manufacturer B must invest in advertising, advertising investment can also bring positive net income to manufacturer A, who will also invest in advertising at this moment. Therefore, manufacturers A and B will invest in advertising when supplier M chooses not to label.

Similarly, when supplier M chooses to label, we obtain

$$\pi_{2B}^L = \frac{1}{6} (P_B + \alpha_B (c_0 + c_B)^{(1/2)}) - c_B,$$

$$\pi_{2A}^L = \frac{1}{2} (P_A + \alpha_A c_A^{(1/2)}) - \frac{1}{3} (P_B + \alpha_B (c_0 + c_B)^{(1/2)}) - c_A. \quad (10)$$

In the same way, we can know that manufacturers A and B will invest in advertising when supplier M chooses to label. In summary, manufacturers A and B choose to invest in advertising in AIGM. \square

Proposition 3 indicates that both manufacturers should actively invest in advertising to strengthen competitiveness in the face of the existence of a competitor, which equals equilibrium in the dominant strategy by the competitive game between two manufacturers. Notably, however, overinvestment may adversely affect manufacturers because excessive investment will not only reduce the manufacturers' short-term operating capital but also damage profit and lead to bankruptcy. Therefore, manufacturers should further make a decision on the optimal levels of advertising investment, namely, c_A^* and c_B^* . In the following discussion, we will highlight each manufacturer's optimal advertising investment level under various strategies.

Proposition 4. *Table 3 presents the optimal amount of each manufacturer' advertising investment.*

Proof. We can obtain the manufacturers' expected profit under the different decisions of supplier M using the Shapley value method. When supplier M chooses not to label, we can derive $c_A^{N*} = (1/16)\alpha_A^2$ and $c_B^{N*} = (1/144)\alpha_B^2$ by calculating $d\pi_{2A}^N/dc_A = 0$ and $d\pi_{2B}^N/dc_B = 0$, respectively. Similarly, when M chooses to label, we can obtain $c_A^{L*} = (1/16)\alpha_A^2$ and $c_B^{L*} = (1/144)\alpha_B^2 - c_0$. \square

Analysis of the manufacturers' optimal advertising investment level indicates that manufacturer heterogeneity can

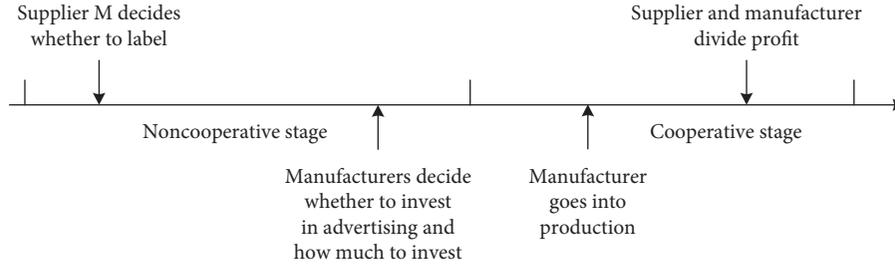


FIGURE 5: Decision sequence of players in AIGM.

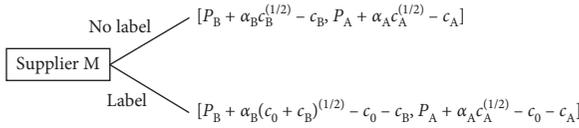


FIGURE 6: Income ranges of supplier M in AIGM.

TABLE 3: Optimal amount of advertising investment.

S_M	c_A^*	c_B^*
No label	$(1/16)\alpha_A^2$	$(1/144)\alpha_B^2$
Label	$(1/16)\alpha_A^2$	$(1/144)\alpha_B^2 - c_0$

lead to differentiation of investment decisions. The supplier's decision to label has no effect on manufacturer A's investment but reduces manufacturer B's investment. According to Assumption (4) in Section 2, labeling does not change the price of manufacturer A's products and will not thus affect manufacturer A's decision. However, supplier M's decision to label will increase the price of manufacturer B's products, which indicates that the supplier partially undertakes the responsibility that jointly improves the value of the products. In this manner, manufacturer B's view, that is, "diffusion of responsibility," is triggered and can be used to denote the psyche of one who wants to decrease his responsibility at the expense of the partner's efforts. Therefore, manufacturer B will reduce his investment level when supplier M chooses to label. Horizontally, regardless of whether the supplier decides to label or not, the well-known manufacturer will always invest more in advertising compared with the weaker manufacturer because the well-known manufacturer wants to consolidate competitiveness and attracts more attention from the supplier. In summary, the weaker manufacturer should appropriately reduce its investment in advertising when the supplier chooses to label, whereas the well-known manufacturer should retain its investment level to be always higher than that of the weaker manufacturer to solidify its market position and competitiveness.

We will further discuss the supplier's decision to label in the face of the manufacturers' equilibrium strategies.

Proposition 5. *Considering advertising investment, supplier M always chooses not to label.*

Proof. According to Table 4, we find that $\pi_{2M}^N - \pi_{2M}^L = c_0 > 0$. Therefore, supplier M, who pursues maximum profit, always opts not to label. \square

TABLE 4: Expected benefits of supplier M in AIGM.

S_M	π_{2M}
No label	$\pi_{2M}^N = (1/2)P_A + (1/6)P_B + (1/8)\alpha_A^2 + (1/72)\alpha_B^2$
Label	$\pi_{2M}^L = (1/2)P_A + (1/6)P_B + (1/8)\alpha_A^2 + (1/72)\alpha_B^2 - c_0$

From the perspective of the individual interests of decision makers and in the face of the manufacturers' investment efforts, the supplier will generate the "diffusion of responsibility" mindset and choose not to label to minimize its investment. From the perspective of the overall interest of the supply chain, when the manufacturers contribute to the cooperative alliance through advertising investment, the supplier's active investment behavior that it still chooses to label may let the total investment outweigh the total return and enter the stage of diminishing returns on scale. In theory, the competitive game equilibrium result that all manufacturers invest in advertising improves the supplier's advantage in the cooperative game, which leads to the cooperative game equilibrium result, where the supplier does not need to label.

In this subsection, we set up the AIGM and use the Shapley value method to calculate the profit of each player under different scenarios and finally obtain optimal decisions by backwards induction. Finding shows that, in the tripartite game with advertising investment between one supplier and two heterogeneous manufacturers, the latter should invest in advertising to enhance competitiveness and the possibility of cooperation with the supplier. Doing so will contribute to improving the value of products, such that the supplier does not need to label. In the following subsection, we will verify the existence of the underinvestment problem and further shed light on the optimal decisions of the supplier and manufacturers in ASM.

3.3. ASM. The supplier usually gives the manufacturers an incentive policy to stimulate investment. In this subsection, we introduce the advertising subsidy mechanism where the supplier will commit to pay a certain percentage of the manufacturers' advertising investment. Figure 7 provides the decision sequence in ASM.

For ease of distinction, we denote π_{2j} and π_{3j} to represent the profit of j in the AIGM and ASM, respectively, where $j \in \{M, A, B\}$. t_i refers to the supplier's subsidy percentage for the manufacturer's advertising investment.

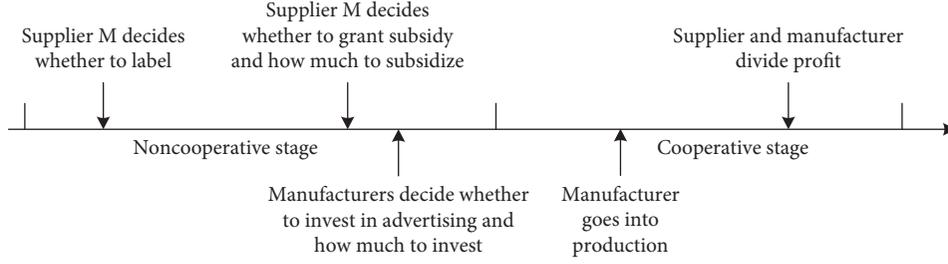


FIGURE 7: Decision sequence of players in ASM.

Therefore, we can express the advertising subsidy mechanism as follows:

$$\begin{aligned}\pi_{3A} &= \pi_{2A} + t_A c_A, \\ \pi_{3B} &= \pi_{2B} + t_B c_B, \\ \pi_{3M} &= \pi_{2M} - t_A c_A - t_B c_B.\end{aligned}\quad (11)$$

Considering the effect of subsidy on earnings based on the AIGM, we obtain the income range of the supplier in ASM, as shown in Figure 8.

Using the same method of analysis in the AIGM, we obtain the optimum decisions of the supplier and manufacturers. First, we analyze whether the manufacturers will choose to invest in advertising in ASM.

Proposition 6. *Manufacturers A and B choose to invest in advertising in ASM.*

Proof. When supplier M chooses not to label, manufacturer B's profits can be acquired by the Shapley value method as follows:

$$\pi_{3B}^N = \frac{1}{6}(P_B + \alpha_B c_B^{(1/2)}) - (1 - t_B)c_B. \quad (12)$$

Finding that manufacturer B's profit is only related to its investment, and advertising investment can bring a positive net income to manufacturer B is easy to understand. Thus, manufacturer B will choose to invest in advertising. Then, we analyze manufacturer A's investment decision and derive its profit as follows:

$$\pi_{3A}^N = \frac{1}{2}(P_A + \alpha_A c_A^{(1/2)}) - \frac{1}{3}(P_B + \alpha_B c_B^{(1/2)}) - (1 - t_A)c_A. \quad (13)$$

Under the premise that manufacturer B must invest in advertising, manufacturer A can derive positive net income from advertising investment. Therefore, manufacturer A will also invest in advertising.

Similarly, when supplier M chooses to label, we have

$$\pi_{3B}^L = \frac{1}{6}(P_B + \alpha_B (c_0 + c_B)^{(1/2)}) - (1 - t_B)c_B, \quad (14)$$

$$\begin{aligned}\pi_{3A}^L &= \frac{1}{2}(P_A + \alpha_A c_A^{(1/2)}) - \frac{1}{3}(P_B + \alpha_B (c_0 + c_B)^{(1/2)}) \\ &\quad - (1 - t_A)c_A.\end{aligned}\quad (15)$$

In the same way, we can know that manufacturers A and B will invest in advertising when supplier M chooses to label. In summary, manufacturers A and B choose to invest in advertising in ASM. \square

We find that, under the advertising subsidy mechanism, the manufacturers will still choose to invest in advertising. In addition, we can speculate that the manufacturers are more willing to invest because the subsidy is harmless and beneficial to them. Therefore, the manufacturers may increase investment under the advertising subsidy mechanism. Next, we will verify whether subsidy will promote the manufacturers' investment by analyzing the manufacturers' optimal investment level and elucidate the optimal subsidy strategy.

Proposition 7. *Table 5 presents the optimal decisions of players in ASM.*

Proof. We can obtain the profit functions of the supplier under different circumstances using the Shapley value method. When the supplier chooses not to label, then

$$\pi_{3M}^N = \frac{1}{2}(P_A + \alpha_A c_A^{(1/2)}) + \frac{1}{6}(P_B + \alpha_B c_B^{(1/2)}) - t_A c_A - t_B c_B. \quad (16)$$

Otherwise,

$$\begin{aligned}\pi_{3M}^L &= \frac{1}{2}(P_A + \alpha_A c_A^{(1/2)}) + \frac{1}{6}(P_B + \alpha_B (c_0 + c_B)^{(1/2)}) \\ &\quad - t_A c_A - t_B c_B - c_0.\end{aligned}\quad (17)$$

Based on equations (12)–(17), we can obtain the optimal decisions of advertising investment and subsidy. When M chooses not to label, we can derive $c_A^{N*} = \alpha_A^2 / (16(1 - t_A)^2)$ and $c_B^{N*} = \alpha_B^2 / (144(1 - t_B)^2)$ from $d\pi_{3A}^N / dc_A = 0$ and from $d\pi_{3B}^N / dc_B = 0$, respectively. Then, we can obtain $t_A^{N*} = 1/3$ and $t_B^{N*} = 1/3$ from $\partial\pi_{3M}^N / \partial t_A = 0$ and from $\partial\pi_{3M}^N / \partial t_B = 0$, respectively. Therefore, we have $c_A^{N*} = (9/64)\alpha_A^2$ and $c_B^{N*} = (1/64)\alpha_B^2$.

When supplier M opts to label, we can derive $c_A^{L*} = \alpha_A^2 / (16(1 - t_A)^2)$ and $c_B^{L*} = \alpha_B^2 / (144(1 - t_B)^2) - c_0$ from $d\pi_{3A}^L / dc_A = 0$ and from $d\pi_{3B}^L / dc_B = 0$, respectively. Then, we have $t_A^{L*} = 1/3$ from $\partial\pi_{3M}^L / \partial t_A = 0$. Based on $\partial\pi_{3M}^L / \partial t_B = 0$, we find that t_B^{L*} satisfies

$$\alpha_B^2 (1 - 3t_B) + 144c_0 (1 - t_B)^3 = 0. \quad (18)$$

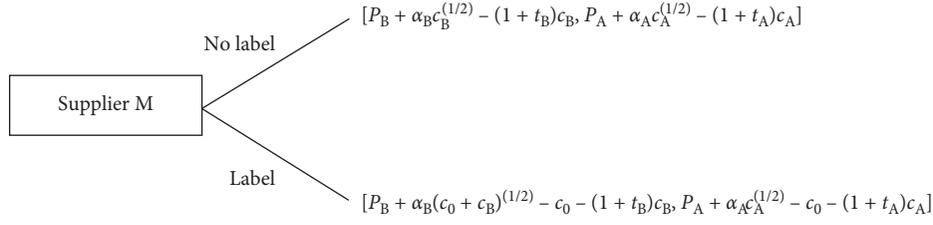


FIGURE 8: Income range of supplier in ASM.

TABLE 5: Optimal decisions of players in ASM.

S_M	c_A^*	c_B^*	t_A^*	t_B^*
No label	$(9/64)\alpha_A^2$	$(1/64)\alpha_B^2$	1/3	1/3
Label	$(9/64)\alpha_A^2$	$(\alpha_B^2 / (144(1 - t_B^{L*})^2)) - c_0$	1/3	[1/3, 1/2]

Based on Equation (18) and $c_B^{L*} = \alpha_B^2 / (144(1 - t_B^{L*})^2) - c_0$, we have the following:

$$t_B^{L*} = 1 + \frac{1}{12} \left(\frac{\alpha_B^2}{K} - \frac{K}{c_0} \right),$$

$$K = \left(12c_0^2\alpha_B^2 + \sqrt{144c_0^4\alpha_B^4 + c_0^3\alpha_B^6} \right)^{(1/3)} > 0, \quad (19)$$

$$c_B^{L*} = \frac{c_0(3c_0\alpha_B^2K^2 + K(12c_0^2\alpha_B^2 - K^3) - c_0^2\alpha_B^2(\alpha_B^2 + 12K))}{(K^2 - c_0\alpha_B^2)^2}. \quad (20)$$

From Equation (18) and $c_B^{L*} \geq 0$, we derive $(3t_B^{L*} - 1)(2t_B^{L*} - 1) \leq 0$ as follows:

$$\frac{1}{3} \leq t_B^{L*} \leq \frac{1}{2}. \quad (21) \quad \square$$

First, we analyze the optimal subsidy strategy of supplier according to Proposition 7. Longitudinally, the subsidy for manufacturer B when supplier M chooses to label is higher than that of the opposite. Based on Proposition 4, manufacturer B emerges with the “diffusion of responsibility” mindset in the face of the supplier’s decision to label. Therefore, supplier M will endow manufacturer B with more subsidies in an attempt to eliminate the mindset as much as possible. Horizontally, when supplier M chooses to label, the subsidy to manufacturer B is higher than that to manufacturer A because the supplier wants to improve his bargaining power in the negotiation with manufacturer A by claiming to give more subsidies to manufacturer B.

Then, we analyze the optimal advertising investment decision of manufacturers. When supplier chooses not to label, the well-known manufacturer invests more than the weaker manufacturer to attract more attention from the supplier. Therefore, the well-known manufacturer should always retain its investment level to be higher than that of the weaker manufacturer to consolidate its market position. In summary, supplier should endow the weaker manufacturer with more subsidies when labeling, and the well-known manufacturer should invest more than the weaker manufacturer when supplier chooses not to label.

Corollary 1. *When supplier M chooses not to label, an underinvestment problem underlies the manufacturer’s advertising investment. In response, subsidy can stimulate the manufacturers’ investment and mitigate the underinvestment problem.*

Proof. By comparing the corresponding investment levels in Tables 3 and 5, Corollary 1 can be proved. For example, when supplier M chooses not to label, manufacturer A’s optimal investment levels in AIGM and ASM are $(1/16)\alpha_A^2$ and $(9/64)\alpha_A^2$, as shown in Tables 3 and 5, respectively. Therefore, manufacturer A’s investment level in the AIGM is less than that in the ASM, which reflects the underinvestment problem. In addition, subsidy can increase the investment level of manufacturer A by $(5/64)\alpha_A^2$. \square

Corollary 1 confirms the existence of the underinvestment problem and shows that subsidy can stimulate manufacturers’ advertising investment level, which proves the importance of subsidy in coordinating the supply chain. Finally, we will further investigate the influence of subsidy on the supplier.

Proposition 8. *When the supplier chooses not to label, the subsidy strategy has a positive impact on the supplier, such that the supplier will unconditionally issue subsidy to the manufacturers.*

Proof. In the previous analysis, we obtain the profits of supplier M when it does and does not grant subsidy. If the supplier chooses not to label, then

$$\pi_{3M}^N - \pi_{2M}^N = \frac{1}{576} (9\alpha_A^2 + \alpha_B^2) > 0. \quad (22)$$

We find that π_{3M}^N is always higher than π_{2M}^N , which indicates that the subsidy strategy has a positive impact on the supplier, who will unconditionally issue subsidy to the manufacturers when it opts not to label. \square

In the ASM, the advertising subsidy issued by the supplier first promotes the investment of the manufacturers; that is, the higher the investment, the more improved the value of the products. This scenario thereby increases the benefits of the cooperative alliance and ultimately improves the supplier’s profit. Therefore, the supplier should stimulate the manufacturers’ investment by granting subsidies to increase the intensity and promote the positive shift in equilibrium results of the competitive game, so as to gain more benefits in the next cooperative game. In addition, the

supplier should give more subsidy to the weaker manufacturer, whereas the manufacturers should increase their investment levels.

Section 3 established the three models. By comparing the BIGM with the AIGM, we verified the existence of the “diffusion of responsibility” mindset. Furthermore, by comparing the AIGM with the ASM, we confirmed the underinvestment problem and found that subsidy can alleviate this problem. In addition, we noted that manufacturer heterogeneity can lead to the differentiated subsidy strategies of the supplier. Advertising subsidy can coordinate the supply chain and achieve the Pareto improvement. We will further study the supplier’s optimal decision and the impact of subsidy by numerical analysis in response to the complexity of the analytical solution when the supplier chooses to label and grant subsidy.

4. Numerical Analysis

To verify the validity of the model, we carry out numerical analysis at this juncture. According to Assumptions (4) and (5) in Section 2, we set $P_A = 2$, $P_B = 0.5$, and $\alpha_A = \alpha_B = 1$. $\bar{\pi}_M$ and $\underline{\pi}_M$ represent the supplier’s upper and lower profit bounds, respectively.

First, we analyze the supplier’s decision to label in the BIGM. Figure 9(a) depicts the relationship between labeling cost c_0 and supplier M’s profit π_{1M} in the BIGM. We find that when the supplier chooses to label, the upper profit bound decreases, whereas the lower profit bound increases with the increase in labeling cost. Therefore, the profit interval of the supplier’s decision to label decreases with the increase in labeling cost and is always smaller than that of the supplier’s decision not to label. Figure 9(b) is an enlarged image of intersection π_{1M}^N and π_{1M}^L in Figure 9(a), where we find that $\pi_{1M}^L > \pi_{1M}^N$ when $c_0 < 0.0277$. This finding indicates that the supplier should choose labeling when labeling cost is relatively low, otherwise choose not labeling, which confirms Proposition 1.

Similarly, we further explore the supplier’s optimal decision when considering the manufacturers’ advertising investment according to the relationship between labeling cost c_0 and supplier M’s profit π_{2M} in the AIGM, as shown in Figure 10. We find that the upper profit bound of the supplier’s decision to label decreases with the increase in labeling cost, whereas the lower profit bound of the supplier’s decision to label coincides with that of the supplier’s decision not to label. Therefore, the profit interval of the supplier’s decision to label decreases with the increase in labeling cost and is always smaller than that of supplier’s decision not to label because of the existence of labeling cost. In addition, π_{2M}^N is always higher than π_{2M}^L , which indicates that the profit of the supplier’s decision not to label is always greater than that of the supplier’s decision to label. Therefore, when considering advertising investment, the supplier should always opt not to label to maximize profits, which verifies Proposition 5. In addition, we find that $\pi_{2M}^N > \pi_{1M}^N$ by comparing Figure 9 with Figure 10, which indicates that the equilibrium strategy of advertising investment can increase the supplier’s profit.

Next, we shed light on supplier M’s profit in the ASM. Figure 11 displays the relationship between labeling cost c_0 and supplier M’s profit π_{3M} . We find that when the supplier chooses to label, its upper profit bound decreases, whereas its lower profit bound increases with the increase in labeling cost. Therefore, the profit interval of the supplier’s decision to label decreases with the increase in labeling cost and is always smaller than that of the supplier’s decision not to label.

Observation 1. The supplier should always choose not to label in the ASM.

We find that $\pi_{3M}^N > \pi_{3M}^L$ from Figure 11, which indicates that the profit of supplier’s decision not to label is always greater than that of the supplier’s decision to label. Therefore, the supplier should always choose not to label in the ASM to maximize profits.

Based on Observation 1, we find that π_{3M}^N is slightly higher than π_{2M}^N by comparing Figure 10 with Figure 11, which indicates that subsidy can increase the benefits of the supplier. Therefore, the supplier should grant subsidies to the manufacturers to maximize its profits, which confirms Proposition 8. In summary, the supplier should choose not to label and grant subsidy in the ASM.

Figures 9–11 discuss the optimal decision of the supplier in the BIGM, AIGM, and ASM, respectively. In summary, the supplier should choose to label when labeling cost is relatively low without considering advertising investment and should always choose not to label when considering advertising investment. No labeling and granting subsidy are the supplier’s optimal strategy in the advertising subsidy mechanism.

On the basis of these conclusions, we further discuss the impact of subsidy on the supplier under different values of the investment return coefficient α_i . As shown in Figure 12(a), $\pi_{3M}^N - \pi_{2M}^N$ is used to indicate the impact of subsidy on the supplier’s profits. Figure 12(b) presents a corresponding contour map. We find that $\pi_{3M}^N - \pi_{2M}^N > 0$, which increases continuously with the increases in α_A and α_B indicates that subsidy has a sustained positive effect on the supplier. In other words, the greater the ability to earn returns from investment, the more profit increment the subsidy can bring to the supplier. In addition, α_A has a more significant impact on profit increment compared with α_B , which indicates that manufacturer heterogeneity may enable the supplier to obtain different degrees of benefits from the subsidy mechanism. Manufacturer A is a well-known enterprise with good reputation, whereas manufacturer B is a weaker enterprise, which may result in a greater impact on A compared with B in terms of subsidy due to the different investment returns abilities. Therefore, the supplier should not only decide the optimal subsidy rate but also evaluate the investment returns ability of the manufacturers and pay more attention to that of the well-known manufacturer.

Moreover, we will discuss the impact of subsidy on manufacturer A. Figure 13 displays the relationship between $\pi_{3A} - \pi_{2A}$ and α_A . Horizontally, profit margin increases with the increase in α_A . If the supplier decides not to label, then

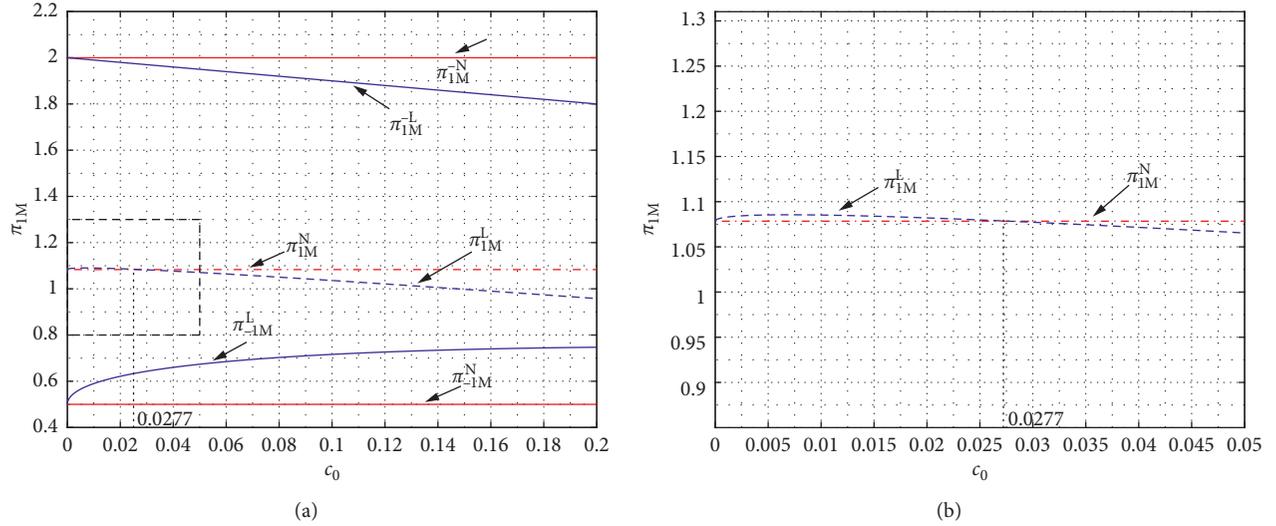


FIGURE 9: Relationship between c_0 and π_{1M} : (a) supplier's profits; (b) enlarged image of inset in (a).

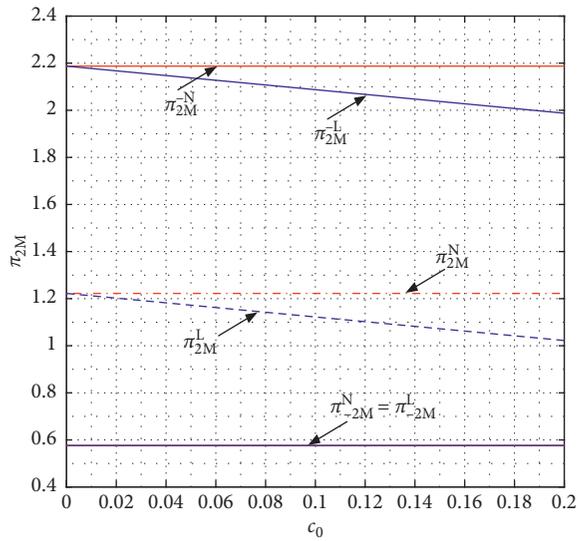


FIGURE 10: Relationship between c_0 and π_{2M} .

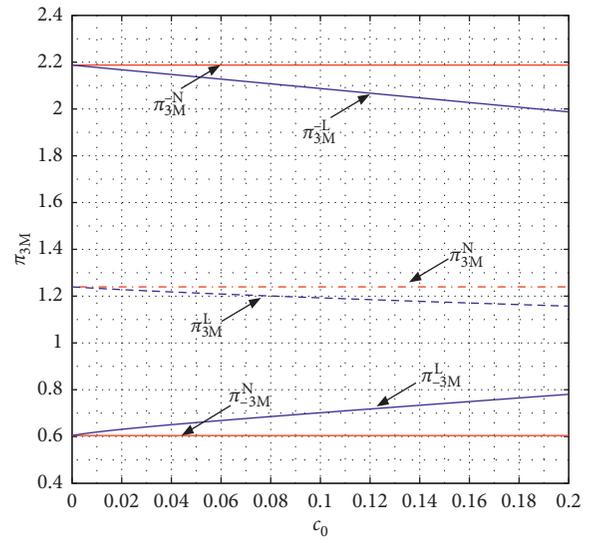


FIGURE 11: Relationship between c_0 and π_{3M} .

subsidy will exert a positive effect on manufacturer A's profit when $\alpha_A > 0.666$. If the supplier decides to label, then subsidy will have a positive effect only when $\alpha_A > 0.189$. This finding indicates that when M chooses to label, manufacturer A will be required to display an increased efficiency in advertising investment. In other words, manufacturer A should improve its investment profitability to ensure the possibility for cooperation with supplier M. Longitudinally, manufacturer A's profit margin is always higher when the supplier decides not to label compared with when the supplier decides to label. This finding indicates that the supplier's decision not to label can bring added benefits not only to itself but also to manufacturer A.

Finally, we discuss the impact of subsidy on manufacturer B. Figure 14 depicts the relationship between $\pi_{3B} - \pi_{2B}$

and α_B . Horizontally, the profit margin increases with the increase in α_B . When the supplier decides not to label, $\pi_{3B}^N - \pi_{2B}^N > 0$, subsidy will exert a continuous positive effect on manufacturer B's profits. When the supplier decides to label, $\pi_{3B}^L - \pi_{2B}^L < 0$, subsidy will exert a continuous negative effect on manufacturer B's profits. Longitudinally, manufacturer B's profit margin is always higher when the supplier decides not to label than that when the supplier decides to label. In summary, subsidy can benefit the weaker manufacturer only under the supplier's optimal decision, that is, not to label.

We refer to Figures 12–14 and find that the advertising subsidy mechanism can enhance the profit of each supply chain member under the optimal strategy set, thus coordinating the organic food supply chain and achieving the Pareto improvement.

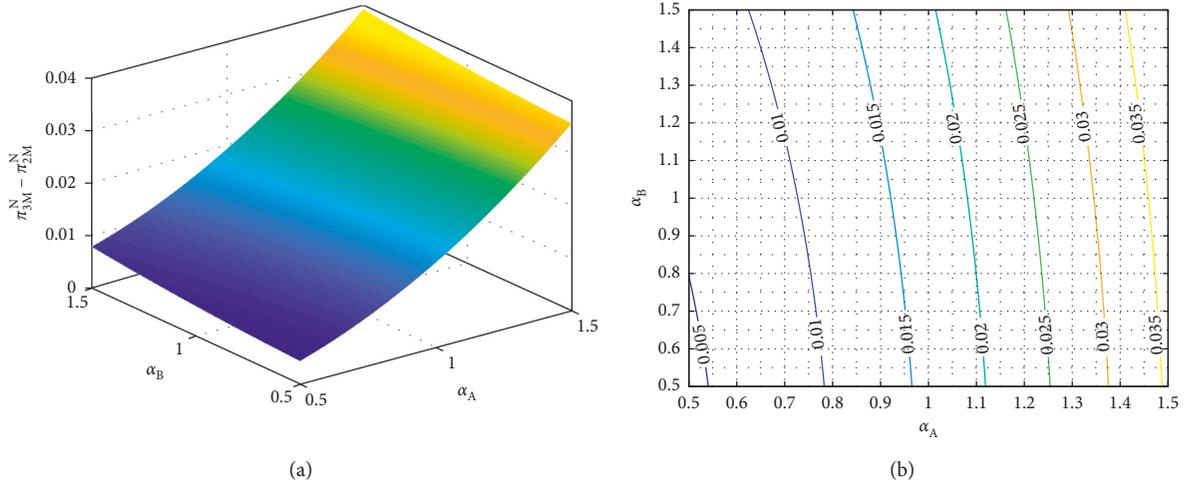


FIGURE 12: Impact of subsidy on supplier: (a) profit increment of supplier; (b) contour map.

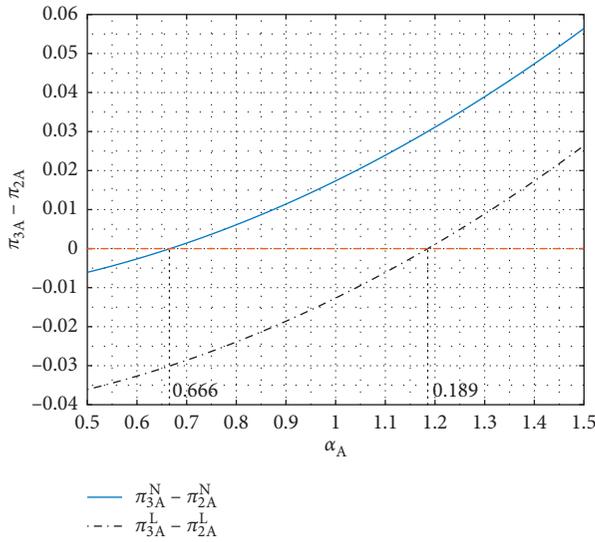


FIGURE 13: Impact of subsidy on manufacturer A.

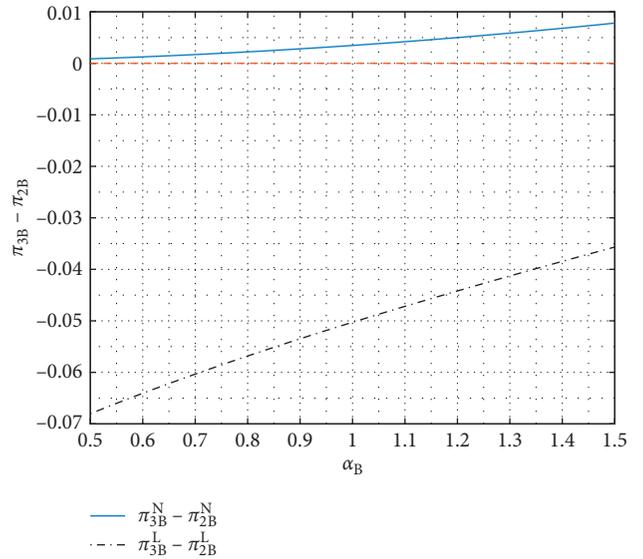


FIGURE 14: Impact of subsidy on manufacturer B.

5. Conclusions and Managerial Insights

In the face of consumers' preference for organic food and the government's low-carbon policy, we establish a tripartite game model to study the decisions of labeling and advertising investment in an organic food supply chain composed of one supplier and two heterogeneous manufacturers by the biform game approach. In addition, we introduced an advertising subsidy mechanism to alleviate the underinvestment problem and coordinate the supply chain. First, this study established the BIGM to investigate the supplier's labeling decision without considering advertising investment. Then, we build the AIGM to further elucidate the impact of the manufacturers' advertising investment on the supplier's labeling decision and obtain the optimal strategies of the supply chain members. Finally, we introduced a coordination mechanism, namely, ASM, to alleviate the underinvestment problem and coordinate the

supply chain and presented the optimal strategies of the supply chain members in the ASM. As a result, we obtained interesting findings with managerial insights.

Without considering advertising investment, the supplier's decision to label is dependent on labeling cost. The supplier should opt to label when labeling cost is relatively low to achieve higher profit. When labeling cost becomes high, labeling investment will enter the stage of diminishing returns to scale, which will adversely affect the supplier's profits. At this time, the supplier should decide not to label. In addition, the cooperative game in this model is super-additive, which indicates that each supply chain member is willing to cooperate because the total benefit from cooperation is always no less than the sum of the income from their respective operations.

Taking advertising investment into account, all manufacturers should invest in advertising to improve

competitiveness, which is the result of dominant equilibrium. When the supplier decides to label, the weaker manufacturer should reduce its investment in advertising appropriately, whereas the well-known manufacturer should maintain its investment level at a higher level than that of the weaker manufacturer to consolidate its market position and competitiveness. In the face of the manufacturers' investment, the supplier should decide not to label so as to prevent advertising investment from entering the stage of diminishing returns to scale.

When considering advertising investment and subsidy, the manufacturers will invest more in advertising, which confirms the existence of underinvestment and indicates the promotion effect of subsidy on advertising investment. Therefore, the supplier should subsidize the manufacturers to stimulate investment and subsidize the weaker manufacturer more to weaken the "diffusion of responsibility" mindset and gain increased bargaining power with the well-known manufacturer. Using the subsidy mechanism to mitigate the underinvestment problem encourages the manufacturers' investment to move toward the optimal equilibrium point. As a result, the profit of the cooperative alliance will tend to peak, such that the supplier may no longer need to label.

By a comparative analysis of the AIGM and BIGM, we find a relationship between competitive game and cooperative game. First, two heterogeneous manufacturers invest in advertising through competitive game and obtain the equilibrium result of competitive game, which improves the supplier's advantage in the next cooperative game. This scenario does not necessitate the supplier to label, thus promoting a positive shift in the equilibrium result of the cooperative game. Furthermore, by a comparative analysis of the AIGM and ASM, we identify the transmission mechanism of advertising subsidy. The supplier can stimulate the manufacturers' investment by issuing subsidies to increase the intensity of the competitive game and promote a positive movement in the equilibrium result of the competitive game and obtain more benefits in the cooperative game. Moreover, we find an interesting phenomenon on cooperation and investment in the organic food supply chain; that is, the "diffusion of responsibility" mindset may exist in the face of the investment behavior of the other side, which will lead to the phenomenon of underinvestment (e.g., manufacturer B decreases its advertising investment level according to the labeling behavior of supplier M in the AIGM) or even the phenomenon of noninvestment (e.g., supplier M decides not to label with the manufacturers' advertising investment).

Although this study garnered several important managerial implications, we acknowledge certain limitations that can be addressed in future studies. By summarizing optimal decisions in the AIGM and ASM, we find that the supplier who makes the decision first always chooses not to label, whereas two manufacturers always choose to invest in advertising. In other words, the supplier can make less effort compared with the manufacturers in a cooperative alliance, which indicates that the decision-making sequence gives the supplier the "first-mover advantage" in the cooperative game. In the future, the research direction will focus on the

optimal strategy when manufacturers make the first decision. In addition, although this study introduced the advertising subsidy mechanism to coordinate the supply chain, this subsidy belongs to one-way subsidy. Therefore, whether or not two-way subsidy is superior over one-way subsidy in organic food supply chains with advertising investment and labeling is also one of the topics that we will discuss in the future.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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