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Choice of cooperation strategy under demand updating and altruistic behavior

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ABSTRACT

The integration of logistics service supply chains to improve the service quality of has become the choice of many logistics integrator. This paper considers two common cooperation modes, namely, enabling cooperation and merger cooperation. Meanwhile, this paper takes demand updating and integrator's altruistic behavior into account, establishes a Stackelberg game model and draws the following key conclusions. First, this paper determines the conditions of cooperation, when provider's profit distribution ratio is in the middle, the integrator and the provider cooperate successfully and adopt the merger strategy. Second, this paper finds that demand updating affects the scope of cooperation. When demand decreases (increases), the scope of cooperation between suppliers and integrator decreases (increases). Finally, when the demand reduction degree is small, the demand updating benefits the integrator's profit. In this situation, integrator has incentive to share updated demand information to provider.

1. Introduction

Logistics is playing an increasingly important role in all walks of life. It has gradually evolved from the competition of a single enterprise to the competition of the performance and efficiency of the whole supply chain [1]. Logistics service quality has gradually become the key point of supply chain performance competition. From the logistics service supply chain's overall perspective, to provide better service quality and obtain better logistics service performance, upstream logistics providers and downstream logistics integrators need to cooperate. For example, relying on its resource advantages, the Cainiao Network, a subsidiary of Alibaba, has cooperated with several express delivery service providers, such as STO Express and YTO Express, to continuously improve the quality of logistics services [2].

Among the current factors affecting the logistics service supply chain's quality, many integrators show two key factors. The first is the altruistic behavior factor. In cooperating with suppliers to improve service quality, integrators in the supply chain show a prominent altruistic tendency [3–5]. This is because logistics providers in a weak position, limited by a lack of funds or technical barriers, have neither the ability nor the motivation to take the initiative to improve their own logistics service quality, and integrators need to take the initiative to help suppliers improve the overall service quality. For example, before STO Express accepted the integration of Cainiao Logistics, its logistics service quality was low, leading to a low market share. Alibaba helped Shentong improve its management ability free of charge, transforming center integration and acquisition, route optimization, and franchisee incentive policy adjustments, with all aspects exhibiting very positive changes [6]. In the process of cooperation with logistics providers, such logistics integrators not only pay attention to their own material benefits but also show altruistic behavior to improve the service level

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and profit of their suppliers, which is very common in the logistics service supply chain [4,7,8].

Additionally affecting the performance of the logistics service supply chain is the cooperation mode between integrators and suppliers. According to the different manifestations of integrators' altruistic behavior in the cooperation process in practice, the cooperation mode between integrators and suppliers can be divided into two kinds. The first kind of cooperation is enabling cooperation under altruistic behavior. When the integrator conducts business cooperation with the provider, it shows an altruistic tendency to actively and freely empower the logistics provider to improve the service quality of the logistics service provider. This paper calls this kind of cooperation the enabling strategy [9,10]. An enabling strategy refers to integrators paying a certain cost to actively assist logistics providers in organizing management training and technological upgrading to help logistics service providers improve their management efficiency and technical service level and ultimately improve the overall performance of the supply chain. Novice network positioning technology companies, for example, can assign and help logistics companies strengthen the efficiency and quality of the logistics industry, and logistics companies can help build electronic business platforms, and consumer logistics data-sharing platforms. Using intelligent digital technology such as single technology can promote intelligent industry transformation because each node can assign and improve the efficiency of the logistics industry

As a whole. Through the application and innovation of digital technology, JD logistics has realized the enabling of logistics service providers. Logistics service providers can rely on JD's big data platform to deeply explore the value development points existing in the supply chain and bring efficient logistics services to customers [11].

The second kind of cooperation is merger and acquisition cooperation under altruistic behavior. Research shows that altruistic behavior impacts service quality in service-oriented enterprises [12,13]. In practice, after the merger and acquisition of service providers by many logistics integrators in the logistics service industry, the logistics integrators will take part in the shares of the logistics providers and eventually distribute the total profits. In the process of cooperation, integrators show an altruistic tendency and actively help suppliers enhance and improve the logistics service quality to enhance the service quality and service performance of the whole logistics service supply chain. For example, in July 2019, Alibaba bought a 49% stake in STO Express, investing RMB 4.67 billion. With Alibaba's investment, STO has brought multiple advantages in technology, organizational structure, and resources to help STO Express further expand the market. After Alibaba's investment, STO's performance has improved significantly [6].

In addition to the above two important factors affecting cooperation performance, rapidly changing customer needs in the external market have also become another important issue for supply chain decision-making. Particularly in the mobile Internet era, the rapid development of information technology brings great convenience for customer consumption and allows customers to demand more diversification at any time. This leads to more intense market demand changes and brings integrator decisions greater challenges; therefore, it is necessary for integrators to grasp and update market demand and make better decisions instantly. Because integrators are closer to customers and have more understanding and a greater grasp of customer needs and market changes, they can update market demands and share data and demand information with logistics providers to achieve good logistics performance [14].

Theoretically, altruistic behavior is widely discussed in the supply chain and marketing, such as the customer altruistic preference [15]; the retailers altruistic behavior [16]; the service integrators show altruistic behavior to share the data [17]; altruistic behavior in Low-Carbon E-Commerce Supply Chain [18]. However, the research on altruism in logistics service supply chain is relatively lacking, Liu et al.(2018b) studied the coordination of logistics service supply chain considering altruistic preferences. With respect to the cooperation strategy [3,19] and demand updating [[4,14,20,21]], there are significant articles in the field of logistics service supply chain. In summary, Although the above three factors have been studied separately in the logistics service supply chain, there has not been a comprehensive consideration of the complex influence of the above three factor. Therefore, this paper considers a logistics service integrator and a logistics service provider. The logistics service integrator updates the market demand and carries out two altruistic cooperation strategies to the logistics service provider. This paper mainly discusses the optimal altruistic degree of integrators, the applicable scope of two altruistic cooperation strategies, and the optimal cooperation strategy of both parties. This paper mainly studies the following issues.

1. How do the two parties choose the altruistic cooperation strategy, and what is the feasible scope of the altruistic cooperation between the two parties?
2. What is the impact of demand updates on the decision-making and profit of both parties? What is the effect on the selection of altruistic cooperative strategies ?
3. How do the altruistic decision-making and profit of both parties change under information asymmetry? What are the incentives for integrators to share requirements information ?

First, for the initial question, when the provider's profit distribution ratio is large, the integrator prefers the enabling strategy, while the provider prefers the merger and acquisition strategy. When the provider's profit distribution ratio is medium, the integrator and the provider cooperate successfully and adopt a merger and acquisition strategy. When the profit distribution ratio of the provider is too high or low, the cooperation between the integrator and the provider will be affected, profit conflict will occur, and cooperation will fail.

Second, if the integrator adopts the enabling strategy for the second problem, when the demand increases, the altruistic degree of the second phase is less than that of the first phase, and vice versa. However, if the demand change trend is uncertain, the degree of altruism under the enabling strategy will increase. If the integrator adopts the strategy, the altruistic degree of the two phases is the same. The optimal altruistic coefficient does not change in the uncertain demand change trend, the demand update does not affect the integrator's altruistic degree. After the demand update, the cooperation conditions between the integrator and the supplier do not change, but the demand update affects the scope of cooperation between the two. When the demand decreases (increases), the scope of cooperation between the supplier and the integrator decreases (increases).

Finally, for the third problem, in the case of demand asymmetry, the decision of the supplier of the second phase will not change, and the decision of the purchase price will be the same as that of the first phase. For integrators, the higher the cost required for quality improvement, the higher the level of altruism, and the lower the cost required for quality improvement, the lower the level of altruism. When the demand reduction degree is large, the integrator sharing the updated demand information with the provider helps improve the level of altruism. When the demand reduction is small, it is beneficial for the integrator to share the updated demand information with the supplier. When demand increases, the integrator sharing updated demand information with the provider is beneficial to the provider's profit. The integrator has the incentive to share the updated requirement information with the supplier when the demand reduction degree is small.

This paper can provide some management suggestions for logistics integrators and logistics providers in practice. First, logistics integrators choose the merger and acquisition strategy more than the enabling strategy, which is also in line with the situation in practice. For example, Alibaba continues to acquire shares of other logistics express companies through the merger and acquisition strategy (e.g., ZTO and STO) to cooperate with other logistics business opportunities and improve their service quality free of charge, enhancing the competitiveness of logistics distribution links. Second, when adopting the strategy, attention should be paid to the profit distribution ratio. Only when the profit distribution ratio is timely is the strategy beneficial to both of them; otherwise, the strategy is a zero-sum game. Finally, when the degree of demand reduction is low, people are more motivated to share updated demand information, which improves altruism level and self-profit. However, when the demand increases, sharing the updated demand information is beneficial to the provider's profit, while the integrator has no incentive to share it. If the integrator wants to attract better cooperation from the provider, it can take the initiative to share the updated demand information. The provider can also have better pre-cooperation communication and agreements with the integrator to proactively share demand information, especially after demand increases.

There are also some theoretical implications, from an academic point of view, first, this paper introduces altruistic behavior and two common cooperation modes into the logistics service supply chain and applies modeling method to explore the impacts. Most previous articles focus on the impact of altruistic behavior on supply chain profits, this paper pays attention to the effect of altruistic behavior on cooperative patterns, which certainly expands the research scenarios of altruistic behavior. Second, the modeling method proposed in this paper is different from the traditional model in which altruistic behavior directly affects profits [4]. Based on the actual background of enterprises in practice, this paper integrates quantitative research on altruistic behavior into the two current cooperation strategies, and then establishes a profit model, which not only conforms to the actual background, but also provides some new perspectives and methods for future research.

The main structure of this paper is as follows. The 2nd section is a literature review of altruistic behavior and two kinds of cooperative strategies. The 3rd section describes the modeling scenario and proposes the corresponding assumptions. In section 4, the altruistic behavior of integrators under the two strategies is modeled and analyzed. Section 4.1 is the modeling and solution analysis before requirement update; 4.2 is the modeling and solution analysis after requirement update. The 5th section is the generalization of the model considering the situation of information asymmetry. The 6th section summarizes this paper's main conclusions and gives the corresponding significance of management and research prospects.

2. Literature review

In the literature review section, we mainly review two aspects related to the research in this paper: Section 2.1 reviews altruistic behavior in the supply chain. Section 2.2 summarizes the application of enabling strategies and merger strategies.

2.1. Research on altruistic behavior in supply chains

The study of altruistic behavior started in the field of behavioral economics [22]. Studies show that decision-makers are not completely rational but show an altruistic tendency to care about the interests of others [23]. In the supply chain area, Loch and Wu (2008) demonstrated through empirical studies that supply chain members make decisions with altruistic preferences to promote cooperation and achieve efficient and sustainable development. Wang et al. (2021) studied the altruistic behavior in service supply chain and found that altruistic behavior can lead to a "transmission effect". Wang(2021) explored the influence of commission on altruistic preference in the low-carbon e-commerce supply chain.

In addition, studies on altruistic behavior in the supply chain also include price decisions [24], inventory decisions [25], supply chain performance [26,27], and supply chain cooperation [3,28]. In the field of the service supply chain, research on altruistic behavior has focused on service quality [29,30], social service motivation [31], In the field of logistics service supply chains, Liu et al. (2018b) studied the influence of altruistic preferences for LSI and FLSP in service supply chains on members' utility and the contract effect of logistics supply chains. Liu et al. (2019) reviewed behavioral studies in the service supply chain from 2009 to 2018, pointing out that the difference between altruistic behavior and reciprocal behavior is that there is no need for preconditions and triggers and that future studies should pay more attention to the actual cases of altruistic preference in the industry. However, the above studies on altruistic behavior in supply chains mainly focus on inventory and cooperation in manufacturing supply chains. Research on logistics service supply chains is still lacking, with the influence of altruistic behavior on cooperation strategies in service supply chains a notable gap in current research.

2.2. Application research on enabling cooperation and merger cooperation

The term empowerment originally found wide use in psychological terms, meaning the process of becoming stronger and more confident by increasing one's ability. It was subsequently introduced into enterprise business management, where the psychological empowerment mechanism focused on the empowerment of employee power and responsibility [32]. Leong et al. (2016) demonstrated how social media empowered community members to achieve collective participation, shared identity, and collaborative control at the community level. The concept of empowerment has gradually expanded from the psychological level and has been widely applied in many industries. Resource empowerment focuses on improving the ability and ability of powerless people to acquire, control and manage resources. [33] point out that resource management capabilities include the ability to acquire, integrate, and release resources. [34] studied the effects of digital empowerment on the waste of power resources and equipment. In terms of technology empowerment, [35] pointed out that the latest developments in RFID, smart sensors, communication technologies, and Internet protocols have made the Internet of Things possible. The Internet of Things promises to connect technologies to enable intelligent decision-making for new applications. At present, the application field of digital empowerment has been extended to the level of e-commerce business ecosystems [9]. In recent years, enabling has been constantly mentioned in the ecological chain of smart logistics. Liu et al. (2020) found that digital enabling ability and information sharing levels are the unique factors affecting the coordination of SLEC organizations. The higher the level of digital enabling ability and information sharing, the higher the coordination degree of ecological chain organizations.

In terms of strategies, some scholars have studied the classification of different types. For example, [36] introduced an important distinction between where technology is a component and where it is not. In terms of technical innovation, [37] showed that companies actively identify and implement potential acquisitions by carrying out corporate venture capital activities.[38] describes how CSR programs promote and strengthen social responsibility and sustainability through mergers and acquisitions. The study found that intensive acquisition programs help companies gain access to technology, people, and innovative resources and concluded that cross-border mergers and acquisitions could be effective platforms for building deals to establish global corporate social responsibility (CSR) programs or to customize CSR programs for different regions. In general, few studies on mergers and acquisitions combine behavioral factors, except the studies by Brekke et al. (2014) and Han et al. (2017), which found that altruistic behavior can improve the quality of medical care after hospital mergers and acquisitions. [39] considered the homogeneous-threshold networks and explored how the threshold affects the convergence time and network equilibrium. [40] investigated the evolutionary dynamics of three zero-determinant (ZD) strategies, which are fair strategy, exploitative strategy, generous strategy, and the results provided some new insights into the evolutionary outcomes of iterated games on complex networks. [41] reviewed some recent advances in the field of indirect reciprocity and reputation mechanism along the routes of theoretical modeling and behavior experiments, found that providing enough information on the individual strategy or reputation status will help players to select the cooperative partners or perform the rational decision, which eventually facilitates the evolution of cooperation. [42] explored important effect of delays generated during the transmission of information on the dynamic evolution of cooperation.

The above studies on empowerment are basically empirical studies and case studies, and there is a lack of quantitative research on the two cooperation strategies. Moreover, the above papers are all about one of the strategies, and there is no simultaneous research on the two cooperation strategies in the same study. This paper will study the two cooperation modes simultaneously through quantitative modeling and obtain the applicable conditions of the two cooperation modes.

2.3. Literature summary

Considering the above literature and the angle of cooperation and mergers studied, and the lack of comprehensive research, this article considers the altruistic behavior in the logistics service supply chain in practice. The logistics services supply chain cooperation is divided into enabling cooperation and cooperation, applying the two kinds of cooperation methods studied in terms of integrators with altruistic tendencies and demand updates. The research related to this article is shown in Table 1 below.

As seen from Table 1, Liu et al. (2018b) considered the impact of altruistic behavior on logistics service performance but did not consider demand updates or cooperation between integrators and providers. Liu et al. (2020) considered the impact of enablement only in the ecological chain on the degree of organizational synergy but did not consider behavioral factors and demand updating. [43] considered the impact of enterprise cooperation on supply chain performance in the case of risk aversion but did not consider the specific form of cooperation. Meglio and Park (2019) studied the impact of merger and acquisition cooperation on corporate social responsibility without considering behavioral factors and demand updating. In this paper, the above factors are considered

Table 1
Comparison between this paper and relevant literature.

	Liu et al., 2018b	Liu et al., 2020	Xu et al., 2015	Meglio and Park(2019)	This paper
Behavior	Altruistic	×	risk aversion	×	Altruistic
Demand updating	×	×	×	×	✓
Cooperation	×	Enabling Form	×	Merger Form	Enabling & Merger
Research content	Logistics Service Performance	Organizational Coordination Degree	Supply Chain Performance	Corporate Social Responsibility	Cooperation Strategy Selection

comprehensively. The two cooperation modes are considered under the circumstance of altruistic behavior and demand renewal, and the choice of cooperation strategy for the logistics service supply chain is studied.

3. Model description

This paper assumes that the logistics service quality of the logistics provider is v, the potential market size is a, the price of the logistics service is p, and the market demand function is $d = a + v - p$ [24]. This paper considers the situation of the two phases. The market demand of the second phase changes and the integrator will update the demand in the second phase. Generally, there are two main changes: one is an increase in demand, and the other is a decrease in demand. This paper mainly studies whether integrators can predict the traffic conditions of demand change trends based on historical data and the information they have mastered. The more complex situations concerning uncertain demand change trends are discussed in the model expansion of Section 5.2. This paper assumes that the change degree of demand is λ; if the market demand increases, then $\lambda > 1$; if the market demand decreases, then $0 < \lambda < 1$, hence the demand of the second phase is $d_2 = \lambda a + v_2 - p$. This paper considers that the integrator's free assistance to the provider will help improve the final logistics service quality. We assume that the altruistic coefficient of the integrator is $\beta(\beta > 1)$ and that market demand becomes $d_j = a + \beta_j v_j - p(j = 1, 2)$.

According to the introduction, in practice, integrators have two kinds of altruistic behavior. The first case is assigned to cooperation, where the integration of the chamber of commerce with altruism can lead to the assignment of logistics service providers to enhance the quality of service, thereby improving overall market demand. The integrator improves the service quality of the provider for free, and the unit cost to be paid is k. In this paper, it is defined as $\beta_j^e (j = 1, 2)$, the altruistic level of integrators under enabling cooperation, and it is decided by integrators. Therefore, under the enabling strategy, the market demand is $d_j^e = a + \beta_j^e v_j - p(j = 1, 2)$. In this case, the integrator and the provider are still in business cooperation, and it is assumed that the unit price of the integrator purchasing logistics services from the provider is w_j.

The second case is merger and acquisition cooperation, in which the integrator to the logistics service provider carries out a certain proportion of equity mergers and acquisitions. After completing the merger and acquisition, the specific logistics service distribution will still be carried out by the provider. Thus the integrator will help the provider in the form of altruism to improve the overall service quality to enhance the overall market demand. This paper defines β^m as the altruistic level of integrators under merger cooperation, which is decided by integrators. Here the market demand becomes $d_j^m = a + \beta_j^m v_j - p(j = 1, 2)$. In the form of merger and acquisition cooperation, the integrator and the provider will eventually have a profit distribution, and the profit distribution ratio of the provider is α. The main mathematical symbols and explanations are shown in Table 2 below.

4. Model building

This section mainly analyzes the two cases, the two kinds of altruism cooperation strategy, and the integrator and provider's profit functions and decision-making processes. In section 4.1, we demonstrate the first phase of integrator and provider profit function modeling. Section 4.2 demonstrates the integrator and provider's profit function for modeling based on the integrator for the updated demand.

4.1. *The first period—Before demand updating*

4.1.1. *Enabling strategy*

As described in the model description, in the case of the enabling strategy, the market demand is $d_1^e = a + \beta_1^e v_1 - p$, and β_1^e is the altruistic coefficient of the first phase. At this point, the profit of the logistics service provider is $\pi_{p1}^e = w_1(a + \beta_1^e v_1 - p)$, the profit of

Table 2
Notation and explanation.

Notations	Descriptions
a	Potential demand scale
p	Market price per unit of logistics service
w_j	$j = 1, 2$, Under the enabling strategy, the logistics service purchase price in integrator phase j, which is decided by the provider
α	Profit distribution ratio of suppliers under a merger strategy
v_j	$j = 1, 2$, The service quality of the logistics service supply chain in period j
β_j^e	$j = 1, 2$, Under the enabling strategy, the altruistic level of the integrator in period j, which is determined by the integrator.
β_j^m	$j = 1, 2$, Under the merge strategy, the altruistic level of the integrator in period j is determined by the integrator
k	The unit cost of altruistic behavior for improving service quality
λ	The change coefficient of demand after demand updating in the second period
η	Probability of demand increasing in the second period
$\varepsilon_\uparrow / \varepsilon_\downarrow$	The uncertainty of demand increasing, $\varepsilon_\uparrow \sim (\mu, \delta_\uparrow^2)$
	The uncertainty of demand decreasing, $\varepsilon_\downarrow \sim (\mu, \delta_\downarrow^2)$
$\pi_{pj}^e(\pi_{pj}^m)$	$j = 1, 2$, under enabling strategy(merge strategy), the profit of provider in period j
$\pi_{ij}^e(\pi_{ij}^m)$	$j = 1, 2$, under enabling strategy(merge strategy), the profit of integrator in period j

the logistics integrator is $\pi_{i1}^{e} = (p - w_1)(a + \beta_1^e v_1 - p) - \frac{1}{2}k(\beta_1^e v_1)^2$, the integrator decides the altruistic coefficient β_1^e, and the supplier decides the purchase price w_1. For the integrator and the provider's profit function, the reverse order method is adopted to solve the profit function. See Appendix A for the specific solving process.

4.1.2. *Merger strategy*

As described in the model, in the case of a merger and acquisition strategy, the market demand is $d_1^m = a + \beta_1^m v_1 - p$, the profit of logistics service provider is $\pi_{p1}^{m} = \alpha\left[p(a + \beta_1^m v_1 - p) - \frac{1}{2}k(\beta_1^m v_1)^2\right]$, the profit of logistics integrator is $\pi_{i1}^{m} = (1-\alpha)\left[p(a + \beta_1^m v_1 - p) - \frac{1}{2}k(\beta_1^m v_1)^2\right]$, in which β_1^m is the altruistic coefficient, α is the proportion of profit distribution, and is the altruistic coefficient of integrator decision-making. For the integrator and the provider's profit function, the reverse order method is adopted to solve the profit function. See Appendix A for the specific solving process.

By solving the integrator and the provider's profit function, we obtain the other integrator's other optimal coefficient under the two altruistic cooperation strategies, as shown in Proposition 1 below. The proof process is shown in Appendix A.

Proposition 1.

(i) When the integrator adopts enabling strategy, the optimal altruistic coefficient is $\beta_1^{e*} = \frac{p-(a-p)k}{2kv_1}$.
(ii) When the integrator adopts merger strategy, the optimal altruism coefficient is $\beta_1^{m*} = \frac{p}{kv_1}$.
(iii) $\beta_1^{m*} > \beta_1^{e*}$.

Proposition 1 shows that for the same provider, the altruistic coefficient under the merger and acquisition strategy is greater than that under the enabling strategy when the integrator and the provider cooperate. This is because the integrators and purchase providers of equity mergers and acquisitions use the profit allocation mechanism to enhance the level of altruism. This is beneficial in improving the overall quality of logistics services. When providers merge, the providers do not make decisions, and only the integrators make decisions. The double marginal effect will disappear, and conveniently, the integrator of good management and quality improvement will give the same level of altruism at this time, with a lower cost.

The conditions for selecting cooperation strategies between integrators and suppliers are analyzed, as shown in Theorem 1 below. The proof is shown in Appendix B.

Theorem 1.

(i) The threshold value of integrator strategy selection is $\alpha_i^1 = \frac{3(p+(a-p)k)^2}{4(p^2+2(a-p)kp)}$, the integrator chooses the enabling strategy if $\alpha > \alpha_i^1$, otherwise the acquisition strategy.
(ii) The threshold value of provider strategy selection is $\alpha_p^1 = \frac{(p+(a-p)k)^2}{2(p^2+2(a-p)kp)}$, the provider chooses the acquisition strategy if $\alpha > \alpha_p^1$, otherwise the enabling strategy.

According to Theorem 1, when the provider's profit allocation proportion is larger, integrators tend to assign a strategy, and providers tend to choose merge strategy. It is quite easy to understand that as the provider, the higher the profit allocation proportion is, the greater the profits for the merge strategy, and the integrator gains profits from the merger and acquisition strategy. Hence, providers are more inclined to use merge and acquisition strategies while integrators tend to assign a strategy.

To make it easier to observe the choice of cooperation strategy between integrators and suppliers, the strategy choice graph can be summarized according to Theorem 1. As shown below, the final choice of cooperation strategy between integrators and suppliers can be summarized as Corollary 1.

Corollary 1: The integrator and the provider will cooperate, mainly through a merger and acquisition strategy; otherwise, the integrator and the provider cannot cooperate.

It can be concluded from Fig. 1 and Corollary 1 that when the profit distribution ratio of the provider is in the middle, the integrator and the provider cooperate successfully and adopt the strategy. When the profit distribution ratio of the provider is too high or too low, the cooperation between the integrator and the provider will be affected, profit conflict will occur, and cooperation will fail.

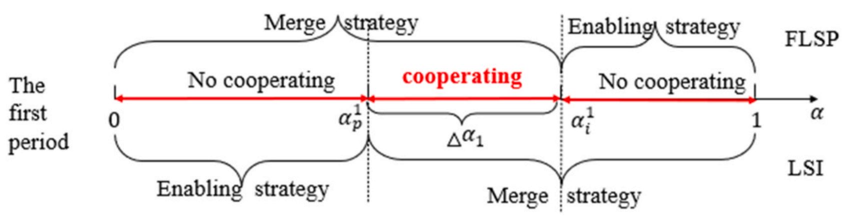

Fig. 1. Cooperation strategy selection between integrator and provider.

4.2. The second period—after demand updating

This section mainly analyzes the situation when the integrator updates the demand after the demand changes. This paper analyses process of logistics services integrator again after the completion of the first issue. Therefore integrators can, according to the first period of merger and acquisition strategy and altruistic coefficients, move to decision-making, the second phase of the service quality according to section 4.1, Corollary 1. In conclusion, due to the first issue of integrators' altruism cooperation with providers, integrators can only take the merge strategy. Hence, the chamber of commerce integration updates the second phase of the logistics service quality, which changes to $v_2 = \frac{p}{k\beta_1^{m*}}$, and updates the demand for the second phase at the same time. According to the model's description, there are two main changes in demand. The first is the increase in demand, and the second is the decrease in demand. In summary, this section establishes the modeling of the decision-making of both parties for demand updates and uses the sequential solution method to solve the two-stage model.

4.2.1. Enabling strategy

The integrator and the provider engage in an enabling partnership, as described in the model description, in the second phase of the enabling strategy. In this case, the market demand is $d_2^e = \lambda a + \beta_2^e v_2 - p$, the logistics service provider's profit is $\pi_{p2}^e = w_2(\lambda a + \beta_2^e v_2 - p)$, the profit of the logistics integrator is $\pi_{i2}^e = (p - w_2)(\lambda a + \beta_2^e v_2 - p) - \frac{1}{2}k(\beta_2^e v_2)^2$, the integrator decides the altruistic coefficient β_2^e, and the supplier decides on the purchase price w_2. For the integrator and supplier's profit functions after the demand update in the second phase, the reverse order solution method is adopted.

4.2.2. Merger strategy

Integrator and provider conduct cooperation through a merger. As described in the model, under the strategy of the second phase, the market demand is $d_2^m = \lambda a + \beta_2^m v_2 - p$, the profit of the logistics service provider is $\pi_{p2}^m = \alpha\left[p(\lambda a + \beta_2^m v_2 - p) - \frac{1}{2}k(\beta_2^m v_2)^2\right]$ the profit of the logistics integrator is $\pi_{i1}^m = (1-\alpha)\left[p(\lambda a + \beta_2^m v_2 - p) - \frac{1}{2}k(\beta_2^m v_2)^2\right]$, β_2^m is the altruistic coefficient of the second phase, α is the profit distribution ratio, which is decided by the integrator. The reverse solving method is adopted to solve the updated integrators and demand for the second phase of the provider's profit function. By solving the integrator and provider's profit function, we get the demand in the second phase of the two updated altruism cooperation strategies and integrate the highest interest coefficient, as shown in the following Proposition 2. See appendix C for the proof process.

4.3. Proposition 2

(i) When the demand trend is determined, the integrator adopts the enabling strategy, and the optimal altruistic coefficient is $\beta_2^{e*} = \frac{\beta_1^{m*}[p - k(\lambda a - p)]}{2p}$.
(ii) When the integrator adopts the merge strategy, the optimal altruism coefficient is $\beta_2^{m*} = \frac{p}{kv_2} = \beta_1^{m*}$, and $\beta_2^{e*} < \beta_2^{m*}$.

According to Proposition 2, if the changing trend in demand is determined, the optimal altruistic coefficient under the two cooperation strategies is consistent with the trend change before the demand update; that is, after the demand update, the altruistic degree under the enabling strategy is still smaller than that under the merger strategy. This shows that the determined demand change does not affect the trend of the altruistic level of integrators' decision-making. The influence of specific demand updating on the level of altruism under the cooperative strategy is analyzed in Section 4.3.

Table 3
Optimal decision and profit of integrator and provider in two periods.

		Logistics integrator		Logistics provider	
		β	π_i	w	π_p
Enabling strategy	The first period	$\beta_1^{e*} = \frac{p-(a-p)k}{2kv_1}$	$\pi_{i1}^{e*} = \frac{(p-(a-p)k)(p+3(a-p)k)}{8k}$	$w_1^* = \frac{p+(a-p)k}{2}$	$\pi_{p1}^{e*} = \frac{(p+(a-p)k)^2}{4k}$
	The second period	$\beta_1^{m*} = \frac{p}{kv_1}$	$\pi_{i2}^{e*} = \frac{p^2 - 3k^2(\lambda a - p)^2 + 2pk(\lambda a - p)}{8k}$	$w_2^* = \frac{k(\lambda a - p)+p}{2}$	$\pi_{p2}^{e*} = \frac{(k(\lambda a - p)+p)^2}{4k}$
Merger strategy	The first period	$\beta_2^{e*} = \frac{\beta_1^{m*}[p - k(\lambda a - p)]}{2p}$	$\pi_{i1}^{m*} = (1-\alpha)\left(\frac{p^2+2(a-p)kp}{2k}\right)$	–	$\pi_{p1}^{m*} = \alpha\left(\frac{p^2+2(a-p)kp}{2k}\right)$
	The second period	$\beta_2^{m*} = \frac{p}{kv_2} = \beta_1^{m*}$	$\pi_{i2}^{m*} = (1-\alpha)\left(\frac{p^2+2(\lambda a-p)kp}{2k}\right)$	–	$\pi_{p2}^{m*} = \alpha\left(\frac{p^2+2(\lambda a-p)kp}{2k}\right)$

5. Discussion

According to the model's solution in Sections 4.1 and 4.2, the integrator and provider's optimal decision and profit are shown in Table 3 below.

First, we analyze the influence of demand updating on the integrator's optimal altruistic decision, as shown in Proposition 3. The specific proof process is shown in Appendix D.

Proposition 3.

(i) When $\lambda > 1$, $\beta_2^{e*} < \beta_1^{e*}$ when $0 < \lambda < 1$, $\beta_2^{e*} > \beta_1^{e*}$。.
(ii) $\beta_2^{m*} = \beta_1^{m*}$.

According to Proposition 3, we can obtain the relationship between demand updating and the degree of altruism, revealing that demand updating may affect changes in the degree of altruism. If the integrator adopts the enabling strategy, when the demand increases, the altruism degree of the second stage is less than that of the first stage. When the demand was reduced, the altruism of the second period was greater than that of the first period. As the demand increases, the integrator acts altruistically, enabling the provider to improve the quality of logistics service and pay extra costs so that the integrator will reduce its altruistic degree. In the case of reduced demand, to obtain more market demand, the integrator will help the provider improve the quality of logistics services to a greater extent to obtain more customers' logistics demands, thus improving overall performance. If the integrator adopts the strategy, the altruistic degree of the integrator is the same in the two phases, and the demand update does not affect the altruistic degree of the integrator.

Subsequently, this paper analyzes the impact of demand updates on integrators and suppliers' profits, as shown in Proposition 4 below. The specific proof process is shown in Appendix D.

Proposition 4：

(i) When market demand increases ($\lambda > 1$), $\pi_{i1}^{e*} > \pi_{i2}^{e*}$, $\pi_{p1}^{e*} < \pi_{p2}^{e*}$, and vice versa
(ii) When market demand increases ($\lambda > 1$), $\pi_{i1}^{m*} < \pi_{i2}^{m*}$, $\pi_{p1}^{m*} < \pi_{p2}^{m*}$, and vice versa

According to Proposition 4, when market demand increases, the profit of the second-stage integrator decreases under the enabling strategy, while the profit of the provider increases. However, under the merger and acquisition strategy, the profit of the second-stage integrator and the provider decreases. When the market demand decreases, the profit of the second-stage integrator increases and the provider's profit decreases under the enabling strategy. In contrast, both the integrator and the provider's profit decrease under the merger and acquisition strategy. Under the merger and acquisition strategy, the market demand increases, and the supplier's logistics purchase price increases, resulting in a double marginal effect. In addition, the negative effect of the purchase price increase on the logistics integrator's profit is greater than the positive effect of the demand increase.

Finally, this paper analyzes the impact of demand update on selecting the two strategies, as shown in Theorem 2 below, and the specific proof process is shown in Appendix E.

Theorem 2：

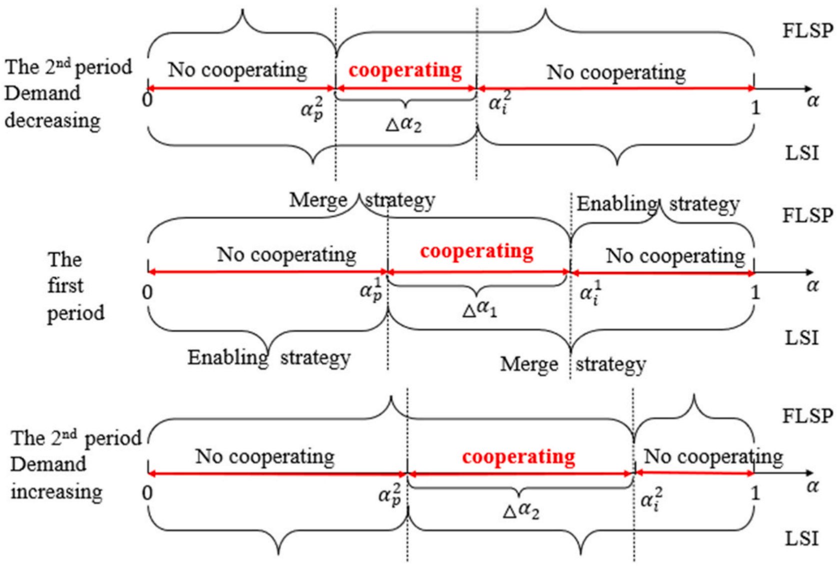

Fig. 2. The choice of cooperation strategy in the case of two periods.

(i) After demand updating, the threshold for the strategy selection of the integrator is $\alpha_i^2 = \frac{3(p+(\lambda a-p)k)^2}{4(p^2+2(\lambda a-p)kp)}$; when $\alpha > \alpha_i^2$, the integrator chooses the enabling strategy and vice versa.

(ii) The threshold value of provider strategy selection is $\alpha_p^2 = \frac{(p+(\lambda a-p)k)^2}{2(p^2+2(\lambda a-p)kp)}$; when $\alpha > \alpha_p^2$, the provider chooses the acquisition strategy and, vice versa, the enabling strategy.

(iii) Letting $\Delta\alpha_j = \alpha_i^j - \alpha_p^j (j = 1, 2)$, $\Delta\alpha_j$ refers to the scope of cooperation between the provider and the integrator under altruistic behavior. This is when $0 < \lambda < 1$, $\Delta\alpha_2 < \Delta\alpha_1$, and when $\lambda > 1$, $\Delta\alpha_2 > \Delta\alpha_1$.

Theorem 2 is similar to Theorem 1. After demand updating, when the supplier has a large proportion of profit distribution, the integrator prefers the empowerment strategy, while the provider prefers the merger strategy. Theorem 2 also shows that when demand decreases, the scope of cooperation between the supplier and the integrator in the second phase decreases. As demand increases, the scope of cooperation between vendors and integrators in phase 2 increases. The choice of cooperation strategy and its changes in the two phases can be summarized in Fig. 2 below. It can be seen from Fig. 2 that, similar to Corollary 1, after the demand update, the cooperation conditions between the integrator and the provider do not change. It is still the case that when the profit distribution ratio of the provider is in the middle, the cooperation between the integrator and the provider is successful, and the merger and acquisition strategy is adopted. When the profit distribution ratio of the provider is too high or too low, the cooperation between the integrator and the provider will be affected, profit conflict will occur, and cooperation will fail. However, demand updating affects the scope of cooperation between the two. When demand decreases, not only does the scope of cooperation decrease, but the profit distribution ratio of the provider also decreases. When demand increases, the scope of cooperation increases, but the provider's profit distribution ratio also increases. Therefore, the increase in demand is good for the provider and bad for the integrator but good for cooperation between the two parties.

The above Fig. 3 can prove Theorem 2, we can see that when $\lambda = 1$, $\alpha_i^2 = \alpha_i^1$ and $\alpha_p^2 = \alpha_p^1$, the scope between the two straight lines (which are denoted as α_i^1 and α_p^1) is $\Delta\alpha_1$, that is only in this scope, the provider and the integrator can cooperate successfully in the first phrase. Meanwhile, the scope between the two curves (which are denoted as α_i^2 and α_p^2) is $\Delta\alpha_2$, in which the provider and the integrator can cooperate successfully in the second phrase. We can see that when $0 < \lambda < 1$, $\Delta\alpha_1 > \Delta\alpha_2$, and when $\lambda > 1$ $\Delta\alpha_1 < \Delta\alpha_2$.

6. Model extension

In this section, we mainly discuss the more complex and general cases, analyze and expand the applicability of the two cooperation strategies, and test the robustness of the above theorems. Section 5.1.1 mainly analyzes information asymmetry, while Section 5.2.2 mainly discusses uncertain demand change trends.

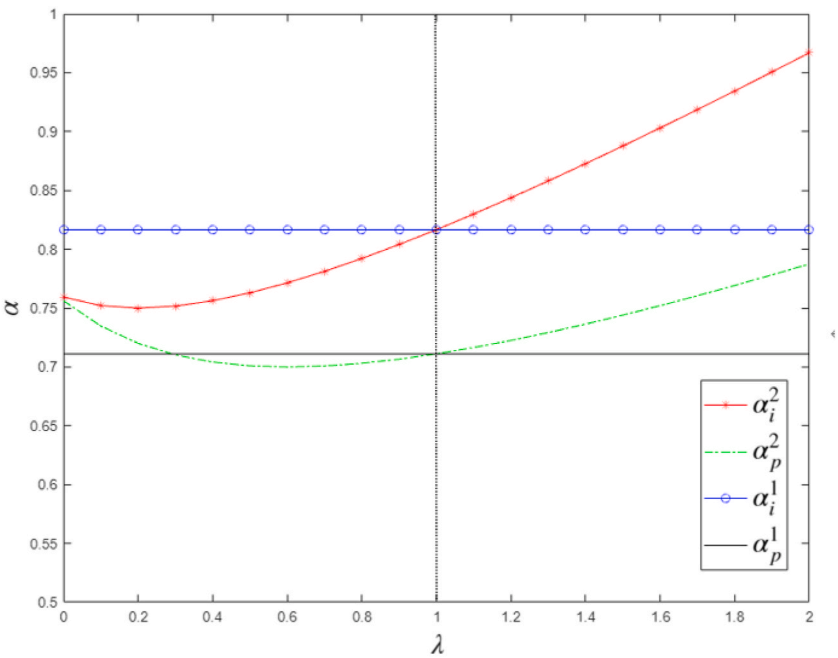

Fig. 3. The impact of λ on α.

6.1. Considering information asymmetry

In practice, information asymmetry often exists in the cooperation between integrators and suppliers. The existence of information asymmetry will affect the decision-making and cooperation of integrators and suppliers to some extent and even lead to cooperation rupture in serious cases. For example, on November 11th, 2018, STO Express updated demand and did not share it with its FLSPs. Due to the rapid changes and tremendous amount of volume, the FLSPs could not meet the service quality guarantee, and many FLSPs violated the specifications or delivery time requirements. STO Express ended with a significant business loss and low customer satisfaction [44]. However, under the merger strategy, the integrator and the provider are integrated, and the information between the provider and the integrator is completely transparent. Therefore, under the strategy, the information asymmetry will not affect the cooperation between the integrator and the provider. However, there is business cooperation between the integrator and the provider under the enabling strategy, and information asymmetry between the integrator and the provider is very common. Therefore, it is necessary to analyze the changes in the cooperation decision of the integrator and the provider under the condition of the coexistence of the enabling strategy and information asymmetry.

In the second stage, after the demand update, the integrator updates the market demand. However, due to the information asymmetry between the integrator and the provider, the integrator will not share its demand information with the provider. It is also impossible to know the specific logistics service quality of the provider in the second phase. However, the service quality of the first phase can be observed through customer delivery at the end of the first phase; thus, the logistics service quality of the first phase is common knowledge. According to the cooperation of the first phase, the integrator tentatively determines the service quality of the second phase of the provider to be the logistics service quality at the end of the first phase, that is $v_2 = \frac{p}{k\beta_1^{m*}}$。

Under the enabling strategy, the updated market demand is $d_2^e = \lambda a + \beta_2^e v_2 - p$. In this case, the integrator will not share the updated market demand with the provider. Therefore, the profit of the logistics service provider is $\widetilde{\pi}_{p2}^e = \widetilde{w}_2(a + \widetilde{\beta}_2^e v_2 - p)$, the profit of the logistics integrator is $\widetilde{\pi}_{i2}^e = (p - \widetilde{w}_2)(\lambda a + \widetilde{\beta}_2^e v_2 - p) - \frac{1}{2}k(\widetilde{\beta}_2^e v_2)^2$, the integrator decides the altruistic coefficient $\widetilde{\beta}_2^e$, and the supplier decides the purchase price $\widetilde{w}_2$. In the case of information asymmetry, the integrator and the provider's profit function after the second demand update is solved by the reverse order solution method, and the optimal decision results of both parties are obtained, as shown in Theorem 3. The specific solution process is shown in Appendix F.

Theorem 3：

(i) $\widetilde{w}_2^* = w_1^* = \frac{k(a-p)+p}{2}$.

(ii) In the case of demand asymmetry, the optimal altruistic coefficient of the integrator's decision in the second stage is $\widetilde{\beta}_2^{e*} = \frac{\beta_1^{m*}[p-k(a-p)]}{2p}$. The change in the level of altruism is related to the marginal cost of quality improvement. When $k > 1$, the level of altruism increases, and when $0 < k < 1$, the level of altruism decreases.

From Theorem 3, the asymmetric demand situation, the second phase of the provider's decision will not change because the supplier cannot observe the change in market demand. When the integrator does not share the updated market demand, the decision still follows the first phase of market demand; hence the purchasing price decision is the same as that in the first phase. For integrators, if the cost of quality improvement is greater, the level of altruism will be higher because a higher degree of altruism is needed to improve the quality of logistics services and obtain market demand. When the cost required for quality improvement is low, a lower degree of altruism can improve the quality of logistics services, and the level of altruism is reduced.

To analyze the impact of demand updates on the profits of integrators and suppliers in the case of information asymmetry, we obtained Proposition 5 through comparison, and the proof process is shown in Appendix G.

Proposition 5: In the case of information asymmetry, when $\lambda > 1$, $\widetilde{\pi}_{p2}^{e*} > \pi_{p1}^{e*}$, $\widetilde{\pi}_{i2}^{e*} > \pi_{i1}^{e*}$, and vice versa.

In the case of information asymmetry, when the demand increases, under the enabling strategy, the second-stage integrator and the provider's profit increases. However, when the demand decreases, the profit of the second-stage integrator and the provider decreases. This is different from the conclusion of the profit change of integrators in Proposition 4. This is because information asymmetry changes the procurement price decision of the supplier, thus reducing the double marginal utility and increasing the profit of integrators. Therefore, information asymmetry is beneficial to the integrators. The specific impact of information asymmetry is shown in the following analysis.

Next, the value of the integrator's updated market information is observed by comparing the decision and profit of the integrator in the two cases of sharing and not sharing with the provider. The results are shown in Theorem 4 below. See Appendix H for the specific proof process.

Theorem 4.

(i) When $\lambda > 1$, $\beta_{p2}^{e*} < \widetilde{\beta}_{p2}^{e*}$, $\pi_{p2}^{e*} > \widetilde{\pi}_{p2}^{e*}$, and vice versa.

(ii) When $\frac{4p-a}{3a} < \lambda < 1$, $\pi_{i2}^{e*} > \widetilde{\pi}_{i2}^{e*}$; when $\lambda < \frac{4p-a}{3a}$ or $\lambda > 1$, $\pi_{i2}^{e*} < \widetilde{\pi}_{i2}^{e*}$.

According to Theorem4 (i), when market demand increases, information asymmetry leads to an increase in the level of altruism and a decrease in the provider's profit. This indicates that when demand increases, information asymmetry is beneficial to improving the level of altruism but harmful to the provider's profit. When demand decreases, information asymmetry leads to a decrease in the level of altruism and an increase in the provider's profit. This indicates that when demand decreases, information asymmetry is harmful to promoting altruism and beneficial to the provider's profit. According to Theorem4 (ii), when the demand increases or decreases to a large extent, information asymmetry leads to an increase in the integrator's profit; when the demand decreases to a small extent, information asymmetry leads to a decrease in the integrator's profit. This shows that the value of market information is beneficial to integrators when demand is low. The value of requirements information and the integrator's motivation for requirements updates are shown in Fig. 4 below.

It can be seen from Fig. 4 that when demand decreases to a large extent, i.e., in region ①, it is beneficial for integrators to share updated demand information with suppliers to improve the level of altruism. When the demand reduction degree is small, i.e., region ②, it is beneficial for the integrator to share the updated demand information with the provider. When the demand increases, i.e., region ③, the integrator shares the updated demand information with the provider, which is beneficial to the provider's profit. Therefore, integrators are motivated to share updated demand information with suppliers when the demand reduction is small.

From Fig. 5(a), we can see that when $\lambda < 1$, $\pi_{p1}^{e*} > \pi_{p2}^{e*} > \widetilde{\pi}_{p2}^{e*}$ and vice versa, which validates Proposition 4(i) and Theorem2(i). According to Fig. 5(b), we can find that when $< \frac{4p-a}{3a}$, $\pi_{i2}^{e*} < \widetilde{\pi}_{i2}^{e*} < \pi_{i1}^{e*}$; when $\frac{4p-a}{3a} < \lambda < 1$, $\widetilde{\pi}_{i2}^{e*} < \pi_{i2}^{e*} < \pi_{i1}^{e*}$; and when $\lambda > 1$, $\pi_{i1}^{e*} < \pi_{i2}^{e*} < \widetilde{\pi}_{i2}^{e*}$. Not difficult to find that Fig. 5(b) confirms the Proposition 4(ii) and Theorem2(ii).

6.2. *Consider the situation when the trend of demand change is uncertain*

In this section, the integrator can only infer a certain probability of the demand change based on the past historical situation for the more complex and uncertain situations posed by demand change trends. This paper assumes that the probability of demand increase is η, and the predicted degree of demand increase is $\varepsilon_\uparrow \sim (\mu_1, \delta_\uparrow^2)$, whereas the probability of demand decrease is $1-\eta$, and the predicted degree of demand decrease is $\varepsilon_\downarrow \sim (\mu_2, \delta_\downarrow^2)$. In the case of an uncertain demand change trend, the average value of demand change predicted by the integrator is $\overline{d}_2 = \eta(a + v_2 - p + \varepsilon_\uparrow) + (1-\eta)(a + v_2 - p - \varepsilon_\downarrow)$, that is, $\overline{d}_2 = a + v_2 - p + \eta\varepsilon_\uparrow - (1-\eta)\varepsilon_\downarrow$. According to the merger strategy adopted in the first phase and the altruism coefficient, the integrator chamber updated the service quality of the second phase as $v_2 = \frac{p}{k\beta_1^{m*}}$. In practice, the mean value μ is based on historical data, hence μ is consistent whether the demand increases or decreases, and we let $\mu_1 = \mu_2 = \mu$ (Lin et al., 2019).

When the integrator and the provider conduct the enabling cooperation, the market demand is $\overline{d}_2^e = a + \beta_2^e v_2 - p + \eta\varepsilon_\uparrow - (1-\eta)\varepsilon_\downarrow$, the profit expectation of the logistics integrator is $E(\widehat{\pi}_{p2}^e) = E\left\{(p - w_2)(a + \beta_2^e v_2 - p + \eta\varepsilon_\uparrow - (1-\eta)\varepsilon_\downarrow) - \frac{1}{2}k(\beta_2^e v_2)^2\right\}$, that is, $E(\widehat{\pi}_{i2}^e) = (p - w_2)(a + \beta_2^e v_2 - p + (2\eta - 1)\mu) - \frac{1}{2}k(\beta_2^e v_2)^2$, the profit expectation of the logistics service provider is $E(\widehat{\pi}_{p2}^e) = w_2(a + \beta_2^e v_2 - p + (2\eta - 1)\mu)$, the integrator makes decisions on the altruistic coefficient β_2^e, and the provider makes decisions on the purchase price. If the demand change trend in the second phase is uncertain, the market demand is $\overline{d}_2^m = a + \beta_2^m v_2 - p + \eta\varepsilon_\uparrow - (1-\eta)\varepsilon_\downarrow$, and the expected profit of the logistics integrator is $E(\widehat{\pi}_{i1}^m) = E\left\{(1-\alpha)\left[p(a + \beta_2^m v_2 - p + \eta\varepsilon_\uparrow - (1-\eta)\varepsilon_\downarrow) - \frac{1}{2}k(\beta_2^m v_2)^2\right]\right\}$, that is, $E(\widehat{\pi}_{i1}^m) = (1-\alpha)\left[p(a + \beta_2^m v_2 - p + (2\eta - 1)\mu) - \frac{1}{2}k(\beta_2^m v_2)^2\right]$. The profit of the logistics service provider is $E(\widehat{\pi}_{p2}^m) = \alpha\left[p(\lambda a + \beta_2^m v_2 - p + (2\eta - 1)\mu) - \frac{1}{2}k(\beta_2^m v_2)^2\right]$, β_2^m is the altruistic coefficient of the second phase, α is the proportion of profit distribution, and the altruistic coefficient of integrator decision-making. The following Theorem 5 is obtained by solution analysis, and the proof is shown in Appendix I.

Theorem 5.

(i) When $\widehat{w}_2^* = \frac{k(a-p+(2\eta-1)\mu)+p}{2}$, and when $\eta > \frac{1}{2}$, $\widehat{w}_2^* > w_1^*$, and vice versa.
(ii) $\widehat{\beta}_2^{e*} = \frac{p-\widehat{w}_2}{kv_2}$, and $\widehat{\beta}_2^{e*} > \beta_1^{e*}$; $\widehat{\beta}_2^{m*} = \frac{p}{kv_2} = \beta_1^{m*}$.
(iii) When $0 < \eta \le \frac{1}{2}$, $\widehat{\beta}_2^{e*} < \widehat{\beta}_2^{m*}$; when $\frac{1}{2} < \eta \le 1$, there is a threshold $\mu_{th} = \frac{p+k(a-p)}{2\eta-1}$, only when $\mu > \mu_{th}$, $\widehat{\beta}_2^{e*} \ge \widehat{\beta}_2^{m*}$.

According to Theorem 5 (i), when the probability of demand increase is large, the purchase price of the integrator's logistics service increases, while when the probability of demand decrease is large, the purchase price of logistics service of the integrator decreases. Theorem 5 (ii) shows that when the demand trend is uncertain, the integrator's altruism coefficient under the enabling strategy increases, which is different from the conclusion under the demand trend. This is because the uncertain trend of demand change makes it difficult to predict market demand accurately. Therefore, the integrator will increase the altruism coefficient to improve the service quality to obtain more market demand and prevent profit reduction. The altruistic coefficient under the merger and acquisition

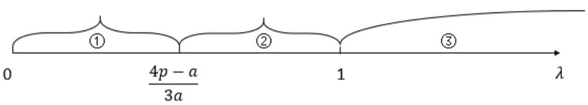

Fig. 4. Value areas for requirements information.

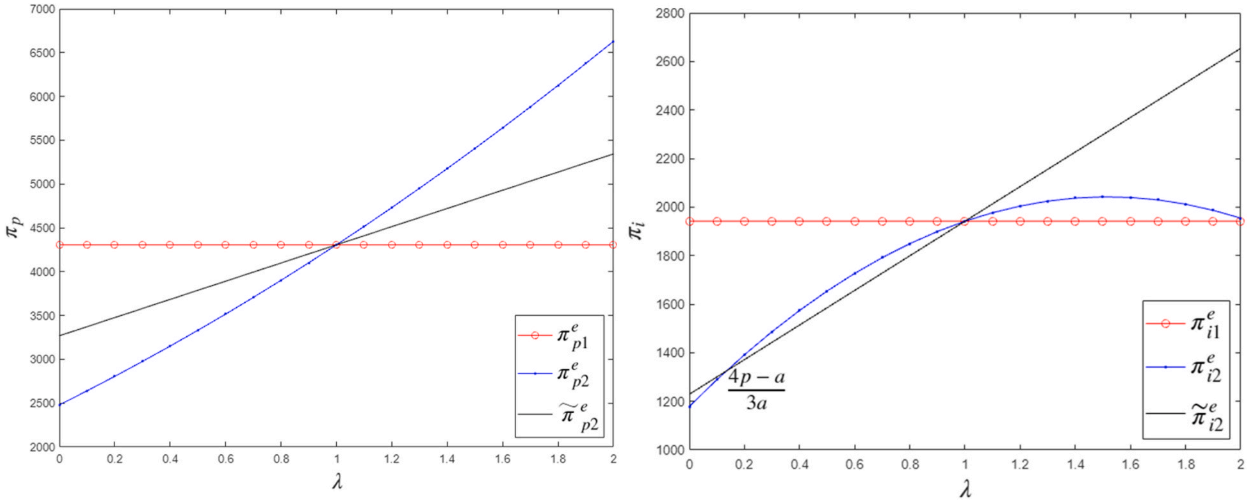

Fig. 5. (a). Impact of λ on provider's profit Fig. 5(b) Impact of λ on integrator's profit.

strategy remains unchanged, consistent with the situation when the demand change trend is determined. This indicates that the optimal altruistic coefficient of the integrator does not change when the logistics demand changes. This is because, after merger and acquisition cooperation, integrators and providers provide logistics services as a whole, eliminating the influence of market demand on the decision-making of altruistic coefficients. At this time, the optimal altruistic coefficient of integrators' decision-making is only affected by the cost of altruistic behavior.

According to Theorem 5 (iii), when the probability of demand increase is small, the altruistic coefficient under the enabling strategy is smaller than that under the merger strategy. However, when the probability of demand increase is large, and the mean value of demand increase is large, the altruistic coefficient under the enabling strategy is larger than that under the merger strategy. Specifically, it can be shown in Fig. 6 below. Within the shadow range (the probability of demand increase is large, and the mean value of demand increase is large), the altruism coefficient under the enabling strategy is large. Within the blank range, the altruism coefficient under the merging strategy is larger. For example, in a promotion festival of e-commerce retail, which is called Double 11 in practice, the altruistic coefficient of enabling cooperation is higher than that of merger and acquisition cooperation, and it will bring better service quality to consumers. In recent years, integrators have been using various methods and altruistic empowerment (data analysis in advance or more intelligent equipment) to improve the overall service quality during the promotion period to obtain greater market demand in the situation of fierce demand competition. According to many news reports, the delivery speed during Singles' Day is very fast, and the logistics during Singles' Day are no longer squeezed after the integrators' altruistic ability is enabled compared with the overstocking of goods during the previous Singles' Day promotion when the integrators did not act altruistically. (sohu News, 2020-11-05).

$\left(\textbf{Note : When } \mu = \mu_{th}, \widehat{\beta}_2^{m*} - \widehat{\beta}_2^{e*} = 0\right)$

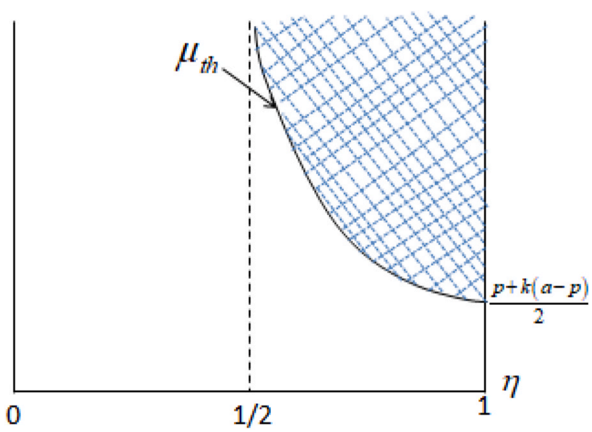

Fig. 6. Comparison of altruistic coefficients under two strategies.

7. Conclusions

7.1. Main conclusions

This paper considers a logistics service integrator and a logistics service provider. The logistics service integrator updates the market demand and carries out two altruistic cooperation strategies with the logistics service provider. At the same time, information asymmetry is considered in the development process, and the following conclusions are drawn.

First, regarding the conditions of the cooperation mode between integrators and providers, this paper finds that when the provider's profit distribution ratio is large, the integrator is inclined to the enabling strategy, while the provider is inclined to the merger and acquisition strategy. When the provider's profit distribution ratio is medium, both the integrator and the provider tend to adopt the merger and acquisition strategy. When the profit distribution ratio of the provider is too high or too low, the cooperation between the integrator and the provider will be affected, profit conflicts will occur, and cooperation will fail.

Second, we examined the impact of demand updates on decision-making and profit. If the integrator adopts the enabling strategy when the demand increases, the second phase's altruism degree is less than that of the first phase, and the profit of the integrator decreases while the profit of the provider increases, and vice versa. If the integrator adopts the merger and acquisition strategy, the altruism degree of the integrator is the same in the two periods, demand update does not affect the altruism degree of the integrator, and the profit of both the integrator and the provider decreases. In the case of an uncertain demand change trend, the optimal altruistic coefficient does not change; thus, the demand update does not affect integrators' altruistic degree.

Third, we looked at the impact of demand updates on the cooperation between the two parties. The demand update does not affect the cooperation conditions between the integrator and the provider, but it affects the scope of cooperation. When the demand decreases, the scope of cooperation between the provider and the integrator decreases. As demand increases, the scope of cooperation between the provider and the integrator increases. Moreover, this paper finds a conclusion that is more in line with practice. When the probability of demand increase is large, and the demand increases sharply, the integrator will enhance its altruistic level to improve the quality of logistics services to obtain greater market demand in fierce market demand competition.

Finally, in the case of demand asymmetry, the second phase supplier's decision will not change, and the purchase price decision will be the same as that of the first phase. When the demand reduction degree is large, the integrator sharing the updated demand information with the provider helps improve the level of altruism. When the demand reduction is small, it is beneficial for the integrator to share the updated demand information with the supplier. When demand increases, the integrator sharing updated demand information with the provider is beneficial to the provider's profit. Therefore, integrators are motivated to share updated demand information with suppliers when the demand reduction is small.

7.2. Management insight

This paper can provide some management suggestions for logistics integrators and logistics providers in practice.

First, this article concludes a better merging strategy for the logistics integrator by considering altruistic behavior and demand updating relative to business strategies. This conforms to the situation in current practice and is similar to Alibaba in mergers and acquisitions in recent years by other logistics express companies, helps providers enhance the level of technology and digitize it to enhance the overall quality of service. Second, this paper concludes that only when the profit distribution ratio is appropriate is the strategy beneficial to both; otherwise, the strategy is a zero-sum game. Therefore, integrators should pay attention to the proportion of profit distribution when adopting a merge strategy. Finally, our study shows that when demand reduction is large, integrators sharing updated demand information with suppliers is beneficial for improving altruism. When the demand reduction is small, it is beneficial for the integrator to share the updated demand information with the supplier. When demand increases, an integrator sharing updated demand information with the provider benefits the provider's profit. Therefore, integrators need to decide whether to share demand information with providers according to demand changes. When the demand decreases to a large extent, sharing updated demand information can enhance the level of altruism and thus improve the quality of logistics services. When the degree of demand reduction is low, the integrator shares the updated demand information, which is beneficial for its own profits. When the demand increases, sharing the updated demand information is beneficial to the profit of the provider. If the integrator wants to attract better cooperation from the provider, it can share the updated demand information.

For logistics providers, this paper finds that the level of altruism under the strategy is higher than that under the enabling strategy. Logistics integrators can help logistics providers better improve the quality of logistics services. Therefore, if providers want to improve their own logistics service quality, the strategy is more beneficial to them. However, logistics providers need to pay attention to the fact that the proportion of profit distribution under strategy should not be too low. In addition, this paper finds that when demand decreases, integrators are more motivated to share. However, when demand increases, demand update sharing is beneficial to providers, resulting in integrators having no incentive to share. Therefore, it is suggested that the supplier and the integrator should communicate and negotiate before cooperation so that the integrator can actively share the demand information, especially when demand is increasing.

7.3. Limitations and future research

This paper mainly studies the analysis of two kinds of cooperation strategies under altruistic behavior, there are some limitations in this paper. On the one hand, the decision variable in this paper is static, not the dynamic decision considering the time factor. On the other hand, this paper only considers two periods of demand updating, not the game cooperation process under multi-period demand changes. Third, we only consider the logistic supply chain of one integrator and one provider, it is necessary to explore the impact of altruistic behavior between integrator and different providers in future research. Forth, we do not consider the altruistic behavior of data sharing, especially as big data playing an increasingly important role in practice. Therefore, the role and influence of altruistic behavior in data sharing and analysis can be studied in the future. In addition, the influence of unfair aversion behavior between different integrators on integrators' altruistic behavior can also be considered.

Author contribution statement

Xinran Shen: Conceived and designed the analysis; Analyzed and interpreted the data; Contributed analysis tools or data; Wrote the paper.

Data availability statement

No data was used for the research described in the article.

Declaration of competing interest

I completed the paper all by myself, there is no competing interests to declare.

Appendix

Appendix A. The proof of proposition1

(1) Enabling strategy

$$\frac{\partial^2 \pi_{i1}^e}{\partial^2 \beta_1^e} = -k(v_1)^2 < 0$$

Let $\frac{\partial \pi_{i1}^e}{\partial \beta_1^e} = v_1(p - w_1) - k\beta_1^e(v_1)^2 = 0$, we can get $\beta_1^{e*} = \frac{(p-w_1)}{kv_1}$, substitute it into the profit function of the provider $\pi_{p1}^e = w_1(a + \beta_1^e v_1 - p) = w_1\left(a + \frac{(p-w_1)}{k} - p\right)$.

The best purchase price of the supplier can be obtained, which is $w_1^* = \frac{p+(a-p)k}{2}$.

Therefore, we can get that $\beta_1^{e*} = \frac{p-(a-p)k}{2kv_1}$.

The optimal profit of the integrator is

$$\begin{aligned}\pi_{i1}^{e*} &= \frac{p^2 - 3(a-p)^2k^2 + 2(a-p)kp}{8k} \\ &= \frac{(p-(a-p)k)(p+3(a-p)k)}{8k}\end{aligned}$$

The optimal profit of the integrator is $\pi_{p1}^{e*} = \frac{(p+(a-p)k)^2}{4k}$.

(2)Merge strategy

$$\frac{\partial^2 \pi_{i1}^m}{\partial^2 \beta_1^m} = -k\left(v_1^m\right)^2 < 0$$

Let $\frac{\partial \pi_{i1}^m}{\partial \beta_1^m} = pv_1 - k\beta_1^m(v_1)^2 = 0$, we can get $\beta_1^{m*} = \frac{p}{kv_1}$.

Substitute it into the profit function of the provider and the integrator, we can get that optimal profit of the provider is $\pi_{p1}^{m*} = \alpha\left(\frac{p^2+2(a-p)kp}{2k}\right)$, the optimal profit of the integrator is $\pi_{i1}^{m*} = (1-\alpha)\left(\frac{p^2+2(a-p)kp}{2k}\right)$.

Appendix B. The proof of Theorem 1

$$\begin{aligned}\pi_{i1}^{m*} - \pi_{i1}^{e*} &= (1-\alpha)\left(\frac{p^2 + 2(a-p)kp}{2k}\right) - \frac{p^2 - 3(a-p)^2k^2 + 2(a-p)kp}{8k} \\ &= 4(1-\alpha)\left(p^2 + 2(a-p)kp\right) - p^2 + 3(a-p)^2k^2 - 2(a-p)kp \\ &= 3(p+(a-p)k)^2 - 4\alpha\left(p^2 + 2(a-p)kp\right)\end{aligned}$$

We can get the threshold $\alpha_i = \frac{3(p+(a-p)k)^2}{4(p^2+2(a-p)kp)}$.

$$\pi_{p1}^{m*} - \pi_{p1}^{e*} = \alpha\left(\frac{p^2 + 2(a-p)kp}{2k}\right) - \frac{(p + (a-p)k)^2}{4k}$$

We can get the threshold $\alpha_p = \frac{(p+(a-p)k)^2}{2(p^2+2(a-p)kp)}$.

Appendix C. Proof of proposition2

(1) Enabling strategy.

Firstly, the integrator decides the optimal altruism coefficient by using the inverse solution method $\frac{\partial\pi_{i2}^e}{\partial\beta_2^e} = (p - w_2)v_2 - k(v_2)^2\beta_2^e$.

We can get $\beta_2^{e*} = \frac{p-w_2}{kv_2}$.

The best purchase price can be obtained by substituting it into the profit function of the supplier, which is $w_2^* = \frac{k(\lambda a-p)+p}{2}$.

Therefore, the optimal altruistic coefficient is finally obtained by $\beta_2^{e*} = \frac{\beta_1^{m*}[p-k(\lambda a-p)]}{2p}$.

$$\beta_2^{e*} - \beta_1^{e*} = \frac{\beta_1^{m*}[p - k(\lambda a - p)]}{2p} - \frac{p - k(a-p)}{2kv_1}$$
$$= \frac{-(1+k)p^2 + p\left(ak + k(1+k)v_1\beta_1^{m*}\right) - \lambda ak^2 v_1\beta_1^{m*}}{2pkv_1}$$
$$= \frac{-(1+k)p^2 + akp + (1+k)p^2 - \lambda akp}{2pkv_1^e}$$
$$= \frac{akp(1-\lambda)}{2pkv_1}$$

(2) Merge strategy

$$\frac{\partial\pi_{i2}^m}{\partial\beta_2^m} = (1-\alpha)\left(pv_2 - k(v_2)^2\beta_2^m\right)$$

We can get $\beta_2^{m*} = \frac{p}{kv_2} = \beta_1^{m*}$.

$$\beta_2^{e*} - \beta_2^{m*} = \beta_1^{m*}\left(\frac{-p - k(\lambda a - p)}{2p}\right) < 0$$

$$\beta_2^{e*} < \beta_2^{m*}$$

Appendix D. Proof of Proposition3 and Proposition4

$$\beta_2^{e*} - \beta_1^{e*} = \frac{[p - k(\lambda a - p)]}{2kv_1} - \frac{[p - k(a-p)]}{2kv_1}$$
$$= \frac{[k(1-\lambda)]}{2kv_1}$$

When $\lambda > 1, \beta_2^{e*} < \beta_1^{e*}$.

When $0 < \lambda < 1, \beta_2^{e*} > \beta_1^{e*}$.

The proof of Proposition5

$$\pi_{i2}^{e*} - \pi_{i1}^{e*} = \frac{p^2 - 3k^2(\lambda a - p)^2 + 2pk(\lambda a - p)}{8k} - \frac{(p - (a-p)k)(p + 3(a-p)k)}{8k}$$
$$= \frac{-3k^2\left((\lambda a - p)^2 - (a-p)^2\right) + 2pk((\lambda a - p) - (a-p))}{8k}$$
$$= \frac{-3k^2 a(\lambda - 1)((\lambda+1)a - 2p) + 2pka(\lambda - 1)}{8k}$$
$$= \frac{ka(\lambda-1)[2p - 3k((\lambda+1)a - 2p)]}{8k}$$

$$2p - 3k((\lambda+1)a - 2p) < 0$$

When $\lambda > 1$, $\pi_{i2}^{e*} < \pi_{i1}^{e*}$; $0 < \lambda < 1$, $\pi_{i2}^{e*} > \pi_{i1}^{e*}$.

$$\pi_{p2}^{e*} - \pi_{p1}^{e*} = \frac{(k(\lambda a - p) + p)^2}{4k} - \frac{(k(a-p) + p)^2}{4k}$$
$$= \frac{ka(k(\lambda a + a - 2p) + 2p)(\lambda - 1)}{4k}$$

$$\begin{aligned}\pi_{i2}^{m*} - \pi_{i1}^{m*} &= (1-\alpha)\left(\frac{p^2 + 2(\lambda a - p)kp}{2k}\right) - (1-\alpha)\left(\frac{p^2 + 2(a-p)kp}{2k}\right) \\ &= (1-\alpha)\left(\frac{2kp(\lambda a - p) - (a-p)}{2k}\right) \\ &= (1-\alpha)\left(\frac{2kp(\lambda - 1)a}{2k}\right)\end{aligned}$$

$$\begin{aligned}\pi_{p2}^{m*} - \pi_{p1}^{m*} &= \alpha\left(\frac{p^2 + 2(\lambda a - p)kp}{2k}\right) - \alpha\left(\frac{p^2 + 2(a-p)kp}{2k}\right) \\ &= \alpha\left(\frac{2kp(\lambda a - p) - (a-p)}{2k}\right) \\ &= \alpha\left(\frac{2kp(\lambda - 1)a}{2k}\right)\end{aligned}$$

When $\lambda > 1$, $\pi_{p2}^{e*} > \pi_{p1}^{e*}$, $\pi_{i2}^{m*} > \pi_{i1}^{m*}$, $\pi_{p2}^{m*} > \pi_{p1}^{m*}$.
When $0 < \lambda < 1$, $\pi_{p2}^{e*} < \pi_{p1}^{e*}$, $\pi_{i2}^{m*} < \pi_{i1}^{m*}$, $\pi_{p2}^{m*} < \pi_{p1}^{m*}$.

Appendix E. Proof of Theorem2

$$d_2^e = \lambda a + \beta_2^{e*} v_2 - p = \frac{p + k(\lambda a - p)}{2k}$$

$$\begin{aligned}\pi_{p2}^{e*} &= w_2\left(\lambda a + \beta_2^{e*} v_2 - p\right) \\ &= \frac{k(\lambda a - p) + p}{2} \cdot \frac{p + k(\lambda a - p)}{2k} \\ &= \frac{(k(\lambda a - p) + p)^2}{4k}\end{aligned}$$

$$\begin{aligned}\pi_{i2}^{e*} &= (p - w_2)\left(\lambda a + \beta_2^{e*} v_2 - p\right) - \frac{1}{2}k\left(\beta_2^{e*} v_2\right)^2 \\ &= \frac{p - k(\lambda a - p)}{2} \cdot \frac{p + k(\lambda a - p)}{2k} - \frac{1}{2}k\left(\frac{p - k(\lambda a - p)}{2k}\right)^2 \\ &= \frac{p^2 - 3k^2(\lambda a - p)^2 + 2pk(\lambda a - p)}{8k}\end{aligned}$$

$$\pi_{p2}^{m*} = \alpha\left(\frac{p^2 + 2(\lambda a - p)kp}{2k}\right)$$

$$\pi_{i2}^{m*} = (1-\alpha)\left(\frac{p^2 + 2(\lambda a - p)kp}{2k}\right)$$

$$\begin{aligned}\pi_{i2}^{e*} - \pi_{i2}^{m*} &= \frac{p^2 - 3k^2(\lambda a - p)^2 + 2pk(\lambda a - p)}{8k} - (1-\alpha)\left(\frac{p^2 + 2(\lambda a - p)kp}{2k}\right) \\ &= \alpha\left(\frac{p^2 + 2(\lambda a - p)kp}{2k}\right) - \frac{3(p + k(\lambda a - p))^2}{8k}\end{aligned}$$

We can get $\alpha_i^2 = \frac{3(p+k(\lambda a-p))^2}{4p^2+2(\lambda a-p)kp}$.

$$\pi_{p2}^{e*} - \pi_{p2}^{m*} = \frac{(k(\lambda a - p) + p)^2}{4k} - \alpha\left(\frac{p^2 + 2(\lambda a - p)kp}{2k}\right)$$

$$\alpha_p^2 = \frac{(p + k(\lambda a - p))^2}{2(p^2 + 2(\lambda a - p)kp)}$$

$$\Delta\alpha_1 = \alpha_i^1 - \alpha_p^1 = \frac{(p + (a-p)k)^2}{4(p^2 + 2(a-p)kp)}$$

$$\Delta\alpha_2 = \alpha_i^2 - \alpha_p^2 = \frac{(p + (\lambda a - p)k)^2}{4(p^2 + 2(\lambda a - p)kp)}$$

Appendix F. Proof of Theorem 3

Firstly, the integrator decides the optimal altruism coefficient by using the inverse solution method, that is $\frac{\partial \widetilde{\pi}_{i2}^{e}}{\partial \widetilde{\beta}_{2}^{e}} = (p - \widetilde{w}_2)v_2 - k(v_2)^2\widetilde{\beta}_2^e$.

We can get $\widetilde{\beta}_2^{e*} = \frac{p-\widetilde{w}_2}{kv_2}$.

The best purchase price can be obtained by substituting it into the profit function of the supplier, which is $\widetilde{w}_2^* = \frac{k(a-p)+p}{2}$.

Therefore, the optimal altruistic coefficient is finally obtained that

$$\widetilde{\beta}_2^{e*} = \frac{\beta_1^{m*}[p - k(a-p)]}{2p}$$

$$\begin{aligned}\widetilde{\beta}_2^{e*} - \beta_1^{e*} &= \frac{\beta_1^{m*}p - (a-p)k}{2p} - \frac{p-(a-p)k}{2kv_1^e}\\ &= \frac{kv\beta_1^{m*}p - kv\beta_1^{m*}(a-p) - p^2 + kp(a-p)}{2pkv_1^e}\\ &= \frac{p^2 - p(a-p) - p^2 + kp(a-p)}{2pkv_1^e}\\ &= \frac{p(k-1)(a-p)}{2pkv_1^e}\end{aligned}$$

Appendix G. Proof of Proposition 5

The maximum profit of the provider is

$$\begin{aligned}\widetilde{\pi}_{p2}^{e*} &= \widetilde{w}_2^*\left(\lambda a + \widetilde{\beta}_2^{e*}v_2 - p\right)\\ &= \frac{(p+(a-p)k)(p+(\lambda a-p)k)}{4k}\end{aligned}$$

The maximum profit of the integrator is

$$\begin{aligned}\widetilde{\pi}_{i2}^{e*} &= \left(p - \widetilde{w}_2^*\right)\left(\lambda a + \widetilde{\beta}_2^{e*}v_2 - p\right) - \frac{1}{2}\left(\widetilde{\beta}_2^{e*}v_2\right)^2\\ &= \frac{(p-(a-p)k)}{2}\cdot\frac{p+(\lambda a-p)k}{2k} - \frac{k}{2}\left(\frac{p-(a-p)k}{2k}\right)\\ &= \frac{p^2 + 2pk(\lambda a - p) - k^2(a-p)((2\lambda+1)a - 3p)}{8k}\end{aligned}$$

$$\begin{aligned}\widetilde{\pi}_{p2}^{e*} - \widetilde{\pi}_{p1}^{e*} &= \frac{(p+(a-p)k)(p+(\lambda a-p)k)}{4k} - \frac{(p+(a-p)k)^2}{4k}\\ &= \frac{(\lambda-1)a(p+(a-p)k)}{4k}\end{aligned}$$

$$\begin{aligned}\widetilde{\pi}_{i2}^{e*} - \pi_{i1}^{e*} &= \frac{p^2 + 2pk(\lambda a-p) - k^2(a-p)((2\lambda+1)a-3p)}{8k} - \frac{p^2 + 2pk(a-p) - 3k^2(a-p)^2}{8k}\\ &= \frac{2pka(\lambda-1) - k^2(a-p)((2\lambda+1)a - 3p - 3a + 3p)}{8k}\\ &= \frac{2pka(\lambda-1) - k^2(a-p)((2\lambda-2)a)}{8k}\\ &= \frac{2ka(\lambda-1)(p-k(a-p))}{8k}\end{aligned}$$

Appendix H. Proof of Theorem4

$$\begin{aligned}\widetilde{\beta}_2^{e*} - \beta_2^{e*} &= \frac{\beta_1^{m*}p - (a-p)k}{2p} - \frac{\beta_1^{m*}p - (\lambda a - p)k}{2p}\\ &= \frac{ka\beta_1^{m*}(\lambda-1)}{2p}\end{aligned}$$

$$\widetilde{\pi}_{p2}^{e*} - \pi_{p2}^{e*} = \frac{(p+(a-p)k)(p+(\lambda a-p)k)}{4k} - \frac{(p+(\lambda a-p)k)^2}{4k} = \frac{ak(1-\lambda)(p+(\lambda a-p)k)}{4k}$$

$$\pi_{i2}^{e*} - \widetilde{\pi}_{i2}^{e*} = \frac{p^2-3k^2(\lambda a-p)^2+2pk(\lambda a-p)}{8k} - \frac{p^2+2pk(\lambda a-p)-k^2(a-p)((2\lambda+1)a-3p)}{8k}$$
$$= \frac{k^2(a-p)((2\lambda+1)a-3p)-3k^2(\lambda a-p)^2}{8k}$$
$$= \frac{a^2k^2\left(2\lambda+1-3\lambda^2\right)+4\lambda apk^2-4apk^2}{8k}$$
$$= \frac{a^2k^2(1-\lambda)(1+3\lambda)+4apk^2(\lambda-1)}{8k}$$
$$= \frac{ak^2(\lambda-1)(4p-(3\lambda+1)a)}{8k}$$

When $\frac{4p-a}{3a} < \lambda < 1$, $\pi_{i2}^{e*} > \widetilde{\pi}_{i2}^{e*}$.
When $\lambda < \frac{4p-a}{3a}$ or $\lambda > 1$, $\pi_{i2}^{e*} < \widetilde{\pi}_{i2}^{e*}$.

Appendix I. Proof of Theorem 5

Enabling strategy.
Firstly, the integrator decides the optimal altruism coefficient by using the inverse solution method

$$\frac{\partial\widehat{\pi}_{i2}^{e}}{\partial\widehat{\beta}_2^{e}} = (p-\widehat{w}_2)v_2 - k(v_2)^2\widehat{\beta}_2^{e}$$

We can get $\widehat{\beta}_2^{e*} = \frac{p-\widehat{w}_2}{kv_2}$.

The best purchase price can be obtained by substituting it into the expected profit function of the supplier, which $\widehat{w}_2^* = \frac{k(a-p+(2\eta-1)\mu)+p}{2}$.

Therefore, we can get $\widehat{\beta}_2^{e*} = \frac{\beta_1^{m*}[p-k(a-p)+(2\eta-1)\mu]}{2p}$.

$$\widehat{\beta}_2^{e*} - \beta_1^{e*} = \frac{\beta_1^{m*}[p-k(a-p)+(2\eta-1)\mu]}{2p} - \frac{p-k(a-p)}{2kv_1}$$
$$= \frac{-(1+k)p^2+akp+(1+k)pkv_1\beta_1^{m*}-ak^2kv_1\beta_1^{m*}+(2\eta-1)\mu kv_1\beta_1^{m*}}{2pkv_1^e}$$
$$\because \beta_1^{m*} = \frac{p}{kv_1}$$
$$\therefore \widehat{\beta}_2^{e*} - \beta_1^{e*} = \frac{p(2\eta-1)\mu}{2pkv_1} > 0 \text{ , } \widehat{\beta}_2^{e*} > \beta_1^{e*}$$

(2) Merge strategy

$$\frac{\partial\widehat{\pi}_{i2}^{m}}{\partial\widehat{\beta}_2^{m}} = (1-\alpha)\left(pv_2 - k(v_2)^2\widehat{\beta}_2^{m}\right)$$

We can get $\widehat{\beta}_2^{m*} = \frac{p}{kv_2} = \beta_1^{m*}$.

$$\widehat{\beta}_2^{e*} - \widehat{\beta}_2^{m*} = \beta_1^{m*}\left(\frac{-p-k(a-p)+(2\eta-1)\mu}{2p}\right)$$

When $0 < \eta \le \frac{1}{2}$, $\widehat{\beta}_2^{e*} < \widehat{\beta}_2^{m*}$.
When $\frac{1}{2} < \eta \le 1$, $\mu \ge \frac{p+k(a-p)}{2\eta-1} \ge p+k(a-p)$, $\beta_2^{e*} \ge \beta_2^{m*}$.

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