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# Selection of Competition and Cooperation Strategies for China Railway Express Considerding Routes Consolidation

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***Abstract:*** *The competition and cooperation between domestic freight platform companies of China Europe Express is a hot issue at present. By taken into consideration that the competition among multiple platform companies is influenced by factors such as price and geographical location, a game model based on the Salop market structure was constructed combining with routes consolidation strategies for different scenarios such as whether platform companies cooperate or not, and whether routes consolidation occur during cooperation. The impact of different competition and cooperation strategies on platform companies and social welfare was studied. The research results indicate that cooperation can alleviate price competition among platform companies in the market and improve profit levels. If platform companies consolidate routes during cooperation, the social welfare level is the highest; If the routes are not consolidated during cooperation, social welfare will decrease, and the market price will be the highest at this time. This research can provide theoretical basis for the cooperation between China Europe Express related platform companies and the selection of route consolidation strategies, and provide support for promoting the market-oriented development of China Railway Express.*

***Keywords:*** *railway transportation; competition and cooperation; route consolidation; Salop model; China Railway Express*

## 1. Introduction

The China Railway Express is one of the indispensable trade channels in the world's goods circulation, and its development is facing unprecedented opportunities and challenges. As of the end of June 2023, China Europe Express has operated a total of 74000 trains, transporting 7 million TEUs of goods, with over 50000 types of goods, reaching over 200 cities in 25 European countries. Its logistics distribution network covers the Eurasian continent. With the increase in the number of urban nodes opened domestically by the China Railway Express, problems such as duplicate routes, low resource efficiency, and excessive competition for export goods are becoming increasingly prominent. Local platform companies compete for supply by low prices, which is not conducive to the promotion of market-oriented development of China Railway Express[1]. Collaborating, jointly investing, and forming alliances can attract more sources of goods, and platform companies should work together to seek development[2]. The cooperation between China Railway Express related platform companies has been preliminarily attempted, but the specific forms of cooperation and the impact that will be generated after cooperation still lack theoretical support.

In recent years, more and more scholars have shown great interest and attention to the development of China Europe Express, and have conducted extensive researches on the competition issues encountered in the development of China Europe Express. However, there is still relatively few research on the competition and cooperation between domestic cities[3]. Some researchers considers the transportation organizations of China Railway Express[4, 5]; There is still relatively few research on models where competition and cooperation coexist among multiple platform companies[6], and the situation of routes consolidation during cooperation was not considered. In view of this, a game model based on the Salop market model is constructed for multi-platform companies to compete and cooperate, exploring the selection of competition and cooperation strategies for platform companies under the influence of factors such as price and geographical location. The cooperation strategies include two situations: cooperative and consolidated routes and cooperative non-consolidated routes, in order to provide theoretical support for the healthy and sustainable development of platform companies.

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## 2. Analysis of Competition and Cooperation between China Europe Express

### *2.1. Problem description*

China Railway Express related platform companies are train operators established under local government policies and resources, responsible for soliciting goods from the domestic market and providing international railway logistics transportation agency, multimodal transportation, and other services to domestic freight consignors. The platform companies are responsible for collecting and organizing goods, and signing transportation agreements with domestic and foreign carriers to deliver the actual transportation of goods to domestic and foreign railway transportation carriers. Unlike domestically, overseas railways often adopt a “network transportation separation” model, with railway infrastructure typically managed by overseas carriers which opens to the market for transportation services. When designing international logistics routes, China Railway Express needs to purchase railway transportation services from overseas carriers, who will provide quotes based on the scope of services provided. There is fierce competition among platform companies for cargo sources. But with the promotion of government subsidy exit policies, platform companies can shift from competition to cooperation, such as unified booking of cargo sources and unified organization of shipping. Therefore, this research considers the impact of competition and cooperation between China Europe Express related platform companies on prices, market, profits, and social welfare in a two-layer logistics service supply chain influenced by the logistics transportation costs of upstream overseas carriers.

The consolidation of routes considered in this research refers to the consolidation of freight volume on the operating routes of the train. The containers of the platform companies are no longer separately listed, but are concentrated and shipped uniformly. When collaborating, platform companies can choose whether to consolidate routes. If the routes are consolidated, the two platform companies will organize the supply of goods uniformly, gather them together, ship and deliver them to the same overseas carrier, and negotiate pricing with the goal of maximizing common profits. If the routes are not consolidated, the platform companies will load their cargo containers separately, ship them in columns, and negotiate overseas transportation costs with overseas carriers separately, in which the cooperation will only focuses on the domestic source market, and the independent pricing will be changed to jointly setting market prices to maximize common profits. As shown in Figure 1, the following three scenarios are discussed: In a perfectly competitive situation, the three companies are provided with overseas transportation services by three overseas carriers, and compete for supply of goods domestically based on price and location. In the case of cooperation without consolidating routes, the cooperating platform companies deliver to overseas carriers separately, and then negotiate market prices based on maximizing common profits. Companies without cooperating platforms independently price based on maximizing their own profits. In the case of cooperation and consolidation of routes, the cooperating platform companies will centrally ship the goods and deliver them to the same overseas carrier, and then negotiate pricing based on maximizing common profits. Non cooperating platform companies will still independently price based on maximizing their own profits.

### *2.2. Salop model*

The Salop model is a classic extension of the Hotelling model. The Hotelling model considers that competing companies have differences in product quality and location, and is a classic model for dealing with positional differences among competitors. The platform companies are distributed in various cities in China, and there is price competition between two companies. The starting station of the train is the local railway container center station, with a relatively fixed geographical location. Therefore, the competition between platform companies is related to price, location, etc. The Salop market model can better describe the characteristics of this market. Therefore, this research adopts the Salop cycle model. On this basis, a multi-platform company game model is constructed to study the selection of platform companies under competition and different cooperation strategies.

Consider three China Europe Express related platform companies( $\mathrm{CRE}_i, i=1,2,3$ ), competing for supply based on price and geographical location in the market. The three platform companies are located in $x=0$ (or $x=1$ ), $x=a$ and $x=1-b$ ( $0<a<1-b<1$ ), as shown in Figure 1. Assuming the market is fully covered, shippers are evenly distributed on a circular market with a circumference of 1, meaning that shippers in the market will always choose one of the platform companies to export goods. The closer the distance between platform companies, the more intense the competition becomes.

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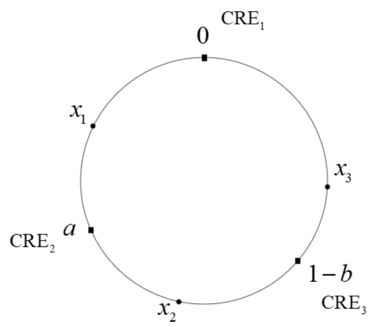


*Figure 1: Salop market*

## 3. A competition and cooperation model for China Railway Express related platform companies

### *3.1. Complete competion between platform companies*

Assuming the ideal utility value of the shipper is $U_0$, and $U_0$ is large enough that the shipper will always choose a platform company to export the goods. The shipper chooses which platform company to export goods from based on maximizing their own utility value. The utility of selecting $\mathrm{CRE}_1$ and $\mathrm{CRE}_2$ by the shipper located at point $x = x_1$ is the same; The utility of selecting $\mathrm{CRE}_2$ and $\mathrm{CRE}_3$ by the shipper at point $x = x_2$ is the same; The utility of selecting $\mathrm{CRE}_1$ and $\mathrm{CRE}_3$ by the shipper located in $x = x_3$ is the same. $x_1, x_2, x_3$ need to meet the following conditions respectively

$$\begin{cases} U_0 - p_1 - tx_1 = U_0 - p_2 - t(a - x_1) \\ U_0 - p_2 - t(x_2 - a) = U_0 - p_3 - t(1 - b - x_2) \\ U_0 - p_3 - t(x_3 - 1 + b) = U_0 - p_1 - t(1 - x_3) \end{cases} \tag{1}$$

Where $p_i$ is assumed as price. $x_i$ is represented as the location of the platform company. and the freight rate from the source to the platform company's origin station is $t$. According to equation (1), the requirements of the shipper can be determined as follows:

$$\begin{cases} q_1 = x_1 + 1 - x_3 \\ q_2 = x_2 - x_1 \\ q_3 = x_3 - x_2 \end{cases} \tag{2}$$

Where $q_i$ is represented as the market demand. Then the profit functions of platform company $\mathrm{CRE}_i$ and overseas carriers are as follows:

$$\pi_i = (p_i - w_i)q_i \tag{3}$$

$$R_i = (w_i - c)q_i \tag{4}$$

Where $w_i$ denotes the price at which overseas carriers provide overseas transportation services. $c$ is the overseas transportation cost.

The decision-making order of the game is that the overseas carrier first determines the price $w_i$ of transportation services provided to the platform company based on profit maximization, and then the platform company sets the transportation prices $p_i$ provided to the shipper, including loading and unloading, operation, etc., based on profit maximization. From this, the optimal decisions and profits $(p_i^{1*}, q_i^{1*}, \pi_i^{1*})$ of platform companies under complete competition can be solved.

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According to the above game sequence, using the backward solving method, firstly, each platform company makes independent decisions with the goal of maximizing its own profit. According to the first order condition of the platform company's profit function with respect to price being zero, $\frac{\partial \pi_i}{\partial p_i}=0$, it can be concluded that the best response function of the platform company's price with respect to the transportation service fee of the overseas carrier can be expressed as

$$p_1=\frac{1}{5}(t+at+bt+3w_1+w_2+w_3)$$

$$p_2=\frac{1}{5}(2t-bt+w_1+3w_2+w_3)$$

$$p_3=\frac{1}{5}(2t-at+w_1+w_2+3w_3)$$

Substitute the above price response function into the profit function of the overseas carrier, and solve for the first-order condition of the transportation service cost to be 0, to obtain the cost of the overseas carrier as

$$w_1^*=c+\frac{1}{10}(7+2a+2b)t$$

$$w_2^*=c+\frac{1}{10}(9-2b)t$$

$$w_3^*=c+\frac{1}{10}(9-2a)t$$

Given $a,b,c$ and $t$, we can get the prices of platform companies are $p_1^{1*}=c+\frac{7}{50}(7+2a+2b)t$, $p_2^{1*}=c-\frac{7}{50}(-9+2b)t$, $p_3^{1*}=c-\frac{7}{50}(-9+2a)t$; we can obtain the demand as $q_1^{1*}=\frac{7+2a+2b}{25}$, $q_2^{1*}=\frac{9-2b}{25}$, $q_3^{1*}=\frac{9-2a}{25}$; then the profits of platform companies can be expressed as $\pi_1^{1*}=\frac{(7+2a+2b)^2t}{625}$, $\pi_1^{1*}=\frac{(9-2b)^2t}{625}$, $\pi_1^{1*}=\frac{(9-2a)^2t}{625}$.

### 3.2. Cooperation on prices

If two of three platform companies choose to cooperate on pricing but retain their own operating lines, while one platform company chooses not to cooperate and sets its own pricing independently, without loss of generality, it can be assumed that platform company 1 and platform company 2 choose to cooperate on pricing, while platform company 3 independently sets its own pricing. The profit-sharing contract between the cooperating platform companies has an allocation ratio of $\theta$, with $\pi_{12}$ representing the common profit. The profits that each company can earn are $\theta\pi_{12}$ and $(1-\theta)\pi_{12}$, respectively. The profits function of platform companies can be expressed as

$$\begin{cases}\pi_{12}=(p_1-w_1)q_1+(p_2-w_2)q_2\\ \pi_3=(p_3-w_3)q_3\end{cases} \tag{5}$$

Since platform company 1 and platform company 2 still retain their respective operating routes in cooperation, they need to coordinate with overseas carriers independently and bear the carriage costs provided by their respective carriers. The profit functions of the three overseas carriers are the same as in Eq. (4). Similarly, the optimal decisions and profits of the platform companies can be obtained as

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$(p_i^{2*}, q_i^{2*}, \pi_i^{2*})$.

### *3.3. Cooperation on transportation*

If two platform companies choose to cooperate by merging their routes and retaining only one route for operation, the cooperating platform companies will consolidate their goods to the origin of one of the companies and send them out together. Assume that platform company 1 and platform company 2 choose to consolidate their routes when cooperating, so only one overseas carrier will provide overseas route services. Both companies will still make decisions based on common profit maximization and implement a profit distribution ratio $\theta$. The profits functions of the platform companies can be expressed as

$$\begin{cases} \pi_{12} = (p_1 - w_1)q_1 + (p_2 - w_1)q_2 \\ \pi_3 = (p_3 - w_3)q_3 \end{cases} \tag{6}$$

The profits functions of overseas carriers can be expressed as

$$\begin{cases} R_1 = (w_1 - c)(q_1 + q_2) \\ R_3 = (w_3 - c)q_3 \end{cases} \tag{7}$$

Similarly, the optimal decisions and profits of the platform companies can be obtained as $(p_i^{3*}, q_i^{3*}, \pi_i^{3*})$.

This section provides insight into the influence of the choice of cooperation decision-making for platform companies on their prices, profits and social welfare.

**Proposition 1**. Comparing the optimal prices in different scenarios, we can obtain $p_i^{1^*} < p_i^{3^*} < p_i^{2^*}$.

Form this proposition, we can find that in the case of price cooperation between platform companies 1 and 2, the price of the platform companies is the highest, while the price of the platform companies in a completely competitive situation is the lowest. This is because in a completely competitive situation, competition among platform companies in the market is fierce, and they compete to attract orders at low prices in order to compete for supply. This is consistent with the actual situation. When there is cooperation between platform companies, the price of the platform company will increase. By comparing the transportation service fees provided by overseas carriers, we can find that if platform companies 1 and 2 choose price cooperation, the transportation service rate meet $w_i^{2^*} > w_i^{1^*}$. If platform company 1 and 2 choose transportation cooperation, we can get $w_1^{3^*} < w_1^{1^*}$, $w_2^{3^*} < w_2^{1^*}$, $w_3^{3^*} > w_3^{1^*}$. From the comparison, we can find that in the case of price cooperation, the platform company's price increases will also increase the cost of transportation services. However, in the case of transportation cooperation, platform company 1 and platform company 2 will see a decrease in transportation service fees while increasing prices, which is what the platform companies hope to see. Platform company 3, which does not participate in the cooperation, will also see a corresponding increase in transportation service fees.

**Proposition 2.** Comparing the demand of platform companies in three scenarios yields

(a) As for platform companies 1 and 2, $q_1^{2*} + q_2^{2*} < q_1^{1*} + q_2^{1*}$, $q_1^{3*} + q_2^{3*} < q_1^{1*} + q_2^{1*}$.

(b) As for platform company 3, $q_3^{2^*} > q_3^{1^*}$, $q_3^{3^*} > q_3^{1^*}$.

The results suggest that cooperation in this situation will lead to a redistribution of market shares, with the combined market share of the two partner platform companies decreasing to a certain extent, while the market share of platform company 3 increases. This is because the market share obtained from the Salop model is related to the distance between the platform companies and the price of the platform companies. When the distance remains constant, the size of the market share is affected by changes in price. It can be seen that the cooperative platform companies 1 and 2 have set higher price levels, resulting in a decrease in the market. When both platform companies 1 and 2 increase their prices, the price of platform company 3 will also increase accordingly, thus forming a virtuous cycle and alleviating the

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problem of "low-price" competition in the market. When the positions of the three companies are fixed, an increase in price will lead to a decrease in demand. On the premise that the market is fully covered, the increase in price of the cooperative platform companies is greater than that of the non-cooperative companies, so the demand of the non-cooperative companies will increase.

**Proposition 3.** Comparing the profits of platform companies in three scenarios, we can obtain $\pi_{12}^{2^*} > \pi_{12}^{3^*} > \pi_1^{1^*} + \pi_2^{1^*}$, $\pi_3^{3^*} > \pi_3^{2^*} > \pi_3^{1^*}$.

It can be seen that cooperation between platform company 1 and platform company 2 is beneficial to increasing mutual profits. Cooperation between platform companies 1 and 2 and retaining platform company 2's route services is the most beneficial for increasing the mutual profits of both. Platform company 3 can benefit from any form of cooperation. Although there is competition between platform companies, cooperation can enable platform companies to achieve "win-win". In summary, cooperation is always beneficial for platform companies in this market.

Considering the different effects of competing and cooperating strategies on the prices, market shares, and profits of platform companies, we can intuitively understand that in a situation of perfect competition, the competition between platform companies is affected by price and distance. In order to attract supply, platform companies set low prices, and the cooperation between platform company 1 and platform company 2 can alleviate the pressure of supply competition in the market. Therefore, the prices of platform companies increase, and profits also increase. If the route service of platform company 2 is abandoned, it is equivalent to the platform companies that cooperate with platform company 2 and platform company 3 jointly dividing the market share of platform company 2. In a situation where the total market share is fixed, the market share of platform company 3 increases, so the total share of the cooperating platform companies 1 and 2 decreases. Therefore, it can be considered that cooperation has positive externalities.

## 4. Social welfare

Competition and cooperation among platform companies will have different impacts on social welfare. Usually, social welfare includes the sum of platform company profits and consumer utility. Let $U^{1^*}$, $U^{2^*}$ and $U^{3^*}$ represent the total utility of consumers in three senarios; $\prod^{1^*}$, $\prod^{2^*}$ and $\prod^{3^*}$ represent total profits; $SW^{1^*}$, $SW^{2^*}$ and $SW^{3^*}$ represent social welfare.

$$\begin{aligned} U^{1^*} &= \int_0^{x_1} (U_0 - p_1 - tx)dx + \int_{x_1}^{a} (U_0 - p_2 - t(a-x))dx + \int_a^{x_2} (U_0 - p_2 - t(x-a))dx \\ &+ \int_{x_2}^{1-b} (U_0 - p_3 - t(1-b-x))dx + \int_{1-b}^{x_3} (U_0 - p_3 - t(x-1+b))dx \\ &+ \int_{x_3}^{1} (U_0 - p_1 - t(1-x))dx \end{aligned} \tag{8}$$

Similarly, we can obtain the expressions $U^{2^*}$ and $U^{3^*}$ of consumer utilities.

The profits of platform companies are as follows:

$$\begin{cases} \prod^{1^*} = \pi_1^{1^*} + \pi_2^{1^*} + \pi_3^{1^*} \\ \prod^{2^*} = \pi_{12}^{2^*} + \pi_3^{2^*} \\ \prod^{2^*} = \pi_{12}^{3^*} + \pi_3^{3^*} \end{cases} \tag{9}$$

The social welfare is

$$SW^{i^*} = U^{i^*} + \prod^{i^*} \tag{10}$$

Substituting the above equilibrium results from previous section into this expression, we can get the total social welfare.

**Proposition 4.** Comparing the social welfare, we can obtain $SW^{2^*} < SW^{1^*} < SW^{3^*}$.

From this proposition, we see that platform companies choosing transportation cooperation can improve overall social welfare, while choosing price cooperation will reduce social welfare. When platform companies only cooperate on price, their prices will increase, resulting in a decrease in overall consumer utility and ultimately leading to a decrease in social welfare. When platform companies choose transportation cooperation, joint transportation between platform companies improves route utilization and transportation efficiency, which is conducive to large-scale transportation and reduces the flow of goods, providing consumers with better international transportation services, thereby overall improving social welfare.

## 5. Numerical illustration

This section further visually compares and analyzes the relationship between platform companies' willingness to cooperate and profit distribution ratios, as well as the changes in social welfare under different levels of competition through numerical experiments. We select Chongqing, Guizhou, and Chengdu as the research objects, which are located in close proximity, have similar types of supply sources, and have overlapping supply hinterlands as shown in Table 1. Set $a = 0.28$, $b = 0.22$, $c = 20$, $t = 10$.

*Table 1: The distance between Platform Companies*

| Companies cities | Chongqing | Chengdu | Guizhou |
|---|---|---|---|
| Chongqing | 0 | 303 km | 380 km |
| Chengdu | / | 0 | 644 km |
| Guizhou | / | / | 0 |

The equilibrium solution can be obtained by substituting the relevant parameters into the model in the previous section, as shown in Table 2.

*Table 2: Equilibrium Solution Results for Different Scenarios*

| Scenarios | Platform companies | Prices | Market share | Profit |
|---|---|---|---|---|
| Complete competition | Chongqing | 21.20 | 0.32 | 1.02 |
| | Guiyang | 21.98 | 0.34 | 1.17 |
| | Chengdu | 21.82 | 0.33 | 1.13 |
| Cooperation on price | Chongqing | 23.30 | 0.31 | 4.28 $\theta$ |
| | Guiyang | 24.06 | 0.34 | 4.28($1-\theta$) |
| | Chengdu | 23.82 | 0.34 | 1.19 |
| Cooperation on transportation | Chongqing | 30.38 | 0.22 | 2.67 $\theta$ |
| | Guiyang | 30.85 | 0.29 | 2.67($1-\theta$) |
| | Chengdu | 29.37 | 0.48 | 2.34 |

The willingness of platform companies to choose cooperation is related to the size of the profit distribution ratio $\theta$. When $\theta \in [\theta_1, \theta_2]$, $\pi_i^{j^*} > \pi_i^{1^*}$. From Figure 2, we can find that when $0.26 < \theta < 0.75$, only when both platform companies 1 and 2 receive profits greater than those in perfect competition can they have the willingness to cooperate in pricing. Further, when $0.42 < \theta < 0.59$, only when the profits of platform company 1 and platform company 2 are greater than those of perfect competition, will they choose transportation cooperation. This indicates that cooperative transportation has higher requirements for profit distribution, requiring platform companies to further negotiate and negotiate profit distribution.

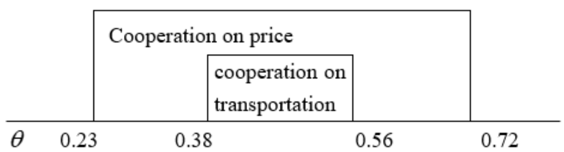


*Figure 2: Profit distribution ratio under different cooperation strategies*

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## 6. Conclusions

The transportation organization model of China Railway Express is the focus of industry, and optimizing the organization of trains and coordinating transportation resources requires active cooperation and coordination among domestic China Railway Express related platform companies in the competition process. The new organizational form of the China Europe Express is still a hot topic that needs to be explored. This research uses the Salop model to study the impact of competition and cooperation behavior of China Europe Express related platform companies on prices, profits, profit distribution ratio, and social welfare. The following conclusions can be obtained.

When there are multiple platform companies in the market, achieving cooperation between any platform company will help alleviate the “low price” competition in the supply competition, improve the market price level, and market share will be redistributed according to price changes. Cooperation has a positive externality, and cooperation can increase the profits of platform companies in the market. Therefore, China Railway Express related platform companies should actively cooperate to promote market-oriented operation of China Railway Express and achieve win-win results.

When platform companies cooperate to consider whether to consolidate routes, it is mainly determined by the profit distribution ratio, which has an impact on the level of social welfare. When the profit distribution ratio is within a certain range, cooperation will enable both parties to obtain greater profits, otherwise profits will decrease. Only when the profit distribution of the train is relatively small can a cooperative alliance be formed, and the consolidation of routes is also affected by the profit distribution ratio. Therefore, when reaching cooperation, both parties need to negotiate a profit distribution ratio and distribute profits reasonably.

The competition and cooperation decisions of platform companies affect the overall level of social welfare. When two platform companies choose to cooperate but not consolidate routes services, the overall level of social welfare will increase. Vice versa, social welfare will decrease, but the platform company’s marketization level is the highest.

The competition between China Railway Express related platform companies considered in this research is based on price and geographical location competition. It analyzes and discusses the optimal strategy choices of platform companies in the market when multiple platform companies compete completely and compete and cooperate, as well as the impact on social welfare, to provide reference suggestions for the future development of China Railway Express.

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