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The Impact of Aggregation Platforms on the Ride-Sourcing Market with Different Models of Companies

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ABSTRACT

With the booming development of the ride-sourcing (RS)industry, aggregation platforms that integrate RS companies have emerged in recent years, such as Gaode and Meituan. Aggregation platforms can consolidate resources and avoid fragmentation of the market. But the emergence of aggregation platforms has also changed the market structure and brought challenges. This paper explores the impact of aggregation platforms on the market with two models of companies: customer-to-customer (C2C) companies, and business-to-customer (B2C) companies. C2C companies adjust supply and demand to maximize revenue by determining travel fares and the cut taken from the travel fares, i.e., the commission. B2C companies will be affected by the decisions of C2C companies. Numerical studies have shown that joining an aggregation platform reduces the optimal commission of C2C companies, which leads to a decrease in optimal revenues. In addition, the revenue of part-time drivers and B2C companies increase significantly. Besides, this paper explores the impact of drivers' sensitivity to income on the RS market. This research can provide a reference for the operation of the company after joining the aggregation platform.

KEYWORDS

Ride-sourcing market, aggregation platform, customer-to-customer, business-to-customer

Introduction

In recent years, the RS industry has developed rapidly. As of November 30, 2022, 294 RS companies across China have obtained operating licenses. These companies can be divided into two types. One is the asset-light model represented by Didi and Hello Inc, which recruits private cars as operating vehicles, named C2C. The other is the asset-heavy model represented by Cao Cao Travel and T3 Travel, with the company's vehicles as the main transport capacity, named B2C. In the C2C model, the drivers work freely and can choose whether to provide service according to expected income. The company takes a part of the travel fares paid by passengers, which is called a commission. Under the B2C model, the company has vehicles and employed full-time drivers.

Small-scale companies are at a disadvantage in market competition. The emergence of aggregation platforms represented by Gaode and Meituan solves the survival problem of small-scale companies. The aggregation platform distributes the received orders to the companies on the platform and companies can operate with low investment. In recent years, aggregation platforms have developed rapidly. The proportion of orders completed by aggregation platforms increased from 22% in July to 25% in November.

However, the imbalance between supply and demand in the RS market is becoming increasingly prominent. Studies have shown economic levers can alleviate this imbalance [1-4]. The RS market is a typical two-sided market with significant cross-network externalities [5]. [6] established an economic model that includes demand, labor supply, and matching between demand and supply. [7] built a dynamic unbalanced model that tracks the time-varying number of passengers, vacant vehicles, and occupied vehicles. [8,9] both modeled the matching process between driver and passengers as an unobservable queue when studying supply and demand matching.

As an emerging model, there is relatively little research on RS aggregation platforms. [10] considered the differences in aggregation platforms' scale and customers' preferences. They simulated the duopoly price game scenario by using the two-sided market theory and the Hotelling model. [11] constructed a Steinberg game model between an aggregation platform and two RS companies to explore the pricing strategy. [12] constructed an RS market with multiple competitors and compared the system performance with or without aggregation platforms under Nash equilibrium and socially optimal. Studies have shown that aggregation platforms can increase total RS demand and social welfare.

The above literature provides important theoretical methods and research perspectives for RS market modeling. However, in-depth analysis shows that the existing literature needs to enrich the research on the coexistence and mutual influence of B2C and C2C models. Let alone the impact of the aggregation platform on companies with different models. Therefore, this paper explores the impact of aggregation platforms on the RS market where companies with different models coexist.

Ride-Sourcing Market Modeling

In modeling, it is assumed that the aggregation platform does not charge anything. In company i, q_i and N_i denotes the demand and the vehicle fleet size, w_i and w_i^v denotes the waiting time for passengers and vacant vehicles, $w_i q_i$ and N_i^v denote the number of unserved passengers and the number of vacant vehicles. The vehicle fleet size for each company equals the sum of the vacant vehicles ($N_i^v + q_i w_i^v$) and occupied vehicles ($q_i T$), as shown in Eq. (1). T denotes the average in-vehicle time. Vacant vehicles consist of available idle vehicles (N_i^v) and those on the way to pick up the assigned passengers ($q_i w_i^v$). Let m^{c-v} denote the matching rate of vacant vehicles with unserved passengers, this paper uses the matching function proposed by [13], as Eq. (2):

$$N_i^v = N_i - q_i * (w_i^v + T) \tag{1}$$

$$m^{c-v} = m_i = M(w_i q_i, N_i^v) \tag{2}$$

Further, we adopt the Cobb-Douglas type production function to concretize the matching function. As shown in Eq. (3), α_c and α_v denotes the resilience of the matching rate with unserved passengers and vacant vehicles, respectively. A is a positive parameter that characterizes the spatial characteristics of the RS market, which is negatively correlated with the search area of the vacant vehicles.

$$m^{c-v} = m_i = A(w_i q_i)^{\alpha_c}(N_i^v)^{\alpha_v} \tag{3}$$

The waiting time for passengers and vehicles is shown in Eq. (4) and Eq. (5), respectively:

$$w_i = \frac{w_i q_i}{m_i} = \frac{1}{A(w_i q_i)^{\alpha_c - 1}(N_i^v)^{\alpha_v}} \tag{4}$$

$$w_i^v = \frac{N_i^v}{m_i} = \frac{1}{A(w_i q_i)^{\alpha_c}(N_i^v)^{\alpha_v - 1}} \tag{5}$$

Before Joining Aggregation Platforms

The two RS companies operate independently before joining aggregation platforms. For passengers, the cost of choosing RS is the composite cost. The travelers' travel mode choice is represented in Fig. 1.

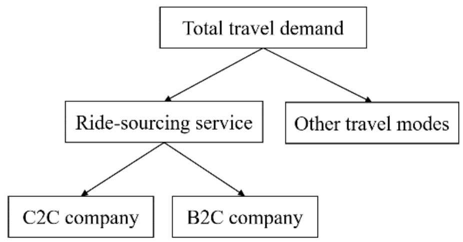


Figure 1: The travel structure without aggregation platforms

For travelers who choose RS, the generalized travel cost can be expressed as the travel fare plus the time cost, including waiting time and in-vehicle time, as shown in Eq. (6). F_i denotes the travel fare per trip, ∂ denotes the unit time cost.

$$C_i = F_i + \partial(w_i + T) \tag{6}$$

Let subscripts 1 and 2 indicate the C2C company and the B2C company, respectively. Drivers in C2C companies are freelancers and decide whether to provide service based on the expected income. The labor supply in the C2C company N_1 is shown in Eqs. (7)-(8):

$$R = \frac{(1-\rho)\cdot F_1 \cdot q_1}{N_1} - (\varepsilon + c)(w_1^v + T) \tag{7}$$

$$N_1 = S \cdot U(R) \tag{8}$$

where R denotes the expected income of the drivers, and ρ denotes the commission of the RS company. ε denotes the driver's unit time cost, and c denotes the vehicle's operating cost per unit of time. S denotes the total number of drivers registered in the C2C company, and $U(R)$ denotes the function of labor supply with expected income, $0 \leq U(R) \leq 1$.

For the B2C company, drivers are full-time and in a fixed number. Let N_2 denote the number of full-time drivers. The composite cost of choosing RS C_b can be expressed as Eq. (9), where λ is a constant parameter.

$$C_b = \frac{1}{\lambda} ln \sum_i exp(\lambda C_i) \tag{9}$$

Let C_p represent the travel cost of choosing other travel modes. σ and θ are the parameters of the Logit model, the total demand for RS and the demand for each company can be expressed by Eq. (10) and Eq. (11):

$$q_c^b = Q \cdot \frac{exp(-\sigma C_b)}{exp(-\sigma C_b) + exp(-\sigma C_p)} \tag{10}$$

$$q_i = q_c^b \frac{exp(-\theta C_i)}{\sum_i exp(-\theta C_i)} \tag{11}$$

After Joining the Aggregation Platform

When the companies join in the aggregation platform, the vehicles of the companies can be considered as a whole. The travel mode choice can be represented by the Logit model in Fig. 2.

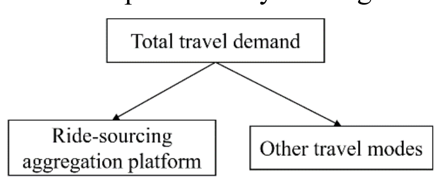


Figure 2: The travel structure after joining the aggregation platform

After joining the aggregation platform, the vehicles of the two companies are uniformly dispatched by the aggregation platform. The number of vehicles is the sum of the vehicles of the two companies. In the aggregation platform, the matching rate of vehicles-passengers m_a, the waiting time of passengers w_a and vacant vehicles w^v can be calculated by Eqs. (2)-(5). The generalized travel cost C_a is expressed by Eq. (12):

$$C_a = F_a + \partial(w_a + T) \tag{12}$$

The total demand for RS on the aggregation platform is:

$$q_c^a = Q \cdot \frac{exp(-\sigma C_a)}{exp(-\sigma C_a) + exp(-\sigma C_p)} \tag{13}$$

Since the travel cost of B2C and C2C companies in the aggregation platform is the same, orders are distributed without discrimination. Therefore, the orders of the two companies are distributed according to their vehicle fleet size, $q_{ai} = q_c^a \cdot N_i / \sum_i N_i$.

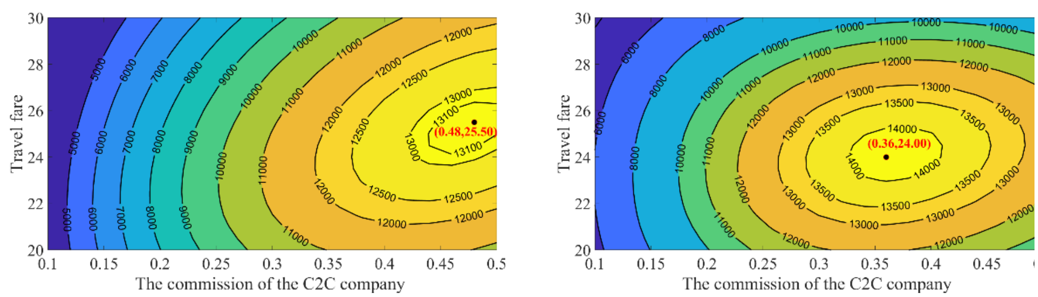
For the C2C company, the company's revenue is equal to the commission minus the company's operating costs χ, which include platform construction, after-sales service, etc. The revenue of the B2C company is shown in Eq. (15), which equals the travel fares minus the drivers' salaries, the cost of the vehicles, and the operating costs of the company.

$$\prod_1 = \rho F_1 q_1 - \chi \tag{14}$$

$$\prod_2 = F_2 q_2 - (c + g) N_2 - \chi \tag{15}$$

Numerical Examples

Take the C2C company for example, Fig. 3 shows that the C2C company's revenue increases first and then decreases as commission and travel fare increase. After joining in the aggregation platform, the optimal commission of the C2C company decreased from 0.48 to 0.36, which is significantly reduced.



(a) Before joining in the aggregation platform (b) After joining in the aggregation platform

Figure 3: The revenue of C2C company

Conclusions

The key findings of this study are summarized as follows. First, the RS demand decreases as travel fares and commissions increase. RS companies joining in aggregation platforms can increase RS demand. Second, C2C companies' revenues first increase and then decrease as travel fares and commissions increase. Joining the aggregation platform reduces the optimal revenue of C2C companies. B2C companies' revenue increases as travel fares first increase and then decrease, and increase with the commissions. Joining aggregation platforms can significantly increase the revenue of B2C companies. Finally, the income of drivers first increases and then decreases with the increase of travel fares, and decreases with the increase of commission. Joining aggregation platforms can increase the revenue of drivers. The magnitude of the increase or decrease of the above indicators is related to the sensitivity of drivers to income.

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Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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