



## The Study on the Pricing decision of Online car-hailing platforms Considering Open participation mode and Driver charges

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**SUMMARY:** *By constructing Hotelling spatial competition models, this study examines how online car-hailing platforms with different open participation models should formulate pricing strategies under varying supply and demand conditions, and analyzes the impact of fees charged to drivers by the platform-on-platform profit under different models. The results indicate that when the supply of ride-hailing services exceeds demand, the platform can achieve greater revenue by adopting a partially open strategy. Conversely, when the market is supply-constrained, the platform can achieve greater revenue by adopting a completely closed strategy. The revenue of online car-hailing platforms adopting different open models is influenced by the cross-group network effects between passengers and drivers. When cross-group network effects are high, the maximum revenue of platforms adopting a complete open model decreases as the platform's platform commission percentage increases when the ride-hailing market is in short supply, and increases as the platform commission percentage increases when supply exceeds demand. The maximum revenue of platforms adopting a full-closed model decreases as the vehicle leasing costs for platform-owned vehicles increase. For platforms adopting a partially open model, the maximum revenue should prioritize assigning orders to self-operated vehicle drivers when supply exceeds demand. Based on the above conclusions, relevant recommendations are proposed for online car-hailing platforms, aiming to provide theoretical guidance for adjusting operational strategies.*

**KEYWORDS:** *online car-hailing platforms; open participation modes; pricing decision; supply-demand condition*

### 1 Introduction

With the development of the sharing economy, China's ride hailing market has formed a pattern dominated by several platforms such as Didi Chuxing and Meituan Taxi. Flexible employment methods represented by online hosts, food delivery riders, and ride hailing drivers have been sought after by people, and such employment forms have significantly surpassed traditional economic sectors in terms of incremental scale, becoming an important driving force for expanding employment capacity [1]. But with the increase in the number of ride hailing licenses and platforms, the supply is becoming increasingly saturated, the competitive environment is fierce, and the daily average order volume of drivers is decreasing, resulting in a decline in revenue flow. Therefore, in the fierce market competition, what operational strategies should ride hailing platforms adopt to maintain platform profit while avoiding the waste of driver resources has become a thought-provoking issue. Based on this,

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this article mainly explores what open strategies should be adopted by ride hailing platforms in different supply and demand environments to maximize platform profit [2]. At the same time, it analyzes the impact of factors such as fees charged by ride hailing platforms to drivers and cross-group network effects on driver scale and platform profit, aiming to provide theoretical guidance for ride hailing platforms to adjust their operational strategies and reduce the waste of driver resources.

Bilateral markets are typically served by one or several competing platforms, providing a place for two different customer groups to operate and trade with each other. The ride hailing market is a typical two-sided market and a typical representative of the sharing economy field. The two-sided market theory is the foundation for studying the ride hailing market. Cross-group network effects are a typical feature of two-sided markets, where one party's revenue is influenced by the other party's participation size. Naumov & Keith [3] considered the pricing problem of ride hailing platforms under different user ownership structures based on the theory of two-sided markets. Chirita & Chirita [4] considered the impact of improving the matching ability between drivers and passengers on the cross-network effect, and analyzed the best pricing scheme of ride hailing platforms under matching ability investment. Maljkovic et al. [5] considered passengers' preferences for the service quality of ride hailing platforms and explored the impact of cross-group network effects and other factors on platform decision-making. Rozin [6] studied the pricing problem of ride hailing platforms by combining inter group network externalities and intra group network externalities based on the theory of two-sided markets. Beguni et al. [7] used the theory of perceived value to analyze the "double-edged sword" effect of same side network externalities on ride hailing platforms, and explored the dynamic changes in customer loyalty in ride hailing aggregation platforms. When analyzing the factors affecting the decision-making of ride hailing platforms based on the theory of two-sided markets in existing literature, most scholars assume that ride hailing platforms are in a complete open model, that is, they only hire individual vehicle drivers for ride hailing services, and the platform takes a commission from the drivers' order income, while ignoring the protection of the rights and interests of hired drivers by ride hailing platforms. Dolata & Schwabe [8] pointed out that the self scheduling of individual vehicle drivers has led to uncertainty in ride hailing driver services. Some ride hailing platforms have gradually shifted from fully open or fully closed modes to partially open modes in order to better meet the needs of ride hailing passengers. Feng et al. used game theory and other methods to study and analyze that an open business model can improve the utility of ride hailing drivers and passengers, greatly enhancing social welfare. Boateng et al. [9] studied and analyzed the impact of vehicle costs on the open strategy selection of ride hailing platforms. Some ride hailing platforms can further meet the needs of passengers in the ride hailing market by adjusting their open modes. At the same time, factors such as passenger waiting costs and vehicle costs can also affect the decision-making of ride hailing platforms.

At present, China's ride hailing market is gradually saturated, and more and more unemployed people choose to become ride hailing drivers. However, there is still a problem of supply shortage due to drivers' unwillingness to take orders during peak travel periods. Rangel et al. [10] studied the fairness issues between ride hailing platforms and drivers, as well as between ride hailing drivers and taxi drivers, and pointed out that both fairness issues can have a negative impact on the utility of ride hailing platforms. Attari [11] pointed out through sample design and other methods that when ride hailing companies provide drivers with welfare benefits such as minimum wage guarantee and allow drivers to screen passenger information, the utility and willingness of drivers to work for ride hailing platforms will increase. Khairani et al. [12] pointed out that the income satisfaction of ride hailing drivers plays an important role in managing driver participation on ride hailing platforms.

Pourrahmani et al. [13] found that there exists an optimal wage level that maximizes the profits of ride hailing platforms, and the optimal wage level is negatively correlated with platform influence. Siddiq & Taylor [14] pointed out that when supply increases and unexpected events occur, due to a significant reduction in passenger flow, there is fierce competition between ride hailing drivers and taxi drivers, which can lead to a significant decrease in driver income or even an inability to make ends meet. Most scholars' research on the revenue of ride hailing platforms mainly considers two aspects: (1) the fees paid by drivers to the platform; (2) The platform sets prices based on factors such as the distance traveled by passengers in order to obtain ride services, and charges drivers a certain platform service fee. Therefore, setting a reasonable commission ratio or service fee is a matter of profit distribution for the company, fundamentally a matter of labor pricing for drivers (labor). Ben-Gal & Tzur [15] pointed out that the differences in travel service providers under the aggregation mode are important factors affecting the platform's commission ratio and the pricing of ride hailing services in the market. Dudin et al. [16] pointed out that online ride hailing platforms will lower the subsidy and pick-up prices for passengers and adopt high platform commission percentages for drivers, which will reduce passengers' willingness to use online ride hailing services. Madanizadeh et al. [17] studied how platforms that use two types of cars, electric and gasoline, for ride hailing services should set the minimum wage for drivers and car rental prices, and pointed out that as the number of drivers increases, ride hailing platforms should reduce the platform commission percentage for electric car drivers.

Overall, there are still certain shortcomings in the existing research on the impact of fees charged by ride hailing platforms to drivers on different driver scales and platform profit [18]. Based on the bilateral market characteristics of the ride hailing industry and considering the cross-group network effects of the ride hailing market, this article constructs a Hotelling spatial competition model to study the impact of the platform's commission ratio or rental fees on the pricing decision and driver scale of ride hailing platforms when hiring individual vehicle drivers or self-operated car drivers alone, as well as hiring two types of drivers simultaneously. Through research and analysis, it is determined which open model ride hailing platforms should adopt under different supply-demand conditions: (1) Developing a reasonable commission ratio or rental fee is the basis for protecting driver rights, ensuring service quality, and improving passenger riding experience. At the same time, it can also help ride hailing platforms control the driver scale of the platform according to the supply-demand condition of the ride hailing market. Enhance the matching ability between drivers and passengers to avoid resource waste; (2) Due to the fierce competition in the current ride hailing market, adjusting the open mode of ride hailing platforms can to some extent help platforms enhance their competitiveness and continuously develop steadily in the ride hailing industry. However, there is relatively little discussion on the differences between different open modes adopted by ride hailing platforms in existing research. This study can fill the gap in existing research in this field and promote the healthy development of the ride hailing industry.

## 2 Problem description and model construction

### 2.1 Complete open model

The ride hailing platform chooses a complete open model, which only hires individual vehicle drivers for services. Drivers who own private cars join the ride hailing platform, pay a certain franchise fee to the platform, receive professional training, and extract a portion of the income obtained from drivers' orders as intermediary fees. Assuming there is only one ride hailing

platform in the market, with a driver scale of  $n_{s1}$  and a passenger scale of  $n_d$ . Assuming that the sensitivity coefficient of passengers to driver size is  $\alpha$ , the sensitivity coefficient of individual vehicle drivers to passenger size in the market is  $\beta$ , and the sensitivity coefficients of passengers and drivers to price are 1. The driver's travel cost is only affected by the passenger's travel distance  $d$ , with a unit distance cost of  $k$ . The passenger's travel distance follows a uniform distribution within the range of  $[0, D]$ . According to the Hotelling spatial competition model, assuming that passengers are distributed in linear cities within the range of  $[0, 1]$ , passengers located at a distance of  $x$  from the ride hailing platform join the platform and obtain the utility of ride hailing services as shown in equation (1). Similarly, individual vehicle drivers are distributed in linear cities within  $[0, 1]$ , and the expected utility value of individual vehicle drivers who are located  $y_1$  away from the ride hailing platform joining the platform to accept orders is shown in equation (2). The distribution of passengers and individual vehicle drivers is shown in Figure 1. This section assumes that the revenue of ride hailing platforms is only affected by order prices and platform commission percentages based on order volume, without considering the cost of ride hailing platforms. The revenue is shown in equation (3).

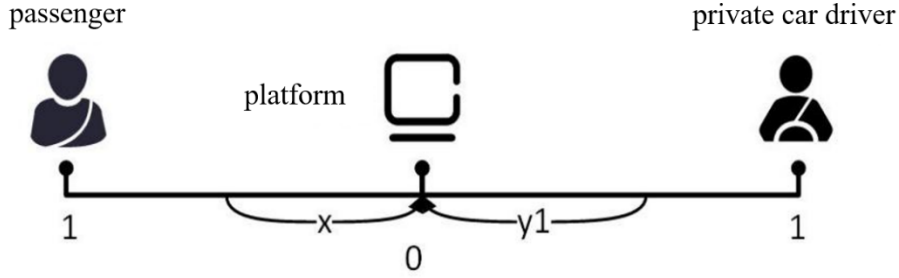


Figure 1: Distribution of Passengers and Individual vehicle drivers

$$U_C = u - p - C_c x + \alpha n_{s1} \quad (1)$$

$$U_{S1} = p(1 - \lambda) - C_s y_1 + \beta n_d - k \frac{D}{2} \quad (2)$$

$$\pi_1 = \lambda p D_1 \quad (3)$$

## 2.2 Full-closed model

The ride hailing platform chooses a full-closed model, and hiring self owned car drivers can provide job opportunities for drivers who do not have private cars [19]. All the income obtained by drivers from taking orders belongs to the platform, and the platform pays the minimum wage guarantee to drivers every month, and provides subsidies to drivers based on their mileage of taking orders. Assuming that the travel distance of passengers follows a uniform distribution within the range of  $[0, D]$ , when the travel distance  $d$  is greater than  $d^*$ , the platform will subsidize the driver for the excess travel cost, that is, self-operated car drivers only need to pay for the travel cost within the range of  $[0, d^*]$ . Assuming that the scale of self-operated car drivers employed by ride hailing platforms is  $n_{s2}$ , the scale of passengers in the market is  $n_d$ , and passengers are evenly distributed within the range of  $[0, 1]$ . Assuming that the sensitivity coefficient of passengers to driver size is  $\alpha$ , the sensitivity coefficient of self-operated car drivers to passenger size in the market is  $\beta$ , and the sensitivity coefficients of passengers and drivers to price are 1. The distribution of passengers and self-operated car drivers is shown in Figure 2. Assuming that the revenue of ride hailing

platforms is only affected by order prices, rental fees, salary guarantees, subsidy fees, and order quantities. The utility of passenger transportation is shown in equation (4), the expected utility of self-operated car drivers receiving orders is shown in equation (5), and the platform profit is shown in equation (6).

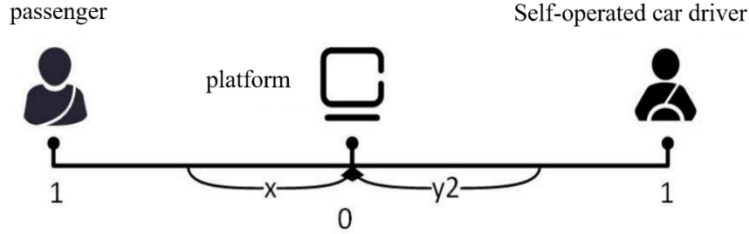


Figure 2: Distribution of Passengers and Self-operated Vehicle Drivers

$$U_C = u - p - C_c x + \alpha n_{s2} \quad (4)$$

$$U_{S2} = w - C_s y_2 + \beta n_d - m - \frac{k d^{*2}}{2D} - \left(1 - \frac{d^*}{D}\right) k d^* \quad (5)$$

$$\pi_2 = (p + m - w) D_2 - k \frac{D - 3d^*}{2} \left(1 - \frac{d^*}{D}\right) D_2 \quad (6)$$

### 2.3 Partial Open Mode

The ride hailing platform chooses a partially open mode, hiring both self-operated car drivers for services and individual vehicle drivers for services [20]. The distribution of passengers and drivers is shown in Figure 3. There is a competitive relationship between individual vehicle drivers and self-operated car drivers. Assuming that the sensitivity coefficient of self-operated car drivers to the scale of individual vehicle drivers is  $\gamma$ , and the sensitivity coefficient of individual vehicle drivers to the scale of self-operated car drivers is  $\sigma$ . The main revenue of ride hailing platforms comes from the order income of two types of drivers.  $\pi_1^*$  represents the order income of individual vehicle drivers,  $\pi_2^*$  represents the order income of self-operated car drivers, and  $\theta$  represents the probability of ride hailing platforms assigning orders to individual vehicle drivers. Assuming that passengers are only sensitive to the total size of drivers, the passenger utility is shown in equation (7), the expected utility of the two types of drivers is shown in equations (8) and (9), and the platform profit is shown in equation (10). Table 1 shows the parameters and symbols involved in the study of three different open modes.

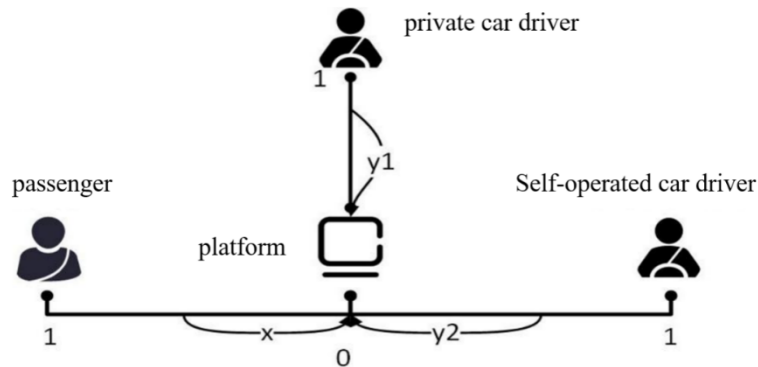


Figure 3: Distribution of Drivers and Passengers in Partial Open Mode

Table 1: Parameter and Symbol Explanation

| parameter | Symbol Description   |
|-----------|--|
| $U_C$     | Passenger utility  |
| $U_{S1}$  | Private car driver utility   |
| $U_{S2}$  | Utility of self-operated car drivers   |
| $u$       | Fixed utility of passenger transportation  |
| $p$       | Passenger fare   |
| $C_c$     | Unit distance cost for passengers choosing ride hailing platforms                                |
| $d$       | Passenger travel distance  |
| $k$       | Unit travel distance cost  |
| $\lambda$ | The platform's commission ratio for individual vehicle drivers                                   |
| $w$       | The minimum wage subsidy provided by the platform to self-operated car drivers                   |
| $m$       | Rental fees for self-operated car drivers  |
| $C_s$     | Unit distance cost for drivers joining ride hailing platforms                                    |
| $n_d$     | Passenger scale  |
| $n_{s1}$  | Scale of individual vehicle drivers  |
| $n_{s2}$  | Scale of self-operated car drivers   |
| $\alpha$  | Sensitivity coefficient of passengers to the size of the driver                                  |
| $\beta$   | Sensitivity coefficient of drivers to passenger size   |
| $\gamma$  | Sensitivity coefficient of self-operated car drivers to the scale of individual vehicle drivers  |
| $\sigma$  | Sensitivity coefficient of individual vehicle drivers to the scale of self owned car drivers     |
| $\theta$  | Probability of platform dispatching orders to individual vehicle drivers under partial open mode |
| $x$       | Distance for passengers to choose ride hailing platforms   |
| $y_1$     | Distance for individual vehicle drivers to join ride hailing platforms                           |
| $y_2$     | Distance for self-operated car drivers to join ride hailing platforms                            |
| $D_i$     | Online ride hailing order volume   |
| $\pi$     | Revenue of ride hailing platforms  |

$$U_C = u - p - C_c x + \alpha(n_{s1} + n_{s2}) \quad (7)$$

$$U_{S1} = p(1 - \lambda) - C_s y_1 + \beta n_d - k \frac{D}{2} - \sigma n_{s2} \quad (8)$$

$$U_{S2} = w - C_s y_2 + \beta n_d - m - \frac{k d^{*2}}{2D} - \left(1 - \frac{d^*}{D}\right) k d^* - \gamma n_{s1} \quad (9)$$

$$\pi_3 = \pi_1^* + \pi_2^* \quad (10)$$

### 3 Model analysis

#### 3.1 Complete open model

By selecting the complete open model and making the utility of passengers and individual vehicle drivers equal to 0, the indifference utility points  $x^*$  and  $y_1^*$  for passengers and individual vehicle drivers can be obtained. When the distance between passengers and individual vehicle drivers to the ride hailing platform is less than or equal to the indifference

point, and their utility is greater than 0, passengers and individual vehicle drivers will choose to join the ride hailing platform [21]. Due to the assumption in this study that passengers and drivers are evenly distributed, the size of passengers and individual vehicle drivers is equal to  $x^*$  and  $y_1^*$ , respectively. After calculation, the size of passengers and individual vehicle drivers can be obtained as shown in equation (11), which can then be used to determine platform profit and best pricing scheme decision based on different supply-demand conditions.

$$\begin{cases} n_d = \frac{\alpha k D - 2\alpha p(1-\lambda) + 2C_S(p-u)}{2\alpha\beta - 2C_C C_S} \\ n_{s1} = \frac{C_C k D - 2C_C p(1-\lambda) + 2\beta(p-u)}{2\alpha\beta - 2C_C C_S} \end{cases} \quad (11)$$

Due to the shortage of supply during peak usage periods, the order volume  $D_1$  of ride hailing platforms is equal to the passenger scale. By taking the partial derivative of the revenue function with respect to price and making it equal to 0, the best pricing scheme that maximizes the platform's revenue can be obtained, as shown in equation (12), and the maximum revenue of the platform is shown in equation (13). By taking the partial derivative of the maximum profit of the platform with respect to the commission ratio, it can be seen that when  $\frac{\alpha - C_S}{\alpha\beta - C_C C_S} > 0$ , the maximum profit of the platform increases with the increase of the commission ratio. In addition, by incorporating the best pricing scheme into the passenger and driver scale functions, when  $2C_S u - \alpha k D > 0$ , the larger the platform's commission ratio, the smaller the scale of individual vehicle drivers, and at this time, the commission ratio of the ride hailing platform needs to meet the following requirements  $\lambda \leq \frac{kD[\alpha^2 + 2C_C C_S - \alpha(\beta + C_C + C_S)] + 2u[2\alpha\beta - C_S(\alpha + \beta + C_C) + C_S^2]}{\alpha D k(\alpha - C_C) + 4\alpha\beta u - 2u C_S(\alpha + C_C)} = \lambda_1^*$ , therefore, in order to reduce the waste of driver resources, the optimal commission ratio for ride hailing platforms is  $\lambda_1^*$ .

When the supply of the ride hailing market is less than the demand, the order volume  $D_1$  of the ride hailing platform is equal to the scale of individual vehicle drivers. Through calculation, the best pricing scheme of the platform can be obtained as shown in equation (14), and the maximum profit can be obtained as shown in equation (15). Analysis shows that when  $\frac{\beta - C_C}{\alpha\beta - C_C C_S} > 0$ , the maximum revenue of ride hailing platforms decreases with the increase of platform commission ratio. When  $2\beta u - C_C k D > 0$ , the passenger scale increases with the increase of platform commission ratio, and the platform commission ratio needs to meet the following requirements  $\lambda \geq \frac{kD[C_C(\beta - C_C + C_S) + \alpha(C_C - 2\beta)] + 2u[\beta(\alpha - \beta + C_C) + C_S(\beta - 2C_C)]}{C_C D k(\alpha - C_C) + 2\alpha\beta u + 2C_C \beta u - 4u C_S C_C} = \lambda_2^*$ , therefore, in order to avoid the situation where passengers join the platform but cannot obtain ride hailing services, resulting in a decrease in their favorability towards the platform, the optimal commission ratio for the platform is  $\lambda_2^*$ .

Scenario 1: Supply  $\geq$  Demand

$$p_1^* = \frac{2C_S u - \alpha k D}{4[C_S - \alpha(1-\lambda)]} \quad (12)$$

$$\pi_1 = \frac{\lambda(\alpha k D - 2C_S u)^2}{16[C_S - \alpha(1-\lambda)](C_C C_S - \alpha\beta)} \quad (13)$$

Scenario 2: Supply  $<$  Demand

$$p_2^* = \frac{2\beta u - C_C k D}{4[\beta - C_C(1-\lambda)]} \quad (14)$$

$$\pi_2 = \frac{\lambda(C_C k D - 2\beta u)^2}{16[\beta - C_C(1-\lambda)](C_C C_S - \alpha\beta)} \quad (15)$$

Based on the previous research and analysis, the following conclusions can be drawn.

**Proposition 1:** When a ride hailing platform chooses a complete open model and only hires individual vehicle drivers, and the supply in the ride hailing market exceeds demand, the best pricing scheme that maximizes the platform's revenue is  $p_1^*$ , at which point the platform's maximum revenue is  $\pi_1$ . When the demand for ride hailing services exceeds supply, the best pricing scheme for the platform is  $p_2^*$ , and the maximum revenue is  $\pi_2$ .

**Inference 1:** When the supply of the ride hailing market exceeds the demand, and the relationship between the network externality effect between passengers and drivers and their unit cost of joining the ride hailing platform satisfies  $\frac{\alpha - C_S}{\alpha\beta - C_C C_S} > 0$ , the commission ratio of the ride hailing platform has a positive impact on the platform's revenue. At the same time, when  $2C_S u - \alpha k D > 0$ , the scale of the platform's drivers decreases with the increase of the commission ratio. At this time, the optimal commission ratio of the platform is  $\lambda_1^*$ .

**Inference 2:** When the demand for ride hailing services exceeds supply and the relationship between the network externalities between passengers and drivers and the unit cost of joining the ride hailing platform satisfies  $\frac{\beta - C_C}{\alpha\beta - C_C C_S} > 0$ , the commission ratio of the ride hailing platform has a negative impact on the platform's revenue. At the same time, when  $2\beta u - C_C k D > 0$ , the driver scale of the platform is not affected by the commission ratio, and the passenger scale increases with the increase of the commission ratio.

### 3.2 Full-closed model

When the ride hailing platform chooses a full-closed model, the utility points  $x^*$  and  $y_2^*$  of passengers and self-operated drivers can be obtained by setting the utility of passengers and self-operated drivers to 0, respectively [22]. When the distance between passengers and self-operated car drivers to the ride hailing platform is less than or equal to the indifference point, and their utility is greater than 0, passengers and self-operated car drivers will choose to join the ride hailing platform. After calculation, the scale of passengers and self-operated car drivers can be obtained as shown in equation (16), and the platform profit and best pricing scheme decision can be determined based on different supply-demand conditions.

$$\begin{cases} n_d = \frac{\alpha k d^{*2} - 2\alpha k D d^* - 2\alpha D m - 2D p C_S + 2D C_S u + 2\alpha D w}{2D(C_C C_S - \alpha\beta)} \\ n_{s2} = \frac{C_C k d^{*2} - 2C_C k D d^* - 2C_C D m - 2D p \beta + 2D \beta u + 2C_C D w}{2D(C_C C_S - \alpha\beta)} \end{cases} \quad (16)$$

When the supply of the ride hailing market exceeds the demand, the order volume  $D_2$  of the ride hailing platform is equal to the passenger scale. By taking the partial derivative of the revenue function with respect to price, which is set to 0, the best pricing scheme that maximizes the platform's revenue can be obtained, as shown in equation (17), and the maximum revenue of the platform can be obtained in equation (18). By taking the partial derivative of the platform's maximum revenue with respect to vehicle rental costs, it can be seen that when  $\alpha\beta - C_C C_S < 0$ , the platform's maximum revenue shows a trend of first decreasing and then increasing with the increase of vehicle rental costs  $m = \frac{\alpha k d^*(d^* - 2D) - k C_S (3d^{*2} - 4d^* D + D^2) + 2D C_S u + 2D w (\alpha - C_S)}{2D(\alpha - C_S)} = m_1^*$ . At that time, the platform's revenue was the lowest. By incorporating the best pricing scheme into the passenger and driver scale functions and separately calculating their partial derivatives with respect to vehicle rental

costs, it can be concluded that when  $\frac{\alpha\beta - 2C_C C_S + C_S\beta}{2C_S(C_C C_S - \alpha\beta)} > 0$ , the scale of self-operated vehicle drivers increases with the increase of vehicle rental costs, and when  $\frac{\alpha - C_S}{2(\alpha\beta - C_C C_S)} > 0$ , the scale of passengers increases with the increase of vehicle rental costs. When the supply of the ride hailing market is less than the demand, the order volume  $D_2$  of the ride hailing platform is equal to the scale of self-operated car drivers. Through calculation, the best pricing scheme of the platform can be obtained as shown in equation (19), and the maximum profit can be obtained as shown in equation (20). The analysis shows that when  $\alpha\beta - C_C C_S < 0$ , the maximum revenue of ride hailing platforms shows a trend of first decreasing and then increasing with the increase of platform vehicle rental fees  $m = \frac{-C_C k d^*(d^* - 2D) + k\beta(3d^{*2} - 4d^*D + D^2) - 2D\beta u + 2Dw(\beta - C_C)}{2D(\beta - C_C)} = m_2^*$ . At that time, the platform's revenue was the lowest. When  $\frac{2\alpha\beta - C_S(\beta + C_C)}{2\beta(\alpha\beta - C_C C_S)} > 0$ , the number of passengers increases with the increase of platform vehicle rental costs. When  $\frac{C_C - \beta}{2(\alpha\beta - C_C C_S)} > 0$ , the number of self-operated vehicle drivers increases with the increase of vehicle rental costs.

Scenario 1: Supply  $\geq$  Demand

$$p_1^* = \frac{\alpha[kd^{*2} - 2kDd^* + 2D(w-m)] + C_S[3kd^{*2} - 2Dkd^* + D^2k + 2D(w+u-m)]}{4DC_S} \quad (17)$$

$$\pi_1 = \frac{\{C_S[-3kd^{*2} + 4d^*Dk - D^2k + 2D(m+u-w)] + \alpha[kd^{*2} - 2d^*kD + 2D(w-m)]\}^2}{16D^2C_S(C_C C_S - \alpha\beta)} \quad (18)$$

Scenario 2: Supply  $<$  Demand

$$p_2^* = \frac{C_C[kd^{*2} - 2kDd^* + 2D(w-m)] + \beta[3kd^{*2} - 4Dkd^* + D^2k + 2D(w+u-m)]}{4D\beta} \quad (19)$$

$$\pi_2 = \frac{\{\beta[3kd^{*2} - 4d^*Dk + D^2k - 2D(m+u-w)] + C_C[-kd^{*2} + 2d^*kD + 2D(m-w)]\}^2}{16D^2\beta(C_C C_S - \alpha\beta)} \quad (20)$$

Based on the above analysis, the following conclusions can be drawn.

**Proposition 2:** In the case where the ride hailing platform chooses a full-closed model and only hires self-operated car drivers, when the supply in the ride hailing market exceeds the demand, the best pricing scheme that maximizes the platform's revenue is  $p_1^*$ , and the maximum revenue of the platform is  $\pi_1$ . When the demand for ride hailing services exceeds supply, the best pricing scheme for the platform is  $p_2^*$ , and the maximum revenue is  $\pi_2$ .

**Inference 3:** When the supply of the ride hailing market exceeds the demand, and the relationship between the cross-network externality between passengers and drivers and their unit cost of joining the ride hailing platform satisfies  $\alpha\beta - C_C C_S < 0$ , the maximum revenue of the ride hailing platform shows a trend of first decreasing and then increasing with the increase of vehicle rental fees. When  $m = m_1^*$ , the platform's revenue is the lowest. When  $\frac{\alpha\beta - C_C C_S + C_S(\beta - C_C)}{2C_S(C_C C_S - \alpha\beta)} > 0$ , the number of self-operated car drivers increases with the increase of vehicle rental costs. When  $\frac{\alpha - C_S}{2(\alpha\beta - C_C C_S)} > 0$ , the number of passengers increases with the increase of vehicle rental costs.

**Inference 4:** When the online ride hailing market is in short supply and the relationship between the cross-network externality between passengers and drivers and their unit cost of joining the ride hailing platform satisfies  $\alpha\beta - C_C C_S < 0$ , the maximum revenue of the ride

hailing platform shows a trend of first decreasing and then increasing with the increase of platform vehicle rental fees. When  $m = m_2^*$ , the platform's revenue is the lowest. When  $CC \frac{2\alpha\beta - C_S(\beta + C_C)}{2\beta(\alpha\beta - C_C C_S)} > 0$ , the number of passengers increases with the increase of platform vehicle rental costs. When  $\frac{C_C - \beta}{2(\alpha\beta - C_C C_S)} > 0$ , the number of self-operated vehicle drivers increases with the increase of vehicle rental costs.

### 3.3 Partial Open Mode

When the ride hailing platform selects partial open mode, the utility points of passengers and two types of drivers are set to 0, and the indifference utility points of passengers and drivers can be calculated as  $x^*$  and  $y_1^*$ ,  $y_2^*$ , respectively. When the distance between passengers and drivers to the ride hailing platform is less than or equal to the indifference point, and their utility is greater than 0, passengers and drivers will choose to join the ride hailing platform. After calculation, the scale of passengers and drivers can be obtained as shown in equation (21). Based on different supply-demand conditions, the platform's revenue and best pricing scheme decision can be determined, and the impact of the platform's commission ratio or vehicle rental fees on the scale of drivers and platform profit can be analyzed. Among them,  $F = -2Dkd^* - kd^{*2}(D^2 - 2) + D^2k + 2D[w - m - p(1 - \lambda)]$ .

$$\begin{cases} n_d = \frac{2D(C_S^2 - \gamma\sigma)(u-p) + \alpha[2Dp(1-\lambda)(C_S - \gamma) + 2kd^{*2}(C_S - \sigma) + D^2k(\gamma + d^{*2}\sigma - C_S - C_S d^{*2}) - 2D(C_S - \sigma)(d^*k + m - w)]}{2D[\alpha\beta(\gamma + \sigma - 2C_S) + C_C(C_S^2 - \gamma\sigma)]} \\ n_{s1} = \frac{2\beta D(C_S - \sigma)(u-p) + C_C[2DpC_S(1-\lambda) - 2kd^{*2}\sigma + D^2k(d^{*2}\sigma - C_S) - 2D\sigma(d^*k + m - w)] + \alpha\beta F}{2D[\alpha\beta(\gamma + \sigma - 2C_S) + C_C(C_S^2 - \gamma\sigma)]} \\ n_{s2} = \frac{2\beta D(C_S - \gamma)(u-p) + C_C[2kd^{*2}C_S - 2Dp\gamma(1-\lambda) + D^2k(\gamma - d^{*2}C_S) - 2DC_S(d^*k + m - w)] - \alpha\beta F}{2D[\alpha\beta(\gamma + \sigma - 2C_S) + C_C(C_S^2 - \gamma\sigma)]} \end{cases} \quad (21)$$

When the supply of the ride hailing market exceeds the demand, the order volume  $D_3$  of the ride hailing platform is equal to the passenger scale. Assuming that the probability of the platform dispatching orders to individual vehicle drivers is  $\theta$ , and the probability of dispatching orders to self-operated car drivers is  $1 - \theta$ . Assuming that drivers who choose to join the platform will not refuse the platform's orders, the order volume for individual vehicle drivers is  $\theta n_d$ , and the order volume for self-operated car drivers is  $(1 - \theta)n_d$ . The best pricing scheme that maximizes the platform's revenue through calculation is shown in equation (22), and the maximum revenue of the platform is shown in equation (23). Among them:

$$H = -3\gamma(1 - \lambda)(1 - \theta) + C_S[(1 + D^2)(1 - \theta + \theta\lambda) - 3\lambda] - (D^2 - 2)\sigma(1 + \theta\lambda - \theta)$$

$$I = (2\gamma - 2\gamma\lambda - \sigma)(1 - \theta) + C_S(2\lambda - 1 + \theta - \lambda\theta) - \lambda\theta\sigma$$

$$G = Dk(C_S - \gamma)(2 - \lambda - 2\theta + 2\theta\lambda) + 2(m - w)[\gamma(1 - \theta)(1 - \lambda - \sigma) + \lambda(C_S - \theta\sigma)]$$

$$K = (1 - \theta)(2m - Dk - 2w) - 2u(1 + \theta\lambda - \theta)$$

$$L = 2\gamma(1 - \lambda)(1 - \theta) + C_S[2\lambda - 3 + 3\theta(1 - \lambda)] + \sigma(1 - \theta + \theta\lambda)$$

$$M = 3\gamma(1 - \lambda)(1 - \theta) + C_S[(D^2 - 5)(1 + \theta\lambda - \theta) + 3\lambda] + (D^2 - 2)\sigma(1 + \theta\lambda - \theta)$$

$$N = \gamma(1 - \lambda)(1 - \theta) - C_S(2 - \lambda - 2\theta + 2\theta\lambda) + \sigma(1 - \theta + \theta\lambda)$$

$$Q = 2[m(1 - \theta)(m - w) + u(1 + \theta\lambda - \theta)] - Dk(1 - \theta)$$

When the supply of the ride hailing market is less than the demand, the order volume  $D_3$  of the ride hailing platform is equal to the sum of the sizes of the two types of drivers. The best pricing scheme of the platform can be calculated using equation (24), and the maximum revenue can be calculated using equation (25). Among them:

$$R = 2dDk[2\gamma(1 - \lambda) + C_S - \lambda\sigma] + d^*k[(D^2 - 2)(C_S - \lambda\sigma) - 3\gamma(1 - \lambda)] + D^2k[\lambda C_S - \gamma(2 - \lambda)] + 2D(w - m)[\lambda\sigma - \gamma(1 - \lambda) - C_S]$$

$$S = 3d^*k(\gamma - C_S) + 4Dkd^*(C_S - \gamma) + D[(\gamma - C_S)(Dk - 2m) - 2u(C_S + \lambda C_S - \lambda\sigma) - 2wC_S + 2\gamma(u + w)]$$

Scenario 1: Supply  $\geq$  Demand

$$p_1^* = \frac{\alpha\{d^*kH + 2d^*DkI + DG\} + (C_S^2 - \gamma\sigma)[d^*k(4D - 3d^*)(1 - \theta) + DK]}{4D[1 - \theta(1 - \lambda)][\alpha(1 - \lambda)(\gamma - C_S) - C_S^2 + \gamma\sigma]} \quad (22)$$

$$\pi_1 = \frac{\{\alpha[d^*kM - 2d^*DkL + D^2k\lambda(C_S - \gamma) - 2DN(m - w)] - (C_S^2 - \gamma\sigma)[k(1 - \theta)(4d^*D - 3d^{*2} - D^2) + DQ]\}^2}{16D^2[\theta(1 - \lambda) - 1][\alpha(1 - \lambda)(C_S - \gamma) - C_S^2 + \gamma\sigma][\alpha\beta(\gamma - 2C_S + \sigma) + C_C(C_S^2 - \gamma\sigma)]} \quad (23)$$

Scenario 2: Supply  $<$  Demand

$$p_2^* = \frac{\alpha\beta(1 - \lambda)[d^*k(5 - D^2) - 6Dkd^* + 2D(Dk - 2m + 2w)] + C_C R + \beta S}{4D\{\alpha\beta(1 - \lambda)^2 + C_C(1 - \lambda)(\lambda C_S - \gamma) + \beta[\gamma - C_S(1 + \lambda)C_S + \lambda\sigma]\}} \quad (24)$$

$$\pi_2 = \lambda p_2^* n_{s1} + \left[ p_2^* + m - w - \left(1 - \frac{d^*}{D}\right) \frac{D - 3d^*}{2} k \right] n_{s2} \quad (25)$$

The following conclusions can be drawn from the above analysis.

**Proposition 3:** In the case of selecting a partially open mode on a ride hailing platform, where both individual vehicle drivers and self-operated car drivers are employed, when the supply in the ride hailing market exceeds the demand, the best pricing scheme that maximizes the platform's revenue is  $p_1^*$ , and the maximum revenue of the platform is  $\pi_1$ . When the demand for ride hailing services exceeds supply, the best pricing scheme for the platform is  $p_2^*$ , and the maximum revenue is  $\pi_2$ .

**Inference 5:** When the supply exceeds demand in the ride hailing market, the maximum revenue of the platform decreases with the increase of the probability of dispatching orders to individual vehicle drivers, and increases with the proportion of commission to individual vehicle drivers and the increase of rental fees for platform-owned vehicles.

**Inference 6:** When the online ride hailing market is in short supply, the maximum revenue of the platform shows a trend of first increasing and then decreasing with the increase of the platform's commission ratio to individual vehicle drivers, and increases with the increase of self-operated car rental fees.

## 4 Numerical analysis

### 4.1 Complete open model

The set parameters are as follows:  $D=30$ ,  $C_C = C_S = 1$ ,  $k = 2$ ,  $u = 10$ ,  $\alpha > 0$ ,  $\beta > 0$ .

When the supply of the ride hailing market exceeds the demand, the relationship between the platform's best pricing scheme, maximum revenue, and the platform's commission ratio is shown in Figures 4 and 5. The relationship between the scale of passengers and individual vehicle drivers and the platform's commission ratio is shown in Figure 6. When the demand for ride hailing services exceeds supply, the relationship between the platform's best pricing scheme, maximum revenue, and the platform's commission ratio is shown in Figures 7 and 8. The relationship between the scale of passengers and individual vehicle drivers and the platform's commission ratio is shown in Figure 9.

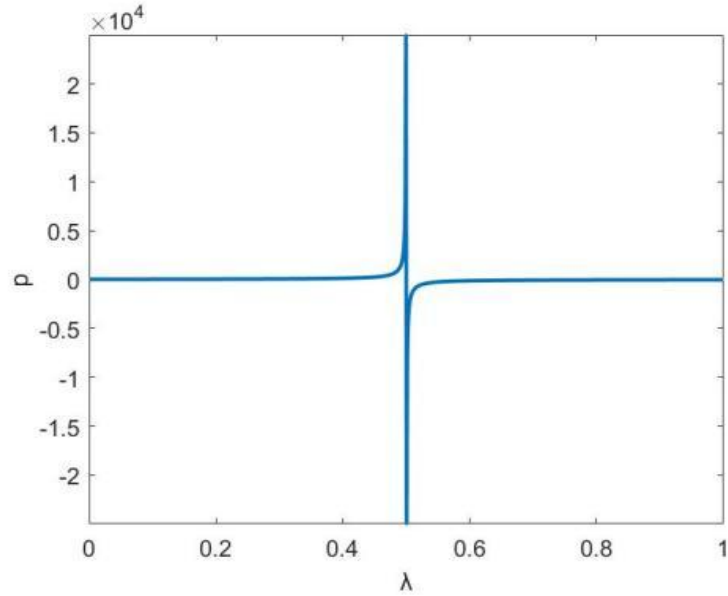


Figure 4: The relationship between best pricing scheme and  $\lambda$

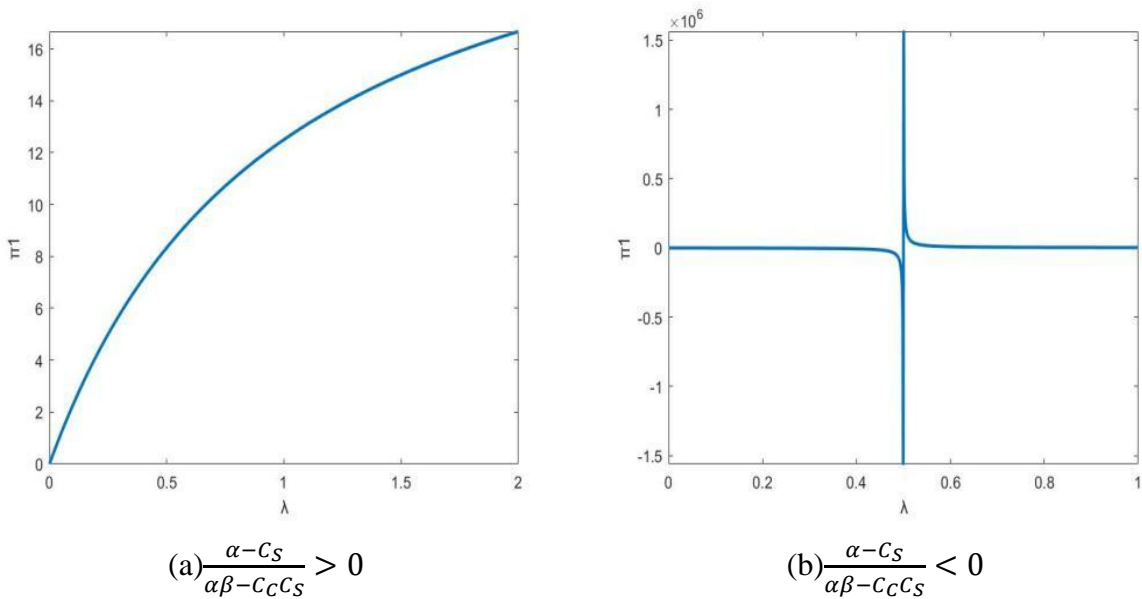


Figure 5: Relationship between Maximum Revenue and  $\lambda$

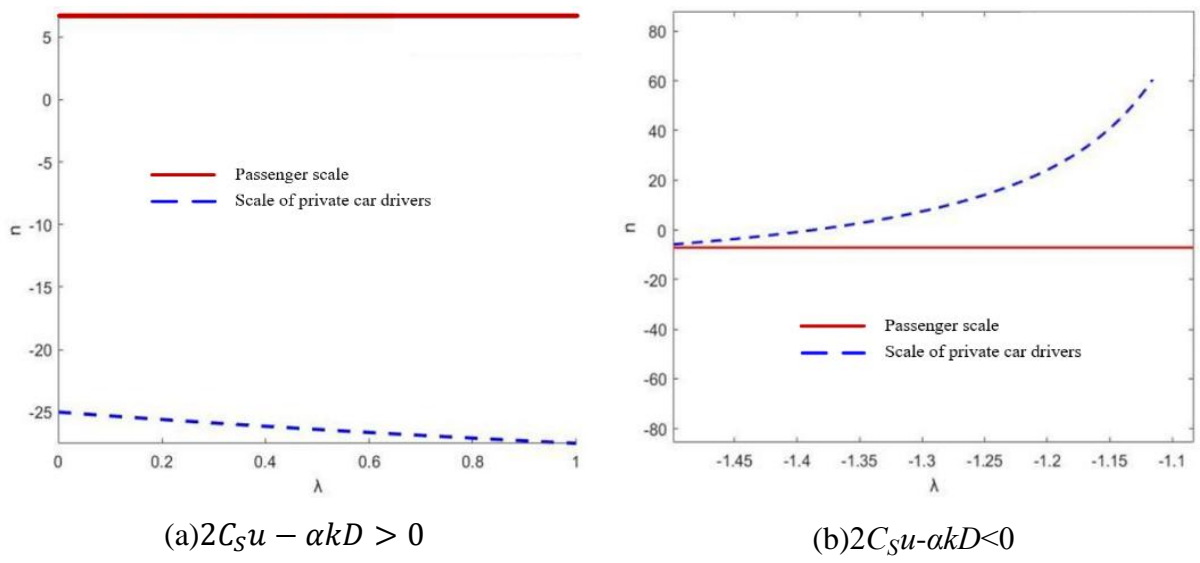


Figure 6: Relationship between passenger and private car driver scale and  $\lambda$

As shown in Figures 4 and 5, when the supply of ride hailing services in the market exceeds demand and the externalities of the cross-network between passengers and drivers satisfy  $\frac{\alpha - C_S}{\alpha\beta - C_C C_S} > 0$ , the best pricing scheme and maximum revenue of the platform both increase with the increase of the commission ratio. As shown in Figure 6, the passenger scale is not affected by the platform's commission ratio. When  $2C_S u - akD > 0$ , the scale of individual vehicle drivers is always smaller than the passenger scale, which contradicts the premise that supply is greater than demand. When  $2C_S u - akD < 0$ , the scale of individual vehicle drivers increases with the increase of the platform's commission ratio. Inference 1 has been validated.

Based on the analysis of the actual situation, when the supply of the ride hailing market exceeds the demand, some drivers are in a state of no orders to take, and the platform does not need to consider the situation of passenger loss caused by drivers not taking orders in a timely manner. When the cross-network externality between passengers and individual vehicle drivers is high, passengers and drivers are more sensitive to each other's scale. The scale of passengers has a greater positive impact on the expected utility of individual vehicle drivers, and the scale of passengers is not affected by the platform's commission ratio. Therefore, increasing the commission ratio of the platform will not lead to a decrease in the scale of drivers. Therefore, increasing the commission ratio of the platform can improve the platform's revenue. When the externalities of the cross-network between passengers and individual vehicle drivers are low, the positive impact of passenger size on the expected utility of individual vehicle drivers is low. Therefore, when the platform's commission ratio is high, the expected utility of individual vehicle drivers decreases, affecting the platform's revenue.

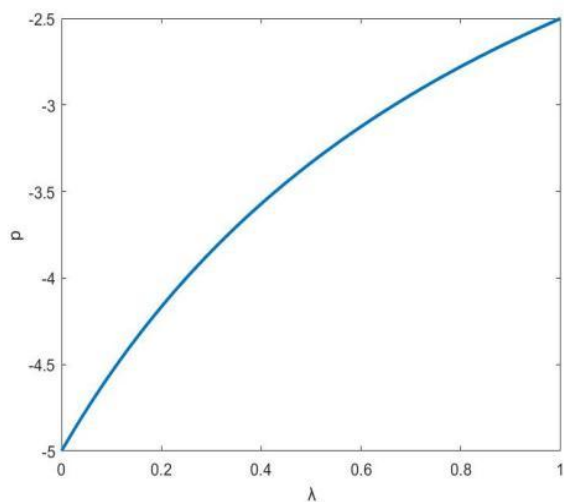
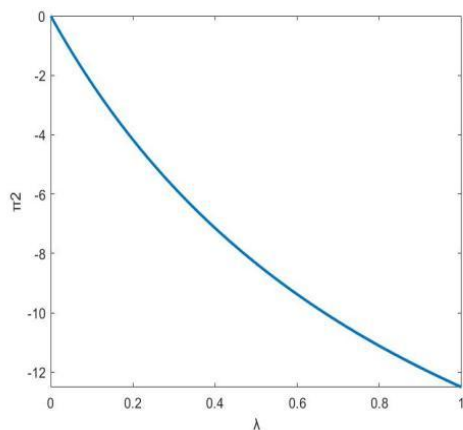
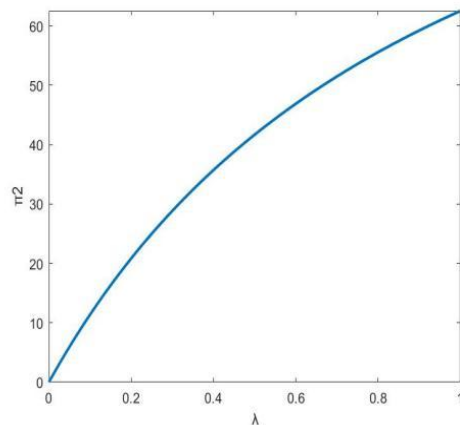


Figure 7: The relationship between best pricing scheme and  $\lambda$

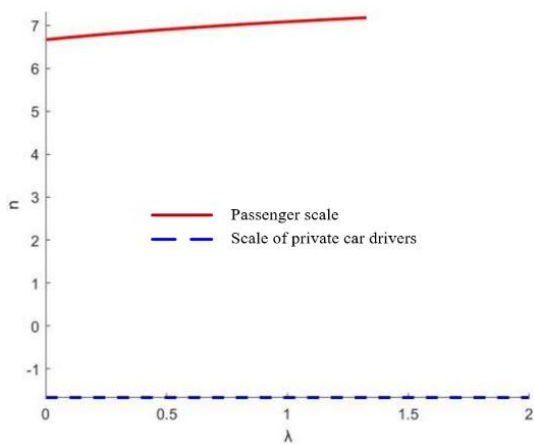


$$(a) \frac{\beta - c_c}{\alpha\beta - c_c c_s} > 0$$

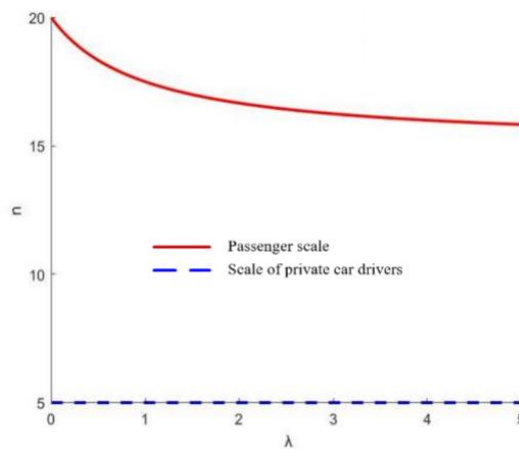


$$(b) \frac{\beta - c_c}{\alpha\beta - c_c c_s} < 0$$

Figure 8: Relationship between Maximum Revenue and  $\lambda$



$$(a) 2\beta u - C_c k D > 0$$



$$(b) 2\beta u - C_c k D < 0$$

Figure 9: Relationship between passenger and private car driver scale and  $\lambda$

As shown in Figures 7 and 8, when the online ride hailing market is in short supply, the best pricing scheme of the platform increases with the increase of the commission ratio. When  $\frac{\beta - C_C}{\alpha\beta - C_C C_S} > 0$ , the maximum revenue of the platform decreases with the increase of the commission ratio. As shown in Figure 9, the scale of individual vehicle drivers is not affected by the platform's commission ratio. When  $2\beta u - C_C kD > 0$ , the passenger scale increases with the increase of the platform's commission ratio. Inference 2 has been validated.

During the peak period of car usage, the online ride hailing market is in short supply, and drivers who join the platform can receive orders. The expected utility of drivers is greater than 0, and increasing the commission ratio of the platform will not make the utility of drivers less than 0. Therefore, individual vehicle drivers who have already joined the platform will not leave the platform, and the scale of drivers will not decrease. However, increasing the platform commission percentage will reduce the willingness of individual vehicle drivers who have not joined the platform to join, resulting in lower order volume on the platform.

### 4.2 Full-closed model

The set parameters are as follows:  $D=30, C_C = C_S = 1, k = 2, u = 10, d^* = 15, w = 3, \alpha > 0, \beta > 0$ . When the supply of the ride hailing market exceeds the demand, the relationship between the best pricing scheme of the platform and the rental cost of platform-owned vehicles is shown in Figure 10, and the relationship between maximum revenue and the rental cost of platform-owned vehicles is shown in Figure 11. The relationship between the scale of passengers and self-operated car drivers and vehicle rental costs is shown in Figure 12. When the online ride hailing market is in short supply, the relationship between the best pricing scheme of the platform and the rental cost of platform-owned vehicles is shown in Figure 13, and the relationship between maximum revenue and the rental cost of platform-owned vehicles is shown in Figure 14. The relationship between the scale of passengers and self-operated car drivers and vehicle rental fees is shown in Figure 15.

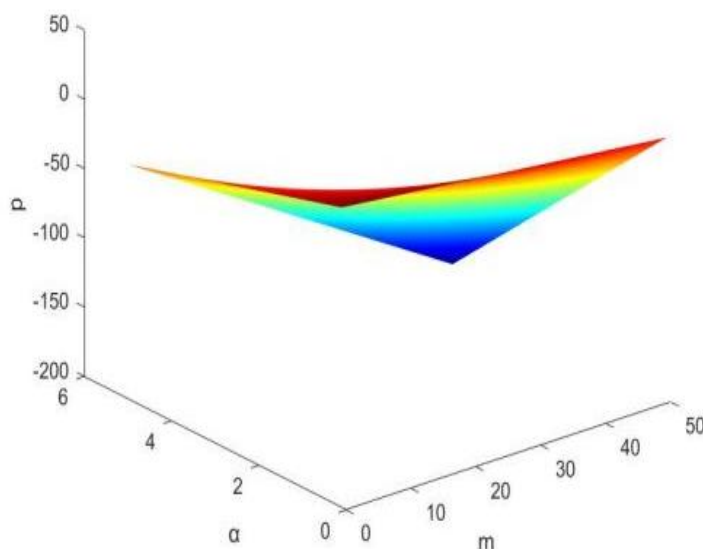
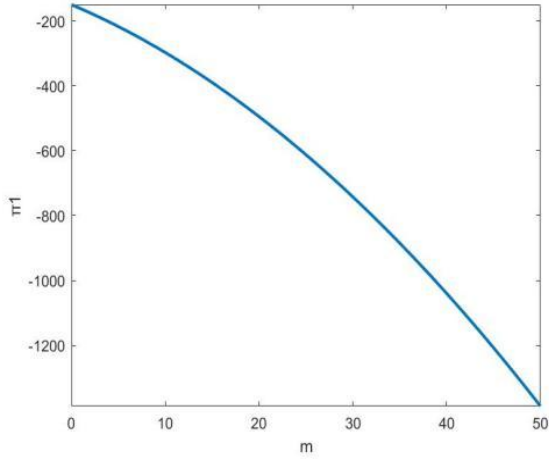
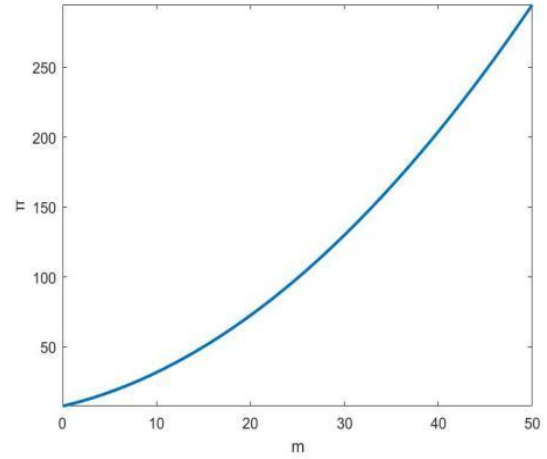


Figure 10: The Relationship between Best pricing scheme and  $\alpha$  and  $m$

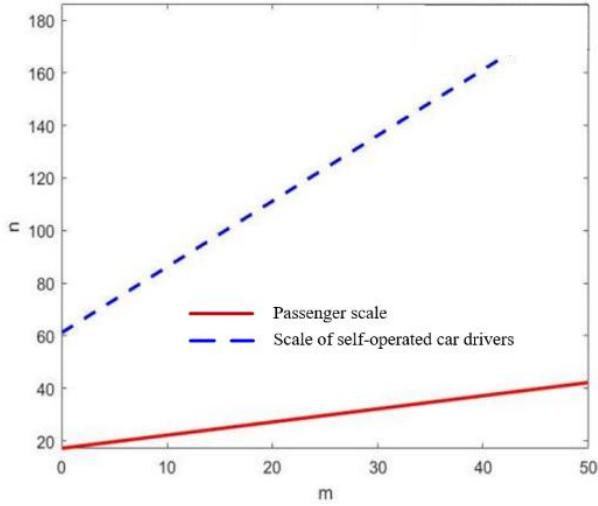


$$(a) \alpha\beta - C_C C_S > 0$$

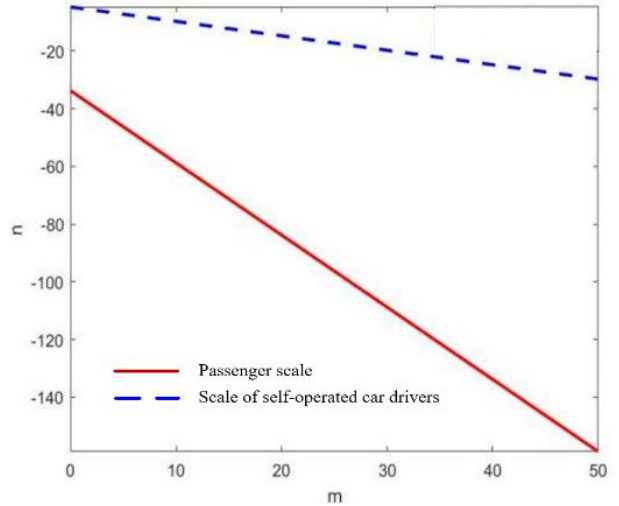


$$(b) \alpha\beta - C_C C_S < 0$$

Figure 11: Relationship between Maximum Revenue and  $m$



$$(a) \frac{\alpha\beta - 2C_C C_S + C_S \beta}{2C_S(C_C C_S - \alpha\beta)} > 0, \frac{\alpha - C_S}{2(\alpha\beta - C_C C_S)} > 0$$



$$(b) \frac{\alpha\beta - 2C_C C_S + C_S \beta}{2C_S(C_C C_S - \alpha\beta)} < 0, \frac{\alpha - C_S}{2(\alpha\beta - C_C C_S)} < 0$$

Figure 12: Relationship between passenger and self-operated vehicle driver scale and  $m$

As shown in Figures 10 and 11, when the supply exceeds the demand in the ride hailing market, the best pricing scheme of the platform increases with the increase of vehicle rental fees. When  $\alpha\beta - C_C C_S > 0$ , the maximum revenue of the platform decreases with the increase of vehicle rental fees. As shown in Figure 12, when the cross-network externality between passengers and self-operated vehicle drivers satisfies  $\frac{\alpha\beta - 2C_C C_S + C_S \beta}{2C_S(C_C C_S - \alpha\beta)} > 0$ ,  $\frac{\alpha - C_S}{2(\alpha\beta - C_C C_S)} > 0$ .

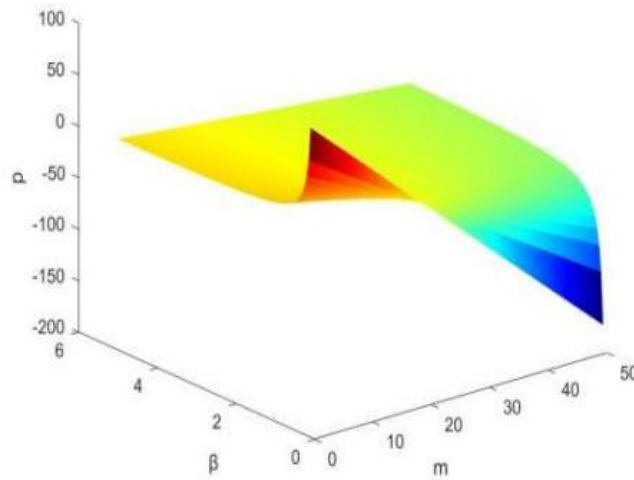
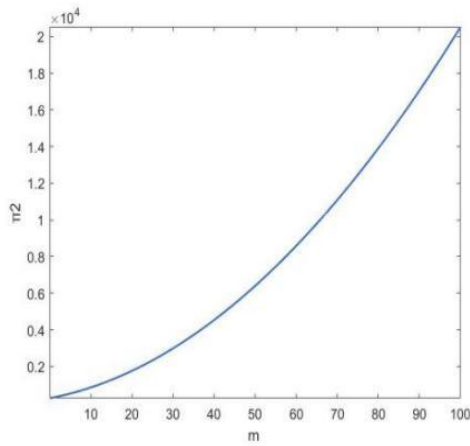
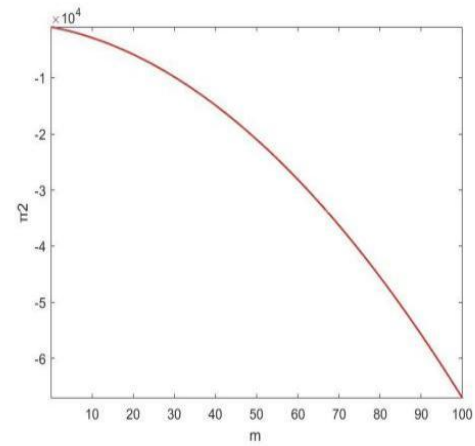


Figure 13: The relationship between best pricing scheme and  $\beta$  and  $m$

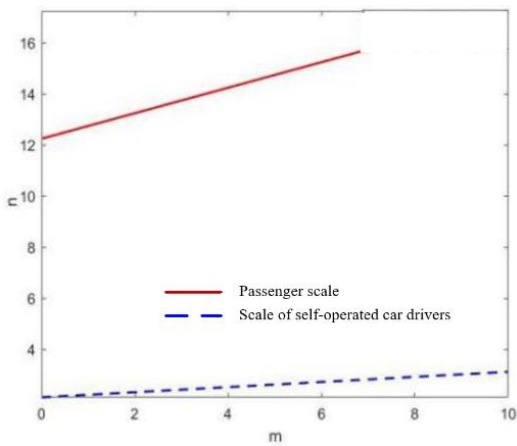


(a)  $\alpha\beta - C_C C_S < 0$

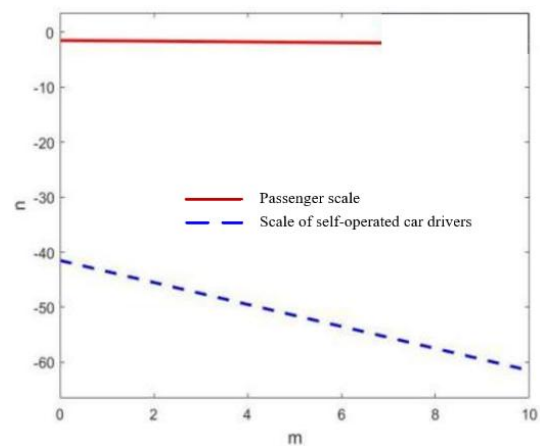


(b)  $\alpha\beta - C_C C_S > 0$

Figure 14: Relationship between Maximum Revenue and  $m$



(a)  $\frac{2\alpha\beta - C_S(\beta + C_C)}{2\beta(\alpha\beta - C_C C_S)} > 0, \frac{C_C - \beta}{2(\alpha\beta - C_C C_S)} > 0$



(b)  $\frac{2\alpha\beta - C_S(\beta + C_C)}{2\beta(\alpha\beta - C_C C_S)} > 0, \frac{C_C - \beta}{2(\alpha\beta - C_C C_S)} > 0$

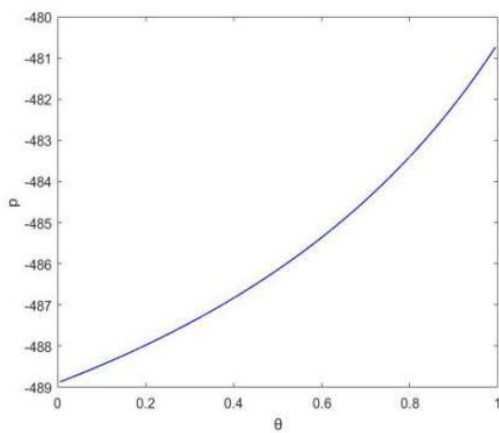
Figure 15: Relationship between passenger and driver scale and  $m$

At that time, the scale of self-operated car drivers and passengers both increased with the increase of vehicle rental fees. Inference 3 has been validated. The supply of the ride hailing market exceeds demand, and some self-operated car drivers have no orders to take on. When the externalities of the cross-network between passengers and self-operated car drivers are large enough, both passengers and self-operated car drivers are sensitive to each other's scale. Increasing the rental cost of vehicles will lead to a decrease in the scale of drivers. After passengers perceive this information, their expected utility decreases, and the number of passengers joining the platform decreases, resulting in a decrease in the maximum revenue of the platform.

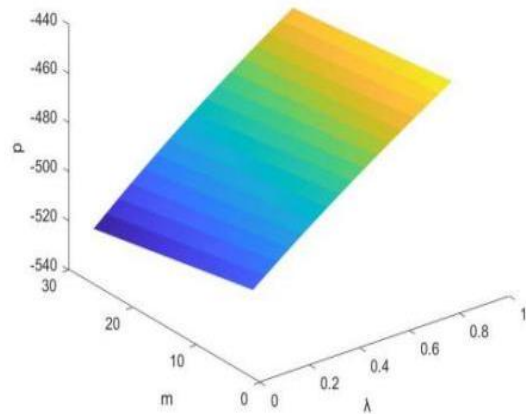
As shown in Figures 13 and 14, when the demand for ride hailing services exceeds supply, the best pricing scheme of the platform decreases with the increase of vehicle rental fees. When  $\alpha\beta - C_C C_S > 0$ , the maximum revenue of the platform decreases with the increase of vehicle rental fees. As shown in Figure 15, when the cross-network externality between passengers and self-operated vehicle drivers satisfies  $\frac{2\alpha\beta - C_S(\beta + C_C)}{2\beta(\alpha\beta - C_C C_S)} > 0$ ,  $\frac{C_C - \beta}{2(\alpha\beta - C_C C_S)} > 0$ . At that time, the scale of self-operated car drivers and passengers both increased with the increase of vehicle rental fees. Inference 4 has been validated. The online ride hailing market is in short supply, and some passengers' travel needs cannot be met in a timely manner. When the cross-network externality between passengers and self-operated car drivers is large enough, both passengers and self-operated car drivers have a relatively high sensitivity to each other's scale. Increasing vehicle rental fees leads to a decrease in the expected utility of drivers, which in turn reduces the platform's order volume and revenue.

### 4.3 Partial Open Mode

The set parameters are as follows:  $D=30$ ,  $C_C = C_S = 1$ ,  $k = 2$ ,  $u = 10$ ,  $d^* = 15$ ,  $w = 3$ ,  $\alpha > 0$ ,  $\beta > 0$ . When the supply of the ride hailing market exceeds the demand, the relationship between the best pricing scheme of the platform and different coefficients is shown in Figure 16, and the relationship between maximum revenue and different coefficients is shown in Figure 17. When the demand for ride hailing services exceeds supply, the relationship between the best pricing scheme of the platform and different coefficients is shown in Figure 18, and the relationship between maximum revenue and different coefficients is shown in Figure 19.

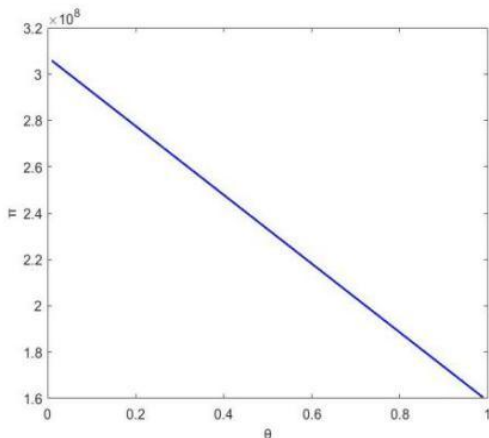


(a) The relationship between best pricing scheme and  $\theta$

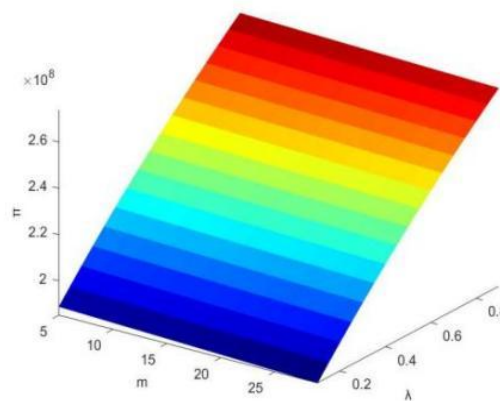


(b) best pricing scheme and  $m, \lambda$

Figure 16: The relationship between best pricing scheme and different coefficients



(a) The relationship between maximum profit and  $\theta$



(b) maximum profit and  $m, \lambda$

Figure 17: The relationship between maximum returns and different coefficients

As shown in Figure 16, when the supply of the ride hailing market exceeds the demand, the best pricing scheme of the platform increases with the probability of dispatching individual vehicle drivers by the platform, increases with the proportion of commission for individual vehicle drivers by the platform, and decreases with the increase of rental fees for platform-owned vehicles. As shown in Figure 17, the maximum revenue of the platform decreases with the increase of the probability of dispatching orders to individual vehicle drivers, and increases with the proportion of commission given by the platform to individual vehicle drivers and the increase of rental fees for platform-owned vehicles. Inference 5 has been validated.

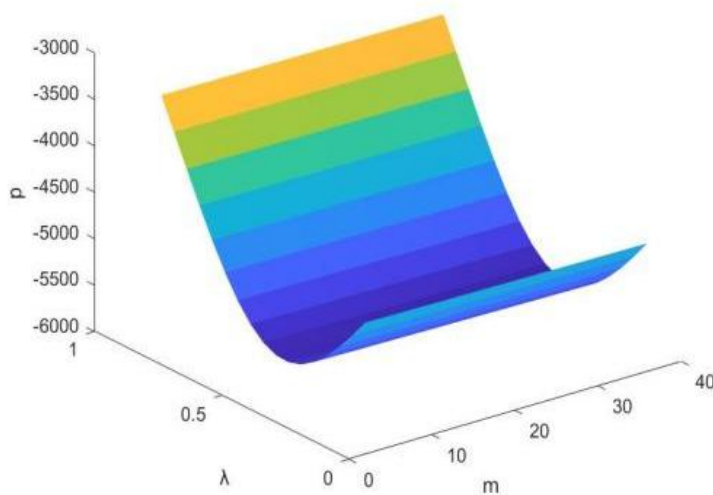


Figure 18: The relationship between best pricing scheme and different coefficients

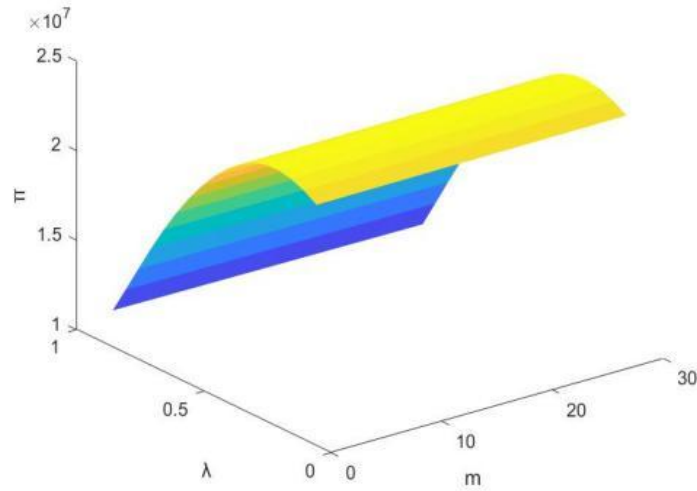


Figure 19: The relationship between maximum returns and different coefficients

As shown in Figure 18, the best pricing scheme of the platform shows a trend of first decreasing and then increasing with the increase of the platform's commission ratio to individual vehicle drivers, and gradually decreasing with the increase of self-operated vehicle rental fees. As shown in Figure 19, the maximum revenue of the platform shows a trend of first increasing and then decreasing with the increase of the platform's commission ratio to individual vehicle drivers, and gradually increasing with the increase of self-operated car rental fees. Inference 6 has been validated.

At the same parameter level, compare the platform returns under the three modes, as shown in Figure 20. It can be observed that when the supply of the ride hailing market exceeds the demand, at the same price level, a partially open model can bring greater profits to the platform. When the demand for ride hailing services exceeds supply, a partially open model brings the least revenue to the platform, while a full-closed model can bring greater revenue to the platform.

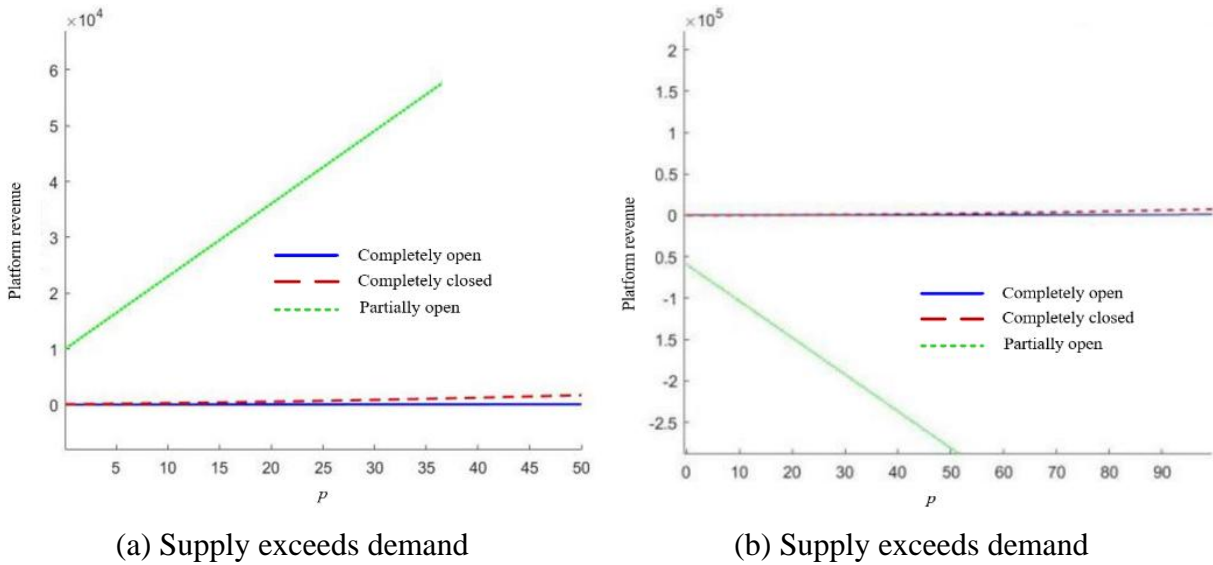


Figure 20: Comparison of platform profit under different open modes

## 5 Conclusion

This article constructs a Hotelling spatial competition model and considers the cross-group network effects of the ride hailing market. It studies and analyzes the impact of the platform's commission ratio for individual vehicle drivers and self-operated car rental fees on platform profit and the size of drivers and passengers under different supply-demand conditions when the platform adopts different open modes. It also compares and analyzes which open mode can bring greater revenue to the platform under different supply-demand conditions. The research results indicate that when the supply in the online ride hailing market exceeds the demand, platforms should prioritize dispatching orders to self-operated car drivers. Increasing the fees charged to drivers by the platform can avoid wasting driver resources and increase platform profit. When the demand for ride hailing services exceeds supply in the market, all drivers on the platform can receive orders. At this time, the platform can adjust the commission ratio for individual vehicle drivers based on the externalities of the cross-network between passengers and drivers, in order to maximize the platform's revenue. At the same time, the platform can increase its revenue by raising the rental fees for platform-owned vehicles.

Based on the above conclusions, it can be found that some of the research results in this article differ from people's conventional thinking. For example, in some contexts, the platform's increase in the commission ratio for individual vehicle drivers or the increase in self-operated car rental fees can lead to an increase in the number of drivers. However, despite this, the final impact of changes in the fees charged by the platform to drivers on the platform's revenue still conforms to the reality. From this, it can be seen that the revenue of ride hailing platforms is not only influenced by the scale of drivers and passengers, but platforms should also consider the long-term perspective when making decisions. Based on this, this article proposes the following suggestions for ride hailing platforms: (1) Ride hailing platforms should timely understand the supply-demand condition of the ride hailing market and make optimal decisions based on different market supply-demand conditions; (2) Online ride hailing platforms with strong comprehensive strength should adjust their opening strategies according to the supply-demand condition of the ride hailing market, in order to obtain greater profits; (3) When making decisions, ride hailing platforms should consider the cross-group network effects between passengers and drivers in order to adjust their operational strategies.

Finally, the research findings of this article to some extent compensate for the shortcomings of existing studies, but there are still certain limitations: (1) This article assumes that there is only one ride hailing platform in the market, without considering the competition between ride hailing platforms, which is inconsistent with the reality. Further analysis should be conducted in subsequent research to make the research results more valuable for reference. (2) This study is based on an idealized environment and ignores some practical factors. In future research, a more comprehensive analysis should be conducted.

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