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# Operational Analysis of Urban Intelligent Transportation System and Strategies for Future Development - Taking Calling Service of Taxi in Wuhan as an Example

Wang Xu, Yao Yangyang, Lin Ying, and Wang Zhenzhen



***Abstract*—**Intelligent Transportation System integrates various modern advanced technologies into the ground transportation system, and it will be the goal of urban transport system in the future because of its comprehensive effects. However, it also brings some problems, such as project performance assessment, fairness of benefiting groups, fund management, which are directly related to its operation and implementation. Wuhan has difficulties in organizing transportation because of its nature feature (river and lake), therefore, calling Service of Taxi plays an important role in transportation. This paper researches on calling Service of Taxi in Wuhan, based on quantitative and qualitative analysis. It analyzes its operations management systematically, including business model, finance, usage analysis and users evaluation. As for business model, it is that the government leads the operation at the initial stage, and the third part dominates the operation at the mature stage, which not only eases the pressure of the third part and benefits the spread of the calling service at the initial stage, but also alleviates financial pressure of government and improve the efficiency of the operation at the mature stage. As for finance, it draws that this service will bring heavy financial burden of equipments, but it will be alleviated in the future because of its spread. As for usage analysis, through data comparison, this service can bring some benefits for taxi drivers, and time and spatial distribution of usage have certain features. As for user evaluation, it analyzes using group and the reason why choosing it. At last, according to the analysis above, the paper puts forward the potentials, limitations, and future development strategies for it.

***Keywords*—**Assessment, Calling service of taxi, Operations management, Strategies, Using groups.

## I. Introduction

INTELLIGENT transportation system integrates advanced information technology, communications transmission technology, electronic sensor technology, control technology and computer technology effectively into traffic management system, so as to establish a wide range, timely, accurate, and efficient transport system. Intelligent transportation system can be benefitial to improve efficiency of existing transportation facilities, reduce the environmental pollution of traffics, ensure traffic safety, and so on [1], [2]. Therefore, it has attracted lots of attentions, and it has become the goal of many cities. While bringing up conveniences, some problems also emerge, such as who operates it, how to obtain funds, fairness of service, and assessment of its performance, all of which will influence its future development. This paper takes calling Service of Taxi in Wuhan as an example to analyze it.

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## II. Brief Description

Taxies are the important part of the public transportation in Wuhan, because of its flexibility and convenience. However, there exit many problems in its operation, such as difficult for the car to find potential users, difficult for the users to get a taxi available in some emergency, inconvenient for special groups to take taxi. All of these problems not only cause the roads are congested and fuels are wasted, but also lead to inconvenience for the citizens.

In order to ease this difficulty, the government of Wuhan increases another 1317 taxis in February 2012, and the total number of taxis reaches 15437[3]. This action also brings up problems. If the increase of taxis is too small, it cannot fundamentally solve the problems. And if the increase is too large, it will have negative impact on the taxi industry.

According to the estimation of relevant ministry, the reasonable amount of taxis is 16600 in Wuhan, but amount of taxis in Wuhan has overreached this number. In addition to increasing the number of taxis, a device, which can improve the efficiency of taxi operation, should be created to connect the users with taxis, in order to meet the soaring demands. On April 1, 2012, calling service is launched in Wuhan. Nearly 5000 taxis are equipped with this calling service device. This number will reach 8000 by the end of this year. Since the service is launched, some people believe that this project is beneficial to living trip for citizens. However, some people argue that the quality of the service is poor, which also costs lots of money, because of its low success rate. Therefore, the authors analyze the management of calling service with quantitative and

qualitative research method.

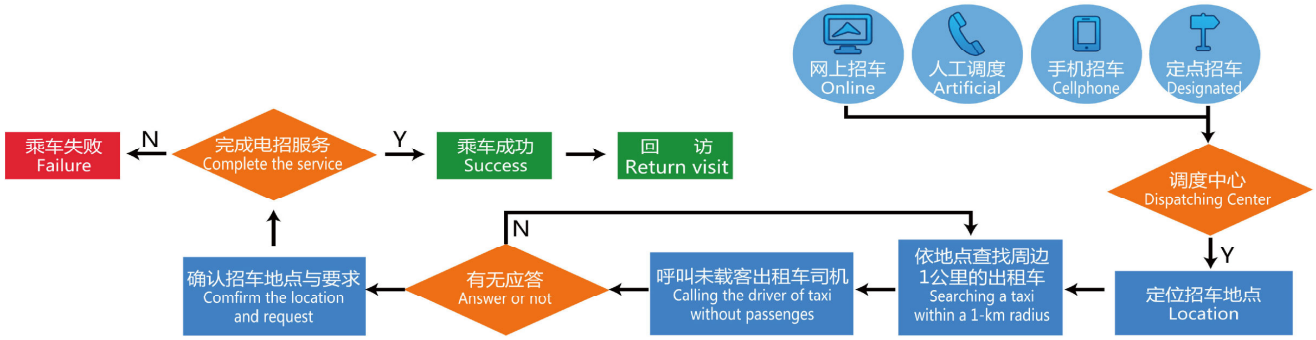



Fig. 1 Procedure for the calling service of taxi

## III. Management

### A. How to Manage

The intelligent calling service system of taxi consists of management platform, control center and vehicle terminal. The operation mode is as follow:

Firstly, users should ask the control center for calling service. Secondly, the operator of the system will search calling service taxis without passengers, 1km around the passenger, and feedback the telephone numbers and related information of taxis available to the user. Finally, the user will get touch with the taxi driver, to confirm the location and get on the taxi, beginning the calling service. When the user reaches the destination, the user should pay extra 2 Yuan to the driver for the calling service. And system will record service information and the contact of user for telephone interview next time (Fig. 1).

The intelligent calling service system of taxi provides a various ways of calling taxi for the citizens in Wuhan:

1) Online service: Login Wuhan Intelligence Operations System of taxi (www.02766667777.com), input the boarding location online, and then calling service system will book a taxi for you;
2) Manual service: Call the taxi control center (027-66667777 Tel) to apply for calling taxi service and locate boarding place;
3) Cell phone GPS service: Download and install the GPS software in the smart phone, and use mobile phone GPS positioning function to automatically search the non-passenger taxi within 1km near the user' locations.
4) Special places' service: equip the special locations such as hotels, railway stations and other public places, with the calling service terminals [4].

### B. Guarantee for Management

During the process of using calling service, there are some phenomena of dishonesty. For example, taxi drivers who have already promised to take this order, fail to pick up the user of calling service, because of picking up other passenger on the halfway. At the same time, some users of calling service break the promise, because the users find other taxis instead, when waiting for the coming drivers who have accepted the order of calling service. Therefore, the intelligent calling service of taxi in Wuhan comes up with an agreement of the service:

On the one hand, if the taxi driver, who has accepted the orders on call, but breaks the contract without reasonable factors, will be punished with stoppage in transit for 15 days after verified.

On the other hand, if one user breaks the appointments, his information will be recorded. If one user has 2 times default records, he cannot use the calling service any longer. The calling service agreement increases the penalty costs for those taxi drivers and users who are defaulting in calling service, and it promotes the success rate of calling service.

## IV. Business Model

According to the characteristics of every city, there are three different operating models as follow government operate dominantly, each taxi company operate alone and the third part operate as whole (Table I). The operating model in Wuhan is combination of government-led operation and third-part operation. The government leads the operation at the initial stage, and the third part dominates the operation at the mature stage.

The operating company invests the equipments alone, to establish the information center and the control center. At the initial stage, the government plays a dominant role in the operation, and pay 60 ¥ for each taxi to the operating company, which can sustain the operation of calling service. One user should hand in extra 2 ¥ to the driver for using calling service, which leads to popularizing the calling service. At the mature stage, if the business volume increases a lot, the government will cancel the financial support, and let the operating company work alone. The operating company can earn the money through the fees which are paid by users 2 ¥ per deal, to meet the expense. This kind of model not only eases the pressure of the third part and promotes the popularization of the calling service at the initial stage, but also alleviates the financial pressure of government and improves the efficiency of the operation at the mature stage.

TABLE I
OPERATING MODEL COMPANION IN CHINA

| Operating Model | Strengths | Weakness | Representative |
|---|---|---|---|
| Government-led operation | 1. better control in operation<br>2. less cost for users | Subsidy policy may bring financial burden | Suzhou |
| Taxi's company operating model | Could control the taxis of its own company better and bring up strong power of execution | 1.disintegrate the resource leading to low efficiency of operation; 2.inconvenient, needs to call different control centers sometimes | Shanghai |
| Third-party operation model | Integrate the resource, improve the efficiency of the calling service | Higher price for users | Beijing |

Source: Authors summarize through the materials online

## V. FINANCIAL CALCULATION

### *A. Financial Calculation at the Initial Stage (2012)*

The costs of the calling service system consist of two parts, terminals, control center (including equipment human resource, house rent and so on). This operating company Suzhou Tianze Information Technology Co. almost invests all cost alone. At the initial stage of operation, it has invested 5000 Car GPS terminals (Table II). The equipments of control center cost ￥4,536,000 annually. HR costs are about ￥2.125 million (Table III). Fees of communications and housing rent are about ￥ 400 million. Maintenance of vehicle equipment costs ￥12.6 million annually. Summarizing all above, the investment is about ￥6757200, if considering the usage of equipment for 5years. Without this consideration, the costs will reach 16506000 in the first year.

TABLE II
VEHICLE TERMINAL AT INITIAL STAGE

| Post | Numbers | Annual salary | Subtotal |
|---|---|---|---|
| The dispatchers | 44 | 36000 | 1584000 |
| Customer service staff | 6 | 36000 | 216000 |
| Technical repair personnel | 5 | 42000 | 210000 |
| Managers | 2 | 57600 | 115200 |
| Total | | | 2125200 |

TABLE III
ANNUAL COST OF HR AT INITIAL STAGE

| Investment content | Unit price | Number | Subtotal |
|---|---|---|---|
| Vehicle terminal | 1480 | 5000 | 7400000 |
| SD card | 30 | 5000 | 150000 |
| Installation fee | 20 | 5000 | 100000 |
| Total | | | 7650000 |

TABLE IV
LIST OF THE INCOME AND EXPENSE AT THE INITIAL STAGE

| Program | Note | Subtotal (calculate by convertion) | Subtotal (calculate by no convertion) |
|---|---|---|---|
| Allowance of government | Subsidize 720 Yuan for one taxi a year, 5000 in total | 3600000 | 3600000 |
| Investment of terminals | 7650000 Yuan in total, could be used for 5 years | -1530000 | -7650000 |
| Investment of control center | 4536000, this equipment could be used for 5 years | -907200 | -4536000 |
| Investment of human resource | 2125200 Yuan in total | -2120000 | -2120000 |
| Investment of rent and communication etc | 2200000 in total | -2200000 | -2200000 |
| Total | | -3157200 | -12906000 |

Source: Suzhou Tianze Information Technology Co. Ltd.

In order to maintain the operation of intelligent calling service system of taxi, the operating system will charge ￥60 per month of each taxi as management fee. However, the fees are paid by the government. This fund is about ￥3.6 million.

Therefore, even with the fund from the government, there exists a big gap between income and investment (Table IV).

### *B. Financial Budget at the Mature Stage*

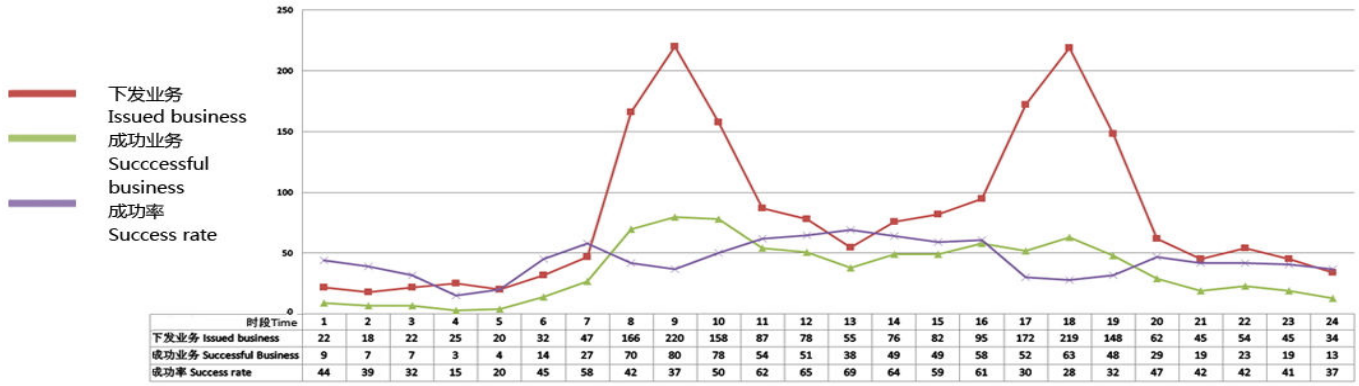
The operating company will expand the amount of the taxis to 15000, causing both the increase of the income and costs. According to the budget of the company, because of the reserve for human resource and equipment, the variable quantity of the income and cost are different. With the development of the calling service, the cooperation can gain profits (Table V).

TABLE V
COST OF DAILY HR OPERATION

| Program | Allowance of government | Investment of terminals | Investment of control center | Investment of human resource | Investment of rent and communication etc | total |
|---|---|---|---|---|---|---|
| Calculate by convertion | 10800000 | -4590000 | -998000 | -2332000 | 2420000 | 460 000 |

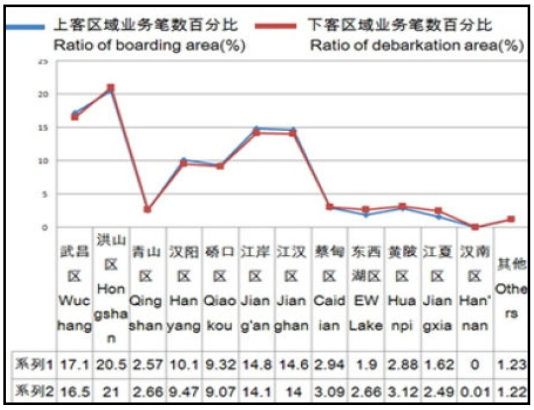
Source: Suzhou Tianze Information Technology Co. Ltd.

When the business volume of the calling service stays stable, government no longer funds this program. And the fees 2 Yuan per deal paid by the users to the drivers are transferred to operating company. Therefore, in order to strike the balance of the income and the costs, the business volume of calling service should increase 14000 deals per day.




| 时段Time | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 下发业务 Issued business | 22 | 18 | 22 | 25 | 20 | 32 | 47 | 166 | 220 | 158 | 87 | 78 | 55 | 76 | 82 | 95 | 172 | 219 | 148 | 62 | 45 | 54 | 45 | 34 |
| 成功业务 Successful Business | 9 | 7 | 7 | 3 | 4 | 14 | 27 | 70 | 80 | 78 | 54 | 51 | 38 | 49 | 49 | 58 | 52 | 63 | 48 | 29 | 19 | 23 | 19 | 13 |
| 成功率 Success rate | 44 | 39 | 32 | 15 | 20 | 45 | 58 | 42 | 37 | 50 | 62 | 65 | 69 | 64 | 59 | 61 | 30 | 28 | 32 | 47 | 42 | 42 | 41 | 37 |

Fig. 2 Time distribution of the daily business volume of the calling service in Wuhan
Source: Suzhou Tianze Information Technology Co. Ltd.




| | 武昌区 Wuchang | 洪山区 Hongshan | 青山区 Qingshan | 汉阳区 Hanyang | 硚口区 Qiaokou | 江岸区 Jiang'an | 江汉区 Jianghan | 蔡甸区 Caidian | 东西湖区 EW Lake | 黄陂区 Huapi | 江夏区 Jiangxia | 汉南区 Hannan | 其他 Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 系列1 | 17.1 | 20.5 | 2.57 | 10.1 | 9.32 | 14.8 | 14.6 | 2.94 | 1.9 | 2.88 | 1.62 | 0 | 1.23 |
| 系列2 | 16.5 | 21 | 2.66 | 9.47 | 9.07 | 14.1 | 14 | 3.09 | 2.66 | 3.12 | 2.49 | 0.01 | 1.22 |

Fig. 3 Business volume comparison of calling service between aboard and debarkation in each district of Wuhan
Source: Suzhou Tianze Information Technology Co. Ltd.

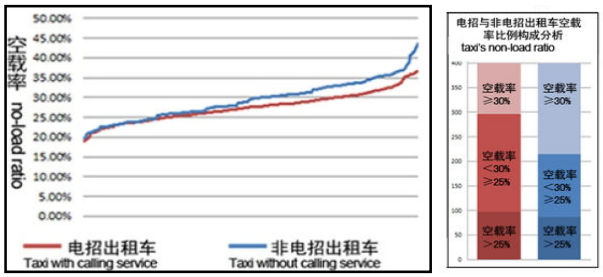



Fig. 4 Success rate comparison between axis with calling service and taxis without calling service in Wuhan
Source: Suzhou Tianze Information Technology Co. Ltd.

TABLE VI
PERFORMANCE COMPARISON BETWEEN TAXIS WITH CALLING SERVICE AND TAXIS WITHOUT CALLING SERVICE IN WUHAN

| Average of each taxi | | |
|---|---|---|
| | Sample with calling service | Sample without calling service |
| Operating mileage | 3259 | 3229 |
| Passenger mileage(km) | 2359 | 2279 |
| No-load mileage (km) | 903 | 951 |
| Total turnover(Yuan) | 6305 | 6079 |
| Total business | 346 | 339 |
| Full-load time(Hour) | 81 | 79 |
| Non-load rate(%) | 2755 | 2933 |

Source: Suzhou Tianze Information Technology Co. Ltd.

## VI. ANALYSIS OF USAGE

Authors take one week (April 18 to April 24) as research period, and randomly select 400 taxis with calling service and 400 taxis without calling service as research samples.

### *A. Business Volume and Turnover*

The total business volume of the 400 taxis with calling service is calculated (Table VI). The business volume of these taxis is 635 times, and total business volume including the calling service and non-calling service is 137,554 times. The business volume of calling service is about 0.46% of the total volume. Turnover of calling service of these taxis is 15,574.6 Yuan, and the total turnover including the calling service and non-calling service is 2,507,986.2 Yuan. The percentage of the call service is 0.62% of the total turnover. At the same time, the authors randomly select 400 non-calling service taxis. The total business volume of these taxis is 137,747 times and total turnover is 2,421,685 Yuan. By calculating, it says that, the percentage of the business volume of the calling service is 0.46%, which is lower than its turnover percentage 0.62%. Additionally, it proves that the turnover per business of the calling service is higher than non-calling service.

### *B. Time Distribution of the Booking Business, Successful Business, and Success Rate*

Calculate the business volume per hour (Fig. 2). There are two peaks in this time distribution: one is located between 7 and 10 AM, and the business volume is 181 times per hour on average. The other one is between16 and 19 PM, and the business volume is 179 times per hour. The time distribution of successful business almost agrees with the trend of the booking service, but a little gentle. There exits one peak in this distribution, located between 7-10 o'clock, and the business volume is 76 times per hour on average. By the contrary, the trend of success rate goes against the former two. The peak is between 10 and16 AM, when amount of booking business reaches the bottom. And the success rate of the peak hours is 63% on average. There are two valleys of success rate. One is located between 7 and 10 AM, 43% on average, and the other one stays between 16 and 19 PM, 30% on average. The time of these two valleys, exactly, are the time when the peaks of the

book business are. The time of lowest success rate is between 3-5 o'clock in the morning, 17.5 on average.

### C. The Spatial Distribution of the Business Volume and Turnover

Calculate the business volume in each district of Wuhan. The business volume of the seven districts is closed, basically striking the balance. The business volume in the main city holds 77.77%, and the percentage in Qingshan district is the lowest, about 2.57% (Fig. 3).

### D. Load Rate Comparison between Taxis with Calling Service and that without Calling Service

Non-load rate is an important index for the taxi which can reflect the operating condition. Non-load rate can be defined as: K=S1/S2 (K-taxi's average rate of non-load driving, S1-taxi's non-load mileage, S2-taxi's total mileage) [5]. Input the sample data of the taxis with calling service and without calling service. The average non-load rate of the 400 taxis with the calling service is 27.55%, by comparison, it is 29.33 for taxis without calling service (Fig. 4). By analyzing the composition structure of the non-load rate, the composition structure of the non-load rate for the taxis without calling service, which is above 30%, 25%-30%, below 25%, is respectively 47%, 31%, 22%. However for the taxis with calling service, it is respectively 26%, 49%, 25% (Fig. 5).

By analysis, the average non-load rate of the calling service group is lower than that of the non-calling service group. And the percentage of the high non-load rate (above 30%) of the calling service group is comparatively less. The conclusion that the calling service can lower the non-load rate of the taxis and improve the efficiency*, is arrived.*

### E. Taxi with Calling Service Has More Economic Efficient

Based on 400 taxi sample with calling service statistics, we calculated one week average performance of each taxi. The average turnover of calling service is ￥24.5, and the average turnover of taxi without calling service is ￥18 (Table VI). The one week business items of calling service taxi sample groups is 346 times, the turnover is ￥6305, and the carrying kilometers is 2356 km. On the contrary, the one week business items of non-calling service taxi sample groups is 339 times, the turnover is ￥6079, and the carrying kilometers is 2279 km. During our research, calling service taxi shows more turnover, further carrying kilometers, and that means more business and more profit.

## VII. Assessment of Users

The authors randomly call back 111 people who phone the commanding center to book the taxis, to enquire the details of this service. There are 73 people succeeding to use the service, and the success rate is 65.76%. The details about the users are analyzed as follow.

### A. Why Use Calling Service

Analyze the reasons why these 73 people choose calling service, and the reasons are shown below (Fig. 5)

1)traffic congestion in peak hours, difficult to take taxi on the street 2) bad weather, such as rain or high temperature; 3) inconvenience because of the users' location, such as residence and office far from the main roads in the city, and public transportation is unavailable; 4) too much luggage , difficult for users bring luggage with them to take a bus; 5) special groups such as the elderly, pregnant women and the disabled; 6) consideration of safety, when it is dangerous to take taxi on the streets at night. Among the reasons above, traffic congestion, bad weather, too much luggage is the main part of calling service, amounting to 72.6.

### B. Analysis of the Satisfaction of Using the Calling Service Successfully

After the investigation, there 39 people satisfied with the service very much, 28 people a little satisfied, 6 people unsatisfied (Fig. 6). The reasons of dissatisfaction are listed as follow:

1) The line of calling service is busy;
2) Take too much time to wait for the taxi

Users want to increase the operators, to enhance the performance of the systems and improve the work efficiency of calling service.

### C. Analysis of the Reason for the Failure in Calling Service Use

Interview 38 customers who failed to use calling service by telephone, at the same time communicate with taxi drivers and telephone operators for calling service, and we summarize the main reason for the failure as follows [6].

1) The number of the calling service taxis is limited, and it does not have a larger coverage;
2) The peak hours of using the calling service and rush time of urban traffic usually come at the same time, and most of taxis have already been in use. Non-load rate of the taxis is very low;
3) The customers break the appointments, because they call another empty taxi on the street when waiting for the booked taxi;
4) The booked taxis break the appointments, and they pick up another user on the half-way;
5) The booked taxis fail to find the customers without accurate location;
6) Taxis are jammed on the way for a long time during rush hours, after the call of the user, leading to the failure of calling service.

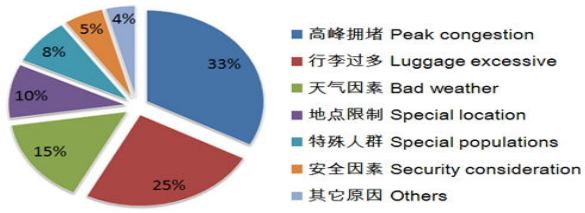



Fig. 5 Satisfaction analysis of the calling service
Source: Questionnaire by author

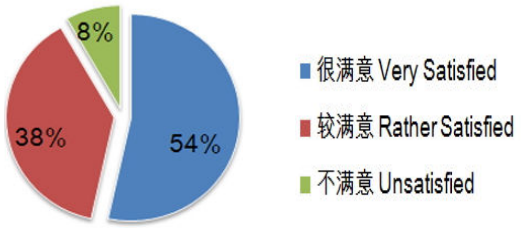



Fig. 6 Reasons for using the service
Source: Questionnaire by author

## VIII. Potential, Restrictions, Future Development

### A. Potential

1) Taxi calling service can decrease the non-load rate, cutting down the fuel consumption and carbon dioxide emissions. This is crucial part of building the low carbon city in the future.
2) Smart phone prevails gradually, and technology of information becomes more advanced. Both of them lays solid physical foundation, which will popularize this service and improve its efficiency.
3) Urban traffic congestion and serious lack of parking space curb the demand of private cars. Actually taxis with calling service can transfer the needs of these consumers.
4) Wuhan has a lot of lakes, and various kinds of departments always occupy large amount of acreage. Both of the two reasons make it difficult to organize the large public transportation. Taxi will act as the important part of public transportation, and it will be valued by the government.

### B. Restrictions

1) Automation of calling service has not been completely achieved. In peak hours, the amount of operators can not satisfy the demand of calling service.
2) Coverage of calling service is low, which makes it difficult to form a large network, seriously affecting the quality of calling service.
3) In the initial stage, the operating company invests much in the equipment and human resource, in addition that the operation is not yet mature. All of these factors increase the cost of calling service. By comparison, the business volume of this time is relatively low, bringing up many great difficulties to the operating company.
4) It is difficult to accurately target, and the taxi can't find the customers quickly. It reduces the service quality.

### C. Future Development

1) Allow more taxis to take part in the calling service, expand the coverage, and achieve full coverage finally.
2) Initially, the government should provide the financial support to the operating company, to ensure the feasibility of calling service. When this service becomes more mature, then the government gradually reduces the intervention.
3) Strengthen the research of calling service, improve it, and make it more automated, intelligent. And through this way, it will promote the operating efficiency, and lower its costs.
4) Some specific places and transportation hub, such as hotels, shopping malls, airports, train stations, should be equipped with the facilities of calling service. At the same time, take full consideration of demand of some specific groups, such as the vulnerable elderly, pregnant women, the disabled, make the calling service system better.

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