Problem Chosen	2022 MCM/ICM Summary Sheet	Team Control Number
C		3256489

The Evaluation scheme about the problem of bus mobile payment

Summary

This paper reffered enclosure data and searched lots of information materials and data,construct ed correspoding mathematical model,which researched the characteristics of passenger travel behavior, platform profit model and future commercial feasibility.

For problem one,first, preprocess the data: read in the data, integrate the data, and screen out the abnormal data which are not swiped and not recorded. Then, taking the basic characteristics of travel payment, such as travel time, payment method and passengers as the basic factors, we utilize Pandas for data analysis and data visualization.After analyzing the payment methods within 24 hours, one week and months, and classifying and comparing the preference choice of similar passengers and the payment method selection probability of different passengers at different times,we figure out the payment methods of passengers in the city in different periods: the payment times of bus card are slightly greater than mobile payment, but they are close to 50%; When facing a variety of payment methods, similar passengers have roughly the same probability of choosing a certain method; When choosing the payment method, passengers will not tend to a certain payment method in a long term.

For problem two,first we explored the profit model of the third-party payment platform: by consulting relevant materials and combining with the characteristics of public transport, get the four revenue channels of the platform: advertising fee, service fee, handling fee and interest income of precipitation funds, as well as three expenditure channels: early advertising and publicity fee, mobile terminal access fee and fixed expenditure. In the process of modeling, considering the scale coefficients corresponding to variables are different, it is necessary to use piecewise function for linear programming. In addition,due to the implicit function relationship between the number of users, platform influence and amount, which needs further discussion. Through the existing data and materials, predict the unknown data, substitute it into the profit model, and quantitatively calculate and analyze the profit situation:

$$W_0 = I_0 - O_0 = (810 + 5.28 + 100 + 0 - 600 - 39.6 - 85) \times 10^4 = 1906800(\text{yuan/month})$$

For problem three,firstly,under the conclusion of question 1, assuming that "one quarter of the buses and subways with mobile payment devices are the most popular lines in the city", the proportion of mobile payment in the vehicles with installed devices is obtained according to the passenger flow data of bus lines. Then, we use the supply and demand relationship to analyze the change trend of the equipment coverage rate, and then use the two models of the innovation diffusion model and the discrete choice model. Under the full coverage condition, the ratio of mobile payment and bus card payment is 86.75% and 13.25% respectively. Finally,wecalculated the profit of the third party platform by using the problem two model. The result is about 7.24179 million yuanper month.

For problem four,firstly access to information to study the business planning and development of the third-party mobile payment platform. Combined with the profit model in this problem for specific analysis. In the light of the mode of cooperation with public transport system, study its profitability and the growth of platform influence. Through the specific data, we can get the corresponding feasible scheme of business planning and development, then get the behavior characteristics, and summarize it into the suggestions of the feasible scheme. To sum up,this paper mainly utilized Pandas data analysis module of Python and MATLAB to program,summarized the characteristics of travel payment, established and solved the revenue and expenditure profit model of the third-party platform, predicts the profit status of the third-party platform under the condition of full coverage of mobile payment equipment, and conducted a feasibility study to better solve the problem.

Keywords: data processing and analysis; linear programming; innovation diffusion model; discrete selection model

Contents

1 Introduction

With the popularization of smart phones and the improvement of mobile payment technology, but existing payment methods of cash payment and physical bus card have some disadvantages,such as inconvenient recharge, easy loss, personal inability to view the card swiping records, cross regional inability to use and other problems in the process of using the bus card. Cash payment brings a lot of inconvenience and increases labor costs, Compared with cash payment and physical bus card swiping, bus mobile payment has gradually come into our sight.

At present, bus mobile payment is generally carried out through a third-party payment platform. Now you need to analyze and evaluate the project.

Question 1: Annex 1 and 2 give the information and data description of some bus payment in a city, and try to analyze the travel payment characteristics of passengers in the city.

Question 2: Try to establish a commercial profit mathematical model of public transport third-party payment platform to quantitatively analyze the revenue, expenditure and profit of public transport third-party payment platform.

Question 3: the data given in question 1 is the data obtained during the trial operation of a quarter of buses and subways after installing mobile payment devices. According to the data in question 1, try to estimate the profitability of all buses in the city after becoming rich through the third platform of public transport.

Question 4: combined with the previous calculation results and conclusions, write a business plan feasibility report within 500 words for the mobile payment company, and give suggestions on the feasibility scheme to increase the company's profits.

2 Problem assumptions

1. It is assumed that a quarter of the buses and subways equipped with mobile payment devices are the most popular lines in the city.
2. Other payment methods other than mobile device payment and bus card payment are not considered
3. Assume that the user's choice is rational

3 Symbol Description

Number	Symblo	Description
0	W_0	Total profit of the model
1	I_0	Total revenue of the model
2	O_0	Total spend for the model
3	r	Precipitation Fund Interest Growth Coefficient
4	ϕ	Prediction coefficient for the number of users
5	γ	Corrected error value for threshold
6	X_c	Arithmetic average of advertising costs
7	N	Threshold for the number of users

4 Problem analysis

4.1 Analysis of question 1

In order to analyze the travel characteristics of passengers in the city, we analyzed the data at different levels from seven aspects. Firstly, according to the information given by the data,such as travel time, passenger ID and payment method are classified and combined for data processing. Analyze the cumulative sum of payment times in a day, a week and different months to indicate which payment method people will choose at different times, classify the people who travel, and analyze the tendency of different people for payment methods. Under the same conditions, screen out the abnormal data that is not within the scope of our discussion, use pandas to read the data, visualize the results, get the data table, and then analyze the data to figure out the possible causes and travel characteristics.

4.2 Analysis of question 2

In order to obtain the third-party profit model, it is necessary to clarify the items that the third-party payment platform needs to pay in revenue and expenditure. The revenue items are divided into advertising fees, service fees, handling fees and interest income of precipitated funds. The expenditure items are divided into: early-stage advertising expenses, mobile terminal access expenses and fixed expenses (infrastructure investment, fixed cost of new projects, employee salary, etc.). Because the profit model involves many variables and there are some other quantities that do not change with the variables, after listing the equation, we refine the variables by using determinant, power function and other functions, and finally find the data and set some quantitative values to obtain the final quantitative analysis results, Calculate the profit model of the third-party payment platform of public transport, which can well match the problem.

4.3 Analysis of question 3

Since only a quarter of the data obtained after the installation of mobile payment devices in buses and subways are given in the problem, in order to establish a model that suit all situations, we need to push the installation ratio from a quarter to all. According to the result of the first question, we put forward the assumption that these quarter of the lines account for the vast majority of passenger flow and demonstrate that the assumption is tenable. Taking this result into the supply demand model to calculate the relationship between customer demand and the full promotion of third-party payment. Then use the innovation diffusion model proposed by the famous economist Rogers to spread the relationship, speculate the passenger flow when the third-party mobile payment platform is 100% applied, and then bring it into the profit model of the second question to calculate the profit of the third-party payment platform.

4.4 Analysis of question 4

On the basis of the first three questions, we make predictions and suggestions for the promotion benefits of the third-party mobile payment platform according to the results obtained from the profit model. Based on the results obtained from the results and data analysis, the feasibility opinion report on the company's development is made as an aid to the company's decision-making.which can give a feasible scheme in the most profitable situation where possible.

5 Model estimating and solving of problem 1

5.1 Data preprocessing

In order to analyze the travel characteristics of people in the city, we analyze the data given in the annex with different parameters such as travel time, payment method, payment proportion of different payment methods, hoping to summarize the travel payment characteristics.

According to the data given in the table in Annex 1, we need to find out the relationship between travel payment method and travel time, so as to analyze the payment characteristics of passengers.

Step: 1 read in data-use pandas to read in the data in the given table.

Step: 2 column name modification - due to the different column names in the given table, we will modify the column name to a unified column name in order to make the subsequent data consolidation normal.

Step: 3 merge data-merge the data in 28 tables and sort them out.

Step: 4 remove abnormal data - in order to analyze the two payment methods between mobile payment and bus card payment, we will display null (no card swiping) and 0001-1-1 (no card swiping record, because of machine failure, but the card swiping method is still recorded.) which are not included in the calculation and output charts.

5.2 Data analysis

It can be seen from the data preprocessing stage that after the preliminary work , we use **pandas** to output visual charts and analyze the data according to the intuitive charts.

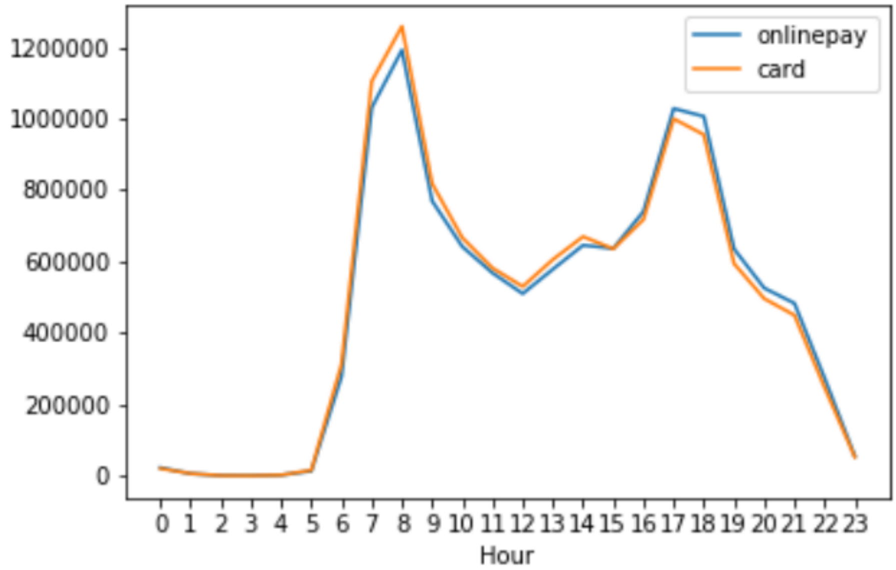

Figure 5.1: The graph of the consumption times of the two payment methods changing with the hour

1. Divide the day into 24 hours as the abscissa, and accumulate the payment times of the two methods respectively. Set the orange line in the figure to represent the payment times of boarding with a bus card, and the blue line to represent the payment times of using a third-party mobile payment platform. The chart can be obtained, as shown in Figure 5.1.

   During the period from 23:00 to 5:00 the next day when the bus and subway are not running, the data in the figure shows that from 5:00 to 7:00, the orange line almost coincides with the blue line, which means that the payment times paid by bus card and third-party mobile platform are almost the same. From 7:00 to 15:00, the orange line is slightly higher than the blue line, Between 7:00 and 8:00, the orange line is significantly higher than the blue line, which shows that the number of bus card payments is obviously more than the third-party payment platform. From 15:00 to 22:00, the blue line is slightly higher than the orange line. From 17:00 to 18:00, the blue line is significantly higher than the orange line, that is, the payment times of the third-party mobile payment platform are significantly higher than that of the bus card.

   The reason may be that many people who are not familiar with using the third-party payment platform (such as older elders) will choose to travel during this period during the morning rush hour, so the payment times of using the bus card will be more. The evening peak is mostly composed of young people after work and school, and they are more dependent on the third-party payment platform, so it will cause the lines in the diagram.

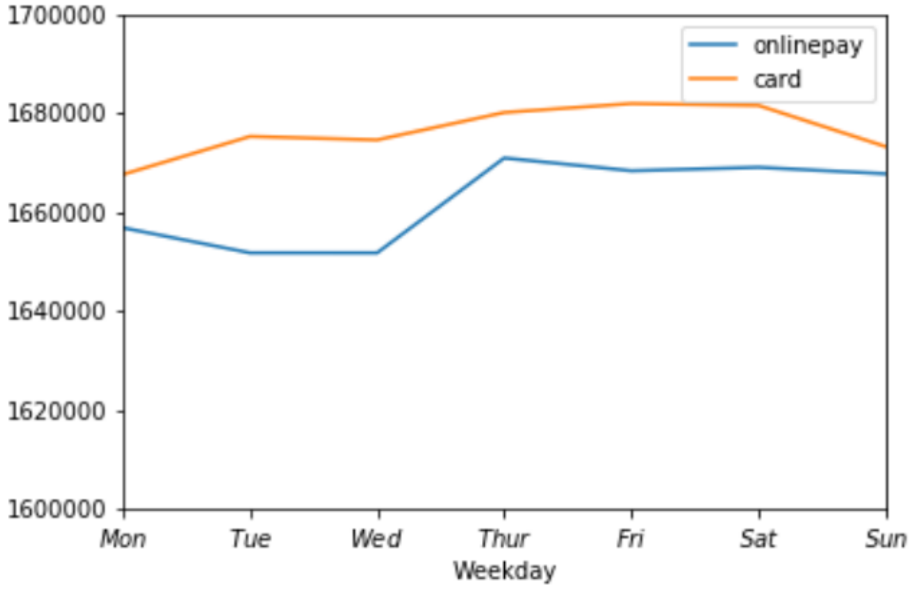

Figure 5.2: The graph of the change of the consumption times of the two payment methods with the number of Sundays

2. Divide the given 28 day data into seven days from Monday to Sunday by week, and still add up the payment times. The orange line in the figure represents the payment times by using the bus card, and the blue line represents the payment times by using the third-party mobile payment platform. The broken line diagram is shown in Figure 5.2.

   It can be seen from the broken line diagram that there is little difference between the number of people using bus cards and the third-party mobile payment platform (it should be noted here that in order to see the specific situation between the broken lines, we reduce the value interval of the whole vertical axis, but in fact, the difference between the two figures is still not large), However, generally speaking, the number of payments using the bus card is greater than that using the third-party mobile payment platform. It can be seen that the difference between the two is the largest on Wednesday and the smallest on Thursday and Sunday.

   Except for some errors in statistical data, the reason may be related to people's preference for travel choice. The number of people who travel on weekdays will peak on Thursday and then stabilize and begin to decrease on weekends. Since the promotion of third-party payment platforms may not be very popular, it can be seen that the number of payments using bus card is still slightly higher than that of mobile payment, but the difference between the two is very small.

3. The data given in Annex 1 are the data collected in February, may, August and November respectively. The abscissa is arranged by month, and the proportion of bus card payment and third-party mobile payment platform payment is taken as the abscissa. The calculated chart is shown in Figure 5-3.

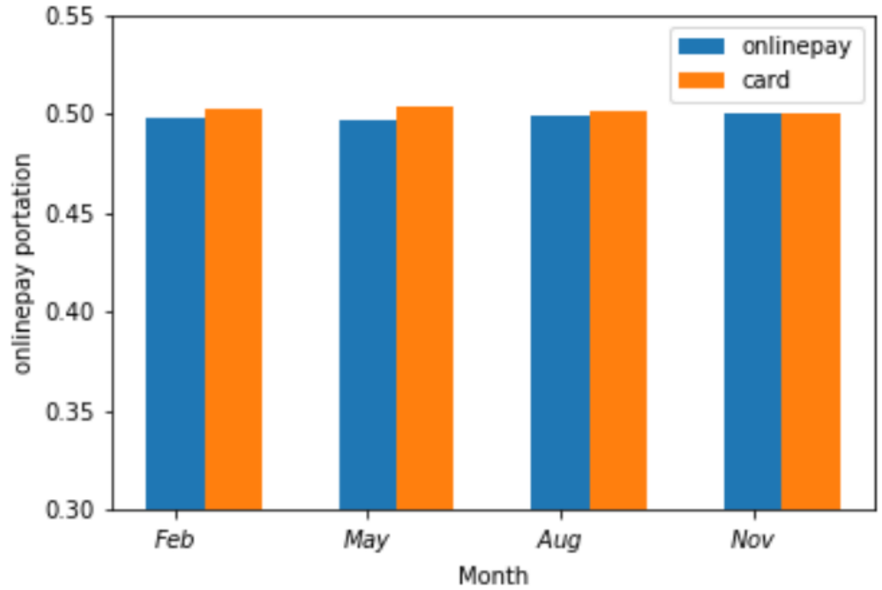

Figure 5.3: Bar chart of monthly proportion of consumption times of two payment methods

We can see from the figure that the gap between the two is very small, that is to say, the number of payments using bus cards is basically the same as that using third-party payments. We can see that the payment times of bus cards in February, may and August are less than those of third-party payment platforms. In November, the two reached balance. And it can be seen that with the increase of months, the number of payments on third-party payment mobile platforms is also increasing slightly.

The main reason is that various cities across the country have promoted the use of mobile payment platforms since 2017, and the promotion work has been basically completed by the end of 2017. Therefore, with the passage of months, the number of payments using third-party payment platforms will increase accordingly. As reflected in the data chart, we can see that the proportion of third-party payment platforms is rising slowly.

4. According to the data given in Appendix 1, taking four months as the abscissa, we will sum up the payment times of the two methods. The orange line in the figure represents the payment times of getting on the bus with the bus card, and the blue line represents the payment times by using the third-party mobile payment platform. The two curves obtained from the payment times of the payment platform are shown in Figure 5.4.

As shown by the curve in the figure, it can be seen that with the increase of months, the overall number of payments using both methods is decreasing, and the decreasing range is almost the same. At the same time, in the process of reduction, the number of payments using the bus card is always higher than that using the third-party mobile payment platform, until August and November, the two are almost equal.

The reasons can be speculated as follows: 1 Due to statistical problems, the number of samples collected in the last three months was less than that in the previous few months.2 Since we excluded the options of not swiping and unsuccessful swiping at the beginning,

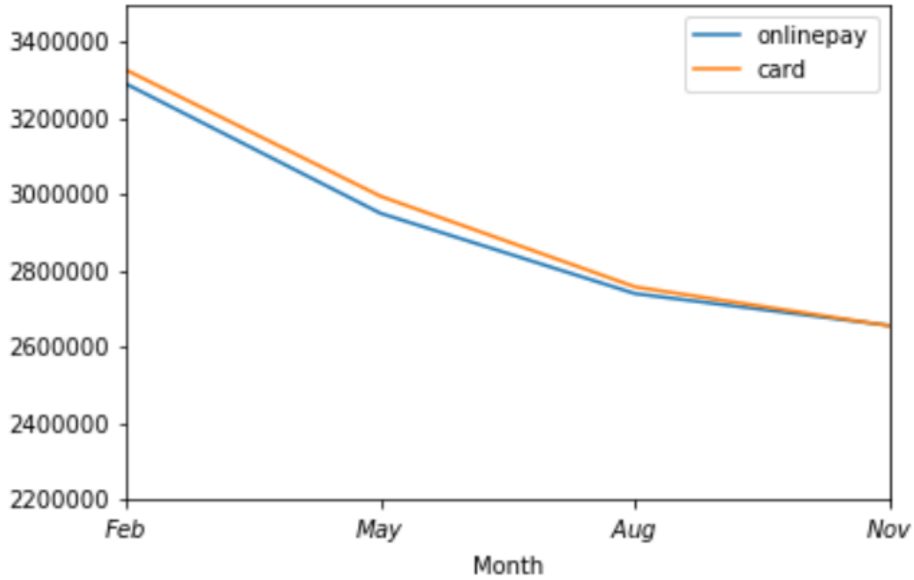

Figure 5.4: The change of consumption times of two payment methods by month

it is also possible that the number of unsuccessful swiping is higher and higher as the month goes on, and the sample of statistical data will be less and less. III With the passage of months, the number of people who choose bus cards and third-party mobile payment platforms to pay gradually decreases, which may be due to the decrease in the number of people who choose to take buses or the increase in the number of cash payments.

5. According to the data given in Appendix 1, we will take the given 28 days as the sample, take the number of trips 200 as the boundary, regard the data of more than 200 trips within 28 days as abnormal data, exclude this part of abnormal data, take the number of trips as the abscissa, and the proportion of this number of trips in the number of trips of all people as the ordinate. The histogram is shown in figures 5-5, 5-6 and 5-7. Among them, 5-5 is the proportion of travel times of the sum of the two methods for all people, 5-6 is the proportion of travel times of people using third-party payment platforms, and 5-7 is the proportion of travel times of people using bus cards.

From the data in Figure 5.5, we can see that the vast majority of people travel 0-25 times in the sampling 28 days, and the peak can account for about 10% of all people. From the data in Figure 5.6, we can see that the vast majority of people who use the third-party payment platform have traveled 0-20 times is the largest in the sampling 28 days.And the peak can account for about 15% of all people. From the data in Figure 5.7, we can see that the vast majority of people who use bus cards have the largest number of trips ranging from 0 to 20 times in the sampling 28 days, and the peak can account for about 18% of all people.

It can be inferred from this that the general number of trips of people in the sampling 28 days is about 0-20. At the same time, among the people who travel 0-20 times, more people use bus cards than those who use third-party payment platforms, that is, among the people who travel at low frequency, more people choose bus cards.

6. According to the data in Appendix 1, we separate the data of each person, divide the

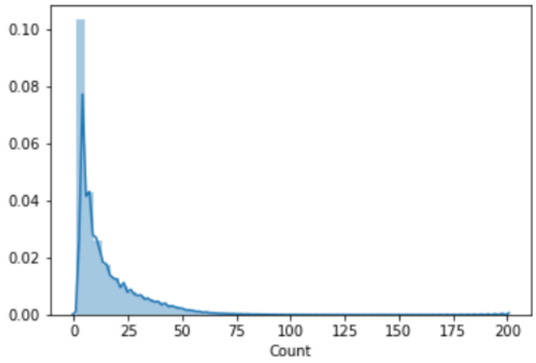

Figure 5.5: User's 28-day travel times and distribution of users

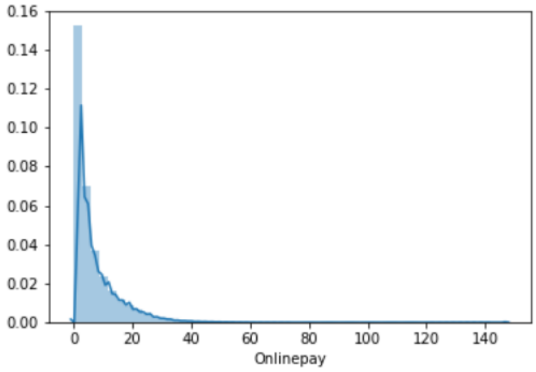

Figure 5.6: User's 28-day travel mobile payment times and distribution

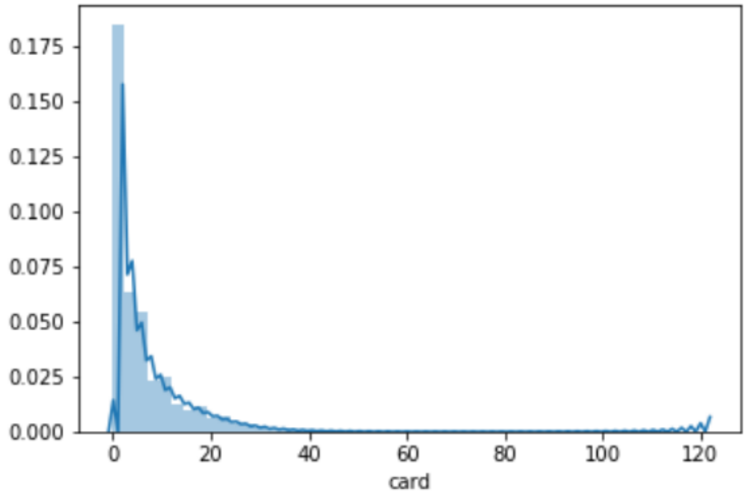

Figure 5.7: User's 28-day bus card payment trip times and distribution map

number of times each person uses the third-party mobile payment platform by the total number of times this person pays in two ways as the abscissa, and take the sum as the ordinate. The distribution diagram is shown in Figure 5.8.

We can get from the figure that the number of people with a ratio of 0.5 is the largest, that is, most people have the same probability of choosing a third-party mobile payment platform and bus card payment.

We can get from the figure that the number of people with a ratio of 0.5 is the largest, that is, most people have the same probability of choosing a third-party mobile payment platform and bus card payment. At the same time, there are more people in 0 and 1, that is, more people choose bus card or third-party payment platform.

The reason why so many people are distributed between 0 and 1 is that many people only record their one trip. When passengers choose a bus card for this trip, they will be distributed at the record point of 0. On the contrary, if they choose a third-party payment platform for payment this time, they will be recorded at the record point of 1.

In order to reduce the impact of such one-time travelers on the results, we screened

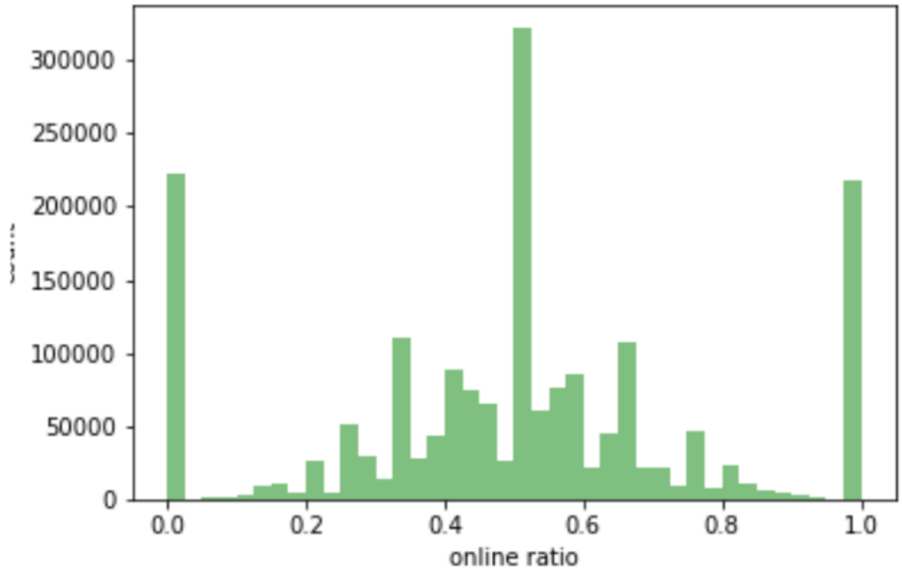

Figure 5.8: Distribution map of the ratio of the number of mobile payments to the total number of trips

again and excluded all people with less than 50 trips within 28 days of the sample record. The distribution diagram is shown in Figure 5.9.

After removing the people with a small number of trips, we can see that the data distribution is obviously concentrated in the interval of 0.4-0.6, with a peak at 0.5, which basically shows a normal distribution, that is, most people choose third-party mobile payment platforms and public transportation. The probability of card trips is the same, or basically the same. From this, we can see that among the people who travel frequently, the vast majority of people will choose both bus cards and third-party mobile payment platforms to travel.

7. According to the data given in Appendix 1, in order to intuitively see the aggregation degree of payment times using different payment methods at different times of each day, we set the abscissa to be each day when the data was collected (take February as an example), and the vertical The coordinates are set to 24 hours in a day, and the color depth is used to indicate the cumulative number of people who paid to get on the bus during this period. The darker the color, the higher the number of payments. The heat map generated based on the data is shown in Figure 5.10 and Figure 5.11, where Figure 5.10 represents the number of payments made using the bus card, and Figure 5.11 represents the number of payments made using a third-party mobile payment platform.

5.3 Summary of data analysis

According to the data form the attached file 1 and 2, we have more analysis about this.

First of all, we can see that the time of sampling data is very scientific, and the months of 2, 5, 8 and 11 are selected that they avoid peak periods like summer and winter, and

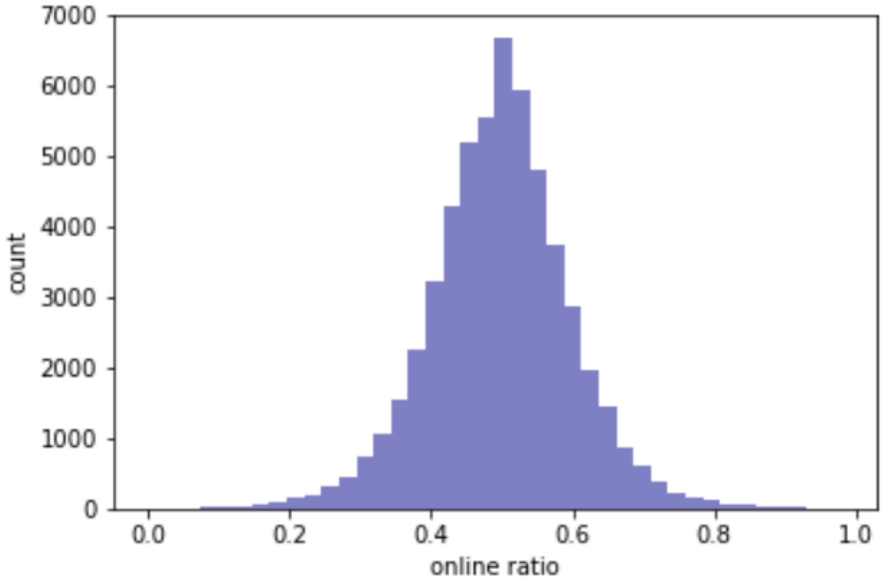

Figure 5.9: Distribution of the ratio of the number of mobile payments to the total number of trips by high-frequency users

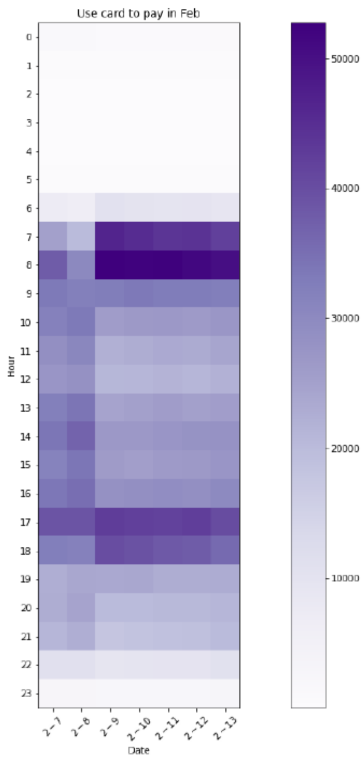

Figure 5.10: Heat map of the number of bus card payments in February

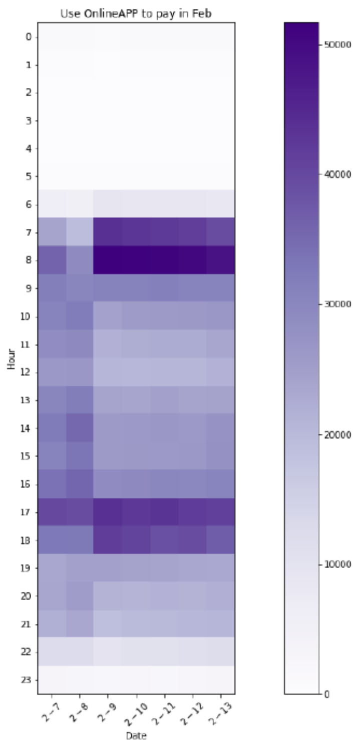

Figure 5.11: Heatmap of Mobile Payments in February

they also avoid holidays in the data collected during those months During the holidays, the seven days of universal significance were chosen. Seven days of data collection can also be seen in the Within a week, the change of payment times is conducive to reflect the reality.

Secondly, before data analysis, we decided to remove abnormal data after the discussion. For example, the payment method is not the brush Card payment methods, and other methods that don't use either bus card payment or mobile payment, and swiping cards The number of unsuccessful payments, after deducting this part of abnormal data, we used software to analyze the data.

Thirdly, we can know the peak of payment in a day by analyzing the change of payment times in 24 hours, and people's tendency to choose different payment methods. And then we looked at a week's worth of data from different months. How the number of payments changes and how people prefer the two payment methods from month to month. In the end, we classified different groups of people, and analyze the tendency of people with different travel times to choose the two payment methods.

Finally, we draw some conclusions as follow:

1) In one day, the morning peak occurs from 7 to 9 in the morning and the evening peak occurs from 17 to 19 in the evening. The number of payment times reaches the one-day peak, and the number of payment by bus card is more than that of mobile payment in the morning peak, while the situation is opposite in the evening peak.

2) In a week, the data reflected that the number of payments made by bus card was slightly higher than that made by third-party payment platforms, and the difference between the two was the smallest on Sunday and the largest on Wednesday.

3) In different months, as the months went by, the number of payments by bus card was slightly higher than the number of mobile payments, and gradually approached the number of payments by third-party mobile payment platforms, while both decreased.

4) Low-frequency travelers and high-frequency travelers have roughly the same preference for payment by bus card and third-party mobile payment platform, that is, when faced with the choice of payment method, about half of them choose to pay by bus card, while the other half choose third-party mobile payment platform.

5) For each passenger, excluding those with low travel times, the result of our data analysis is that the vast majority of people choose to use both payment methods at the same time, and there is no obvious preference for a certain payment method.

Therefore, according to the data in Annex 1, we can draw preliminary conclusions about the payment characteristics of some people in the city above, and analyze the possible reasons for this.

6 Problem 2

6.1 Profit model of third-party payment platform

With the continuous development of third-party payment platforms and the progress of mobile information technology, third-party payments have become an industry with good development prospects. The diversification of operation mode and profit mode makes it have strong market competitiveness. On normal third-party payment platforms, there are four profit models as follows:

1) poundage

Handling fee refers to the difference between the handling fee charged by the third-party payment platform and the procedure fee charged by the bank. Personal services provided by the third-party include transfer, payment, withdrawal, SMS security payment reminder and foreign currency payment, etc. The enterprise service is the commission of clearing transaction related services such as checking amount, checking account, closing payment and refund of money.

The charge ratio ranges from 0.08% to 1.25%, and the charge ratio of transfer and withdrawal is 0.1%. Different service types have different handling fees, and the proportion of handling fees charged for transactions of different amounts of the same service will also be different.

2) advertising

As a high-frequency payment method, the third-party payment platform has a strong ability of publicity due to its convenient mobile client and corresponding Internet platform. Therefore, the third-party payment platform can charge merchants' advertising fees through advertising space as one of the profit channels.

3) Interest income from deposited funds

The definition of precipitation funds is as follows: the pre-deposited currency payment funds actually received by the payment institution when handling the payment business entrusted by the customer.

According to the relevant regulations in the "Administrative Measures for Customer Reserve Funds of Payment Institutions": the ratio of the risk reserve of the third-party payment platform shall not be lower than 1000 of the interest earned by the reserve fund in the bank account, and the highest profit of the third-party payment platform shall be It is 90 0 0 of the interest. According to the relevant regulations and the rules and regulations of the bank, part of the reserves can be deposited in the form approved by the People's Bank of China. The deposit forms are roughly: unit time deposit, demand deposit, agreement deposit and unit call deposit. Currently, demand deposits are used as the main deposit method, but the term shall not exceed three months. The agreed deposit rate of such deposits is roughly 400 500, and each deposit should also pay 0.7800 to the bank. fee.

4) service charge

The third-party payment platform can also provide payment solutions and various value-added services on the basis of providing a basic payment system. With the continuous expansion of the platform, urban life services are continuously combined with it, providing a variety of payment methods, such as electricity bills, water bills, mobile phone bills and other aspects. When the platform provides individuals or organizations with more convenient payment channels, it increases its competitiveness in the market, and at the same time, it charges part of the service fee as one of the platform's profit models. With the continuous improvement of technology and service capabilities, the platform has more competitiveness and attracts customers to expand its influence.

6.2 Expenditure patterns of third-party payment platforms

1) advertising costs

The third-party payment platform cooperates with public transportation, and provides services such as daily recharge and use of transportation costs through the platform, adding new payment modes to facilitate more residents. In order to promote the new services of the third-party payment platform and make more passengers use the third-party payment platform for payment, it is necessary to carry out pre-publicity in newspapers, bus billboards, and station billboards to increase influence.

2) access fee

The current interface access modes of third-party payment platforms mainly include computer website payment, mobile website payment, APP payment, etc. The payment interface rates of various third-party payment companies also tend to be the same. The general industry rate is around 0.6%, entertainment and other virtual services, the rate is 1%.

3) fixed charges

The third-party payment platform requires fixed investment in personnel management, new project services, and bank docking during the operation stage. Such as the construction of infrastructure, the establishment and management of servers, and the negotiation of relevant agreements with banks for reserve funds. Therefore, it is necessary to carry out part of one-time fixed expenditures for infrastructure, etc., and part of continuous expenditures such as labor costs for personnel.

6.3 Profit model of third-party payment platform in public transportation system

The public transportation system has clear economic characteristics, it is to meet the spatial displacement of people in the public area. Public transportation not only needs to meet the requirements of people's livelihood, but also needs to get remuneration from the service objects. When realizing its own economic benefits, it will also have an economic impact on the surrounding areas. At the same time, it has the characteristics of large flow, large amount, and inconvenient management. In addition, the operation of the public transportation system is greatly affected by external factors, policies and line planning. will affect it.

According to the above profit model and expenditure model combined with the environment and characteristics of the public transportation system, the exclusive model of its profit can be obtained:

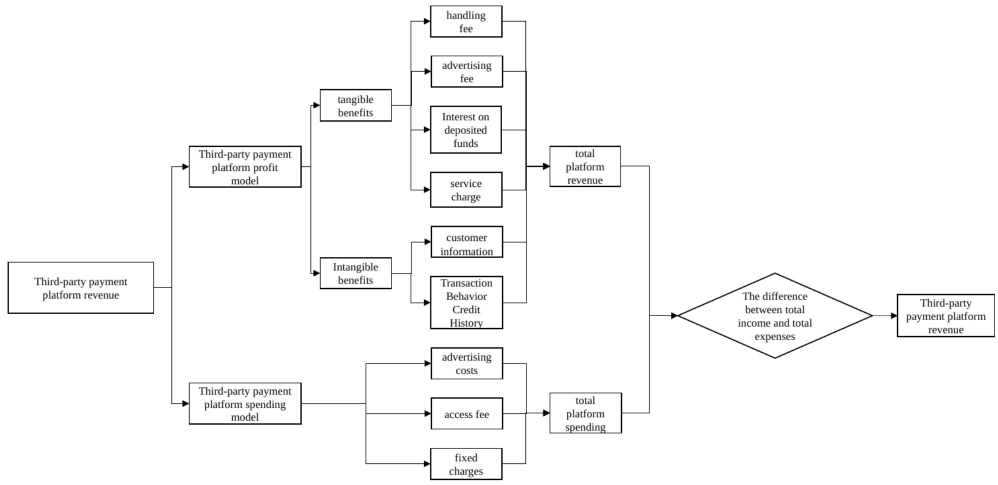

Figure 6.1: Schematic diagram of profit model

6.4 The establishment of the business profit mathematical model of the third-party payment platform

According to the payment characteristics of public transportation combined with the profit model of the third-party payment platform, it is not difficult for us to draw the above-mentioned income-expense flow chart. Then there are:

$$W_0 = I_0 - O_0 \tag{6.4.1}$$

where W_0 is the profit of the model, I_0 is the total revenue of the model, and O_0 is the total expenditure of the model.

From the above flow chart, it can be known that the mathematical expression of the total income I_0 is:

$$I_0 = I_1 + I_2 + I_3 + I_4 \tag{6.4.2}$$

Among them, I_1 is the interest income of precipitation funds, I_2 is the income of handling fees, I_3 is the income of service fees, and I_4 is the income of advertising fees.

Mathematical calculation of interest I_1 of precipitation funds: The generation of interest of precipitation funds is a linear programming problem in dynamic changes, and its linear dynamic system formula is:

$$I_{n+1} = r(I_n + X_n + X_{n-1} + X_{n-2}) \tag{6.4.3}$$

Among them, X_i is the total recharge amount of the i-th month, that is, the precipitation funds.$(i = 1, \ldots, n)$

The growth coefficient r is determined:

$$r = a_1 \bullet a_2 \bullet (1 - a_3) \tag{6.4.4}$$

Among them, a_1 is the agreement deposit rate, a_2 is the maximum interest rate of the deposited funds, and a_3 is the handling fee agreed with the bank.

According to the relevant agreement of the bank, demand deposit is the main deposit method, and its deposit period shall not exceed three months. Then there is the following calculation formula:

$$\begin{aligned} I_{n+1} = & \left(r^n + r^{n-1} + r^{n-2}\right) \bullet X_1 + \left(r^{n-1} + r^{n-2} + r^{n-3}\right) X_2 + \ldots \\ & + \left(r^4 + r^3 + r^2\right) X_{n-3} + \left(r^3 + r^2 + r\right) X_{n-2} + \left(r^2 + r\right) X_{n-1} + r X_n \end{aligned} \tag{6.4.5}$$

Among them, $n \leq 1$, X is the monthly recharge amount, that is, the deposited funds.$(i = 1, \ldots, n)$

Mathematical calculation of handling fee I_2: The charging ratio of handling fee is related to its recharge amount, then the mathematical formula about I_2 at this time is an interval function, and the selection of the interval point is related to the negotiated policy.

$$I_2 = \begin{cases} r_s \bullet X_{si} \bullet n & r_s = 0.08\% \;\; X_{si} \leq 100 \\ r_{s1} \bullet X_{si} \bullet n & r_s = 0.1\% \;\; X_{si} > 100 \end{cases} \tag{6.4.6}$$

Among them, r_s and r_{s1} are the charging ratio of the handling fee, X_{si} is the single recharge amount in the i-th month, and n is the number of people who recharged.

Mathematical calculation of service fee I_3: The proportion of service fee charged is related to its amount, and has a lower limit of the fee and a limit of upper limits.

$$I_3 = r_f \bullet X_{fi} \bullet n, \quad r_f \bullet X_{fi} \subseteq [0.5, 10] \tag{6.4.7}$$

In which r_f is the charge ratio of service fee, X_{fi} is the single amount in the i-month, the $r_f \bullet X_{fi}$ interval is $[0.5, 10]$, and n is the number of recharge.

The mathematical calculation of advertising cost 4I: the amount of advertising cost is related to the number of people. In the low interval, the advertising cost is constant, and in the high interval, the advertising cost is proportional to the number of people.

$$\begin{aligned} I_4 &= A_g & n \leq N \\ I_4 &= A_g + n \bullet X_g & n > N \end{aligned} \tag{6.4.8}$$

Where A_g is the one-off advertising fee paid in the low range, X_g is the advertising fee earned on a single mobile platform in the high range, n is the number of users of the platform, and N is the threshold of the number of users.It can be seen from the above flow chart that the mathematical expression of total expenditure O_0 is

$$O_0 = O_1 + O_2 + O_3 \tag{6.4.9}$$

where O_1 is the advertising cost invested in the early stage, O_2 is the cost of mobile terminal access, and O_4 is the fixed expenditure.

The calculation formula of the propaganda cost of the early advertising is:

$$O_1 = m \bullet X_c \tag{6.4.10}$$

where m is The Times of the early advertising investment and X_c is the cost of a single publicity.

The calculation formula of mobile terminal access charge O_2 is as follows:

$$O_2 = r_j \bullet X_j \bullet n \tag{6.4.11}$$

Where r_j is the charging rate of access fee, X_j is the amount of the fee, and n is the number of access.

The mathematical calculation formula of fixed expenditure O_3 is as follows:

$$O_3 = A_j + A_x + n \bullet c \bullet X_r \tag{6.4.12}$$

where A_j is the input cost of infrastructure, A_x is the fixed cost of new projects, c is the number of employees, X_r is the salary of employees, and n is the number of working months.

The integration of the above mathematical calculation formula of income and expenditure can be obtained:

$$\begin{gathered} W_0 = I_0 - O_0 \\ W_0 = I_1 + I_2 + I_3 + I_4 - (O_1 + O_2 + O_3) \\ W_0 = r\left(I_n + X_n + X_{n-1} + X_{n-2}\right) + r_s \bullet X_{si} \bullet n + r_f \bullet X_{fi} \bullet n + A_g + n \bullet X_g - \\ \left(m \bullet X_c + r_j \bullet X_j \bullet n + A_j + A_x + n \bullet c \bullet X_r\right) \end{gathered} \tag{6.4.13}$$

including:

$$\begin{cases} n \geq 1, i = 1 \ldots\ldots n \\ r_s = 0.08\%, X_{si} \leq 100 \\ r_s = 0.1\%, X_{si} > 100 \\ r_f \bullet X_{fi} \subseteq [0.5, 10] \\ n \leq N, X_g = 0 \\ r \geq 0, X \geq 0, r_s \geq 0, X_{si} \geq 0, r_f \geq 0, X_{fi} \geq 0, A_j \geq 0, A_x \geq 0 \end{cases} \tag{6.4.14}$$

6.5 Quantitative analysis of profit mathematical model model

6.5.1 Quantitative analysis of total revenue I_0

1) Quantitative analysis and calculation of precipitation fund I_1 determination of growth coefficient r

$$r = a_1 \bullet a_2 \bullet (1 - a_3) \tag{6.5.1}$$

where a_1 is the agreement deposit rate, a_2 is the highest acquisition rate of precipitation fund interest, and a_3 is the commission fee agreed with the bank. Then

$$\begin{cases} a_1 = 4.5\% \\ a_2 = 90\% \\ a_3 = 0.78\% \end{cases} \tag{6.5.2}$$

Substitution: $r = 0.045 \bullet 0.9 \bullet (1 - 0.0078) = 0.0401841 \approx 0.04$

X_i is the total recharge amount of month i, i.e. precipitation fund ($i = 1, 2, \ldots, n$), then X_i is the independent variable:

$$I_{n+1} = r\left(I_n + X_n + X_{n-1} + X_{n-2}\right) = 0.04\left(I_n + X_n + X_{n-1} + X_{n-2}\right) \tag{6.5.3}$$

2) Quantitative analysis and calculation of procedure cost I_2: The calculation formula of procedure cost is as follows:

$$I_2 = r_s \bullet X_{xi} \bullet n \tag{6.5.4}$$

this function is an interval function, and the interval point is determined by the charging system to be 100, i.e. the discontinuity point when $X_{si} = 100$:

$$\begin{cases} r_{\mathrm{s}} = 0.08\%, X_{\mathrm{si}} \leq 100 \\ r_{\mathrm{s}} = 0.1\%, X_{\mathrm{si}} > 100 \end{cases} \tag{6.5.5}$$

Wheres X_i is the single recharge amount in i-month and n is the number of recharge people, which constitute the independent variables of this function.

3) Quantitative analysis and calculation of service fee I_3: The calculation formula of service fee is as follows:

$$I_3 = r_f \bullet X_{fi} \bullet n \tag{6.5.6}$$

According to relevant payment regulations:

$$r_f = 0.1\% \tag{6.5.7}$$

where $X - fi$ is the single amount in the i-th month and n is the number of recharge, both of which are independent variables of the function.But due to the restrictions of relevant regulations, I_3 had a corresponding value range $r_f \bullet X_{fi} \in [0.5, 10]$, i.e. and it was proved that:

$$\begin{cases} X_{fi\min} = \frac{0.5}{0.1\%} = 500 \\ X_{fi\max} = \frac{10}{0.1\%} = 10000 \end{cases} \tag{6.5.8}$$

The piecewise function is valid:

$$\begin{cases} I_3 = 0, X_{fi} < 500 \\ I_3 = r_f \bullet X_{fi}, 500 \leq X_{fi} \leq 10000 \\ I_3 = 10, X_{fi} > 10000 \end{cases} \tag{6.5.9}$$

4) Quantitative analysis calculation of advertising cost I_4:

$$\begin{cases} I_4 = A_g & n \leq N \\ I_4 = A_g + n \bullet X_g & n > N \end{cases} \tag{6.5.10}$$

Determination of threshold n:There are two influencing factors that determine n: on the one hand, the number of users using mobile platforms n, and on the other hand, the implicit function of influence $f(n)$. The function of the threshold n is determined as follows :

$$N = \phi \bullet n \bullet f(n) + \gamma \tag{6.5.11}$$

where n is the number of mobile devices in the third-party payment platform, ϕ is the prediction coefficient of the number of users, $f(n)$ is the implicit function of influence, and π is the error value.

6.5.2 Quantitative analysis of total expenditure O_1

1) Quantitative analysis calculation of O_1 advertising and publicity expenses in the early stage:

$$O_1 = m \bullet X_c \tag{6.5.12}$$

where m is the number of times invested in publicity in the early stage and X_c is the cost of a single publicity m and X_c are independent variables of the function and are related to the agreements signed by the third-party payment platform and strategic objectives. According to the analysis data and collection of relevant information, m and X_c are taken as the arithmetic average value of each type:

$$\begin{cases} m = \dfrac{m_1 + m_2 + m_3 + \ldots. + m_n}{n} = \dfrac{\sum_{i=1}^{n} m_i}{n} \\ \\ X_c = \dfrac{X_{c1} + X_{c2} + X_{c3} + \ldots. + X_{cn}}{n} = \dfrac{\sum_{i=1}^{n} X_{ci}}{n} \end{cases} \tag{6.5.13}$$

2) Quantitative analysis and calculation of mobile terminal access charge O_2

$$O_2 = r_j \bullet X_j \bullet n \tag{6.5.14}$$

where the charging ratio of access charge r_j and the amount of charge X_j are the main influencing variables.According to third-party industry payment guidelines:

Product Name	Application Scenario(yuan)	Access Fee	Rate	Margin(yuan)
AAP Payment	Mobile application	0	General industry: 0.6%	0
Mobile website payment	Mobile web page	0	General industry:0.6%	0
computer website pay	PC web page	0	General Industry: 0.6%	0
Pay in person	scan code	0	General industry: 0.6%	0
Transfer to account	Enterprise payment	0	free	0
Alipay batch payment	Enterprise payment	0	single payment rate: 0.5%	0

According to the table: The charging ratio of access fee

$$r_j = 0.6\% \tag{6.5.15}$$

3) Quantitative analysis and calculation of fixed expenditure O_3

$$O_3 = A_j + A_x + n \bullet c \bullet X_r \tag{6.5.16}$$

where A_j is the input cost of infrastructure, A_x is the fixed cost of new project, c is the number of employees, X_r is the employee salary, and n is the number of working months. A_j and A_x are determined values. c, X_r and n are all variables and are related to the actual situation.

6.5.3 Quantitative analysis of total profit W_0

$$W_0 = I_o - O_0 \tag{6.5.17}$$

$$W_0 = I_1 + I_2 + I_3 + I_4 - (O_0 + O_1 + O_2) \tag{6.5.18}$$

Substitute the values after quantitative analysis into:

$$\begin{gathered} W_0 = r\left(I_n + X_n + X_{n-1} + X_{n-2}\right) + r_s \bullet X_{si} \bullet n + r_f \bullet X_{fi} \bullet n + A_g + n \bullet X_g - \\ \left(m \bullet X_c + r_j \bullet X_j \bullet n + A_j + A_x + n \bullet c \bullet X_r\right) \end{gathered} \tag{6.5.19}$$

According to the classification of different constraints, we can obtain the following expressions and constraints:

$$\begin{aligned} W_0 = {} & 0.04\left(I_n + X_n + X_{n-1} + X_{n-2}\right) + 0.08\% \bullet X_{\text{si}} \bullet n + 0.1\% \bullet X_{fi} \bullet n + A_g + n \bullet X_g \\ & - \left(\frac{\sum_{i=1}^{n} m_i}{n} \bullet \frac{\sum_{i=}^{n} X_{ci}}{n} + 0.6\% \bullet X_j \bullet n + A_j + A_x + n \bullet c \bullet X_r\right) \end{aligned} \tag{6.5.20}$$

$$\begin{cases} X_{si} \leq 100 \\ 500 \leq X_{fi} \leq 10000 \\ n > N \\ X \geq 0, r_s \geq 0, A_j \geq 0, A_x \geq 0 \end{cases} \tag{6.5.21}$$

For model 2:

$$W_0 = 0.04\left(I_n + X_n + X_{n-1} + X_{n-2}\right) + 0.1\% \bullet X_{si} \bullet n + 0.1\% \bullet X_{fi} \bullet n + A_g + n \bullet X_g$$
$$- \left(\frac{\sum_{i=1}^{n} m_i}{n} \cdot \frac{\sum_{i=}^{n} X_{ci}}{n} + 0.6\% \cdot X_j \cdot n + A_j + A_x + n \bullet c \bullet X_r\right)$$
$$\begin{cases} X_{si} > 100 \\ 500 \leq X_{fi} \leq 10000 \\ n > N \\ X \geq 0, r_s \geq 0, A_j \geq 0, A_x \geq 0 \end{cases} \tag{6.5.22}$$

For model 3:

$$W_0 = 0.04\left(I_n + X_n + X_{n-1} + X_{n-2}\right) + 0.08\% \bullet X_{si} \bullet n + 0 + A_g + n \bullet X_g$$
$$- \left(\frac{\sum_{i=1}^{n} m_i}{n} \cdot \frac{\sum_{i=}^{n} X_{ci}}{n} + 0.6\% \cdot X_j \bullet n + A_j + A_x + n \bullet c \bullet X_r\right)$$
$$\begin{cases} X_{si} \leq 100 \\ X_{fi} < 500 \\ n > N \\ X \geq 0, r_s \geq 0, A_j \geq 0, A_x \geq 0 \end{cases} \tag{6.5.23}$$

For model 4:

$$W_0 = 0.04\left(I_n + X_n + X_{n-1} + X_{n-2}\right) + 0.1\% \bullet X_{si} \bullet n + 0 + A_g + n \bullet X_g$$
$$- \left(\frac{\sum_{i=1}^{n} m_i}{n} \cdot \frac{\sum_{i=}^{n} X_{ci}}{n} + 0.6\% \cdot X_j \bullet n + A_j + A_x + n \bullet c \bullet X_r\right)$$
$$\begin{cases} X_{si} \leq 100 \\ X_{fi} < 500 \\ n > N \\ X \geq 0, r_s \geq 0, A_j \geq 0, A_x \geq 0 \end{cases} \tag{6.5.24}$$

For model 5:

$$W_0 = 0.04\left(I_n + X_n + X_{n-1} + X_{n-2}\right) + 0.1\% \bullet X_{si} \bullet n + 0 + A_g + n \bullet X_g$$
$$- \left(\frac{\sum_{i=1}^{n} m_i}{n} \cdot \frac{\sum_{i=}^{n} X_{ci}}{n} + 0.6\% \cdot X_j \bullet n + A_j + A_x + n \bullet c \bullet X_r\right)$$
$$\begin{cases} X_{si} \leq 100 \\ X_{fi} > 10000 \\ n > N \\ X \geq 0, r_s \geq 0, A_j \geq 0, A_x \geq 0 \end{cases} \tag{6.5.25}$$

For model 6:

$$W_0 = 0.04\left(I_n + X_n + X_{n-1} + X_{n-2}\right) + 0.1\% \bullet X_{si} \bullet n + 0 + A_g + n \bullet X_g - \left(\frac{\sum_{i=1}^{n} m_i}{n} \cdot \frac{\sum_{i=}^{n} X_{ci}}{n} + 0.6\% \cdot X_j \bullet n + A_j + A_x + n \bullet c \bullet X_r\right)$$

$$\begin{cases} X_{si} \leq 100 \\ X_{fi} > 10000 \\ n > N \\ X \geq 0, r_s \geq 0, A_j \geq 0, A_x \geq 0 \end{cases} \tag{6.5.26}$$

For model 7:

$$W_0 = 0.04\left(I_n + X_n + X_{n-1} + X_{n-2}\right) + 0.1\% \bullet X_{si} \bullet n + 0 + A_g + n \bullet X_g - \left(\frac{\sum_{i=1}^{n} m_i}{n} \cdot \frac{\sum_{i=}^{n} X_{ci}}{n} + 0.6\% \cdot X_j \bullet n + A_j + A_x + n \bullet c \bullet X_r\right)$$

$$\begin{cases} X_{si} \leq 100 \\ X_{fi} > 10000 \\ n > N \\ X \geq 0, r_s \geq 0, A_j \geq 0, A_x \geq 0 \end{cases} \tag{6.5.27}$$

For model 8:

$$W_0 = 0.04\left(I_n + X_n + X_{n-1} + X_{n-2}\right) + 0.1\% \bullet X_{si} \bullet n + 0 + A_g + n \bullet X_g - \left(\frac{\sum_{i=1}^{n} m_i}{n} \cdot \frac{\sum_{i=}^{n} X_{ci}}{n} + 0.6\% \cdot X_j \bullet n + A_j + A_x + n \bullet c \bullet X_r\right)$$

$$\begin{cases} X_{si} \leq 100 \\ X_{fi} > 10000 \\ n > N \\ X \geq 0, r_s \geq 0, A_j \geq 0, A_x \geq 0 \end{cases} \tag{6.5.28}$$

For model 9:

$$W_0 = 0.04\left(I_n + X_n + X_{n-1} + X_{n-2}\right) + 0.1\% \bullet X_{si} \bullet n + 0 + A_g + n \bullet X_g - \left(\frac{\sum_{i=1}^{n} m_i}{n} \cdot \frac{\sum_{i=}^{n} X_{ci}}{n} + 0.6\% \cdot X_j \bullet n + A_j + A_x + n \bullet c \bullet X_r\right)$$

$$\begin{cases} X_{si} \leq 100 \\ X_{fi} > 10000 \\ n > N \\ X \geq 0, r_s \geq 0, A_j \geq 0, A_x \geq 0 \end{cases} \tag{6.5.29}$$

For model 10 :

$$W_0 = 0.04\left(I_n + X_n + X_{n-1} + X_{n-2}\right) + 0.1\% \bullet X_{si} \bullet n + 0 + A_g + n \bullet X_g - \left(\frac{\sum_{i=1}^{n} m_i}{n} \cdot \frac{\sum_{i=}^{n} X_{ci}}{n} + 0.6\% \cdot X_j \bullet n + A_j + A_x + n \bullet c \bullet X_r\right)$$

$$\begin{cases} X_{si} \leq 100 \\ X_{fi} > 10000 \\ n > N \\ X \geq 0, r_s \geq 0, A_j \geq 0, A_x \geq 0 \end{cases} \tag{6.5.30}$$

6.5.4 Exact calculation of mathematical model

Take Model 9 as an example for calculation: Due to the imperfections of known data, after quantitative analysis of existing coefficients, the unknown independent variables are predicted and analyzed according to the basic data provided in the attachment.At the same time, combined with relevant public transport data, mathematical induction method is used to make reasonable inference, so as to obtain the following data: Table model value table just following.

I_n	X_n	X_{n-1}	X_{si}	X_{fi}	A_g	X_g	m_j	X_{ci}	X_j	n
$8.1x10^6$	$6.6x10^7$	$6.6x10^7$	20	20	$1x10^{10}$	15	3	$1x10^6$	20	$3.3x10^6$

Then substitute into the formula of the mathematical model for calculation and obtain:

$$W_0 = I_0 - O_0 = (810 + 5.28 + 100 + 0 - 600 - 39.6 - 85) \times 10^4 = 1906800 \quad (6.5.31)$$

To sum up, under the normal profit model, based on the existing attachment data of the third-party payment platform profit in roughly 61.910 x yuan, belong to the high profit of third-party payment platform.

6.5.5 Analysis of profit Mathematical Model of third-party Payment Platform

The composition of profit model is based on the meaning of ”profit”, that is, ”the value of profit is the difference between total revenue and total expenditure”.The mathematical formula is $W_0 = I_0 - O_0$ (W_0 is the profit of the model, I_0 is the total income of the model, and O_0 is the total expenditure of the model).In this problem, it is necessary to first define the components of income and expenditure, and then establish corresponding mathematical models according to the different situations of each part.Because of the economic characteristics of third-party payment platforms, their income is characterized by ”charging corresponding fees in proportion”, two aspects of piecewise function and linear programming are considered in the establishment of mathematical models.For the determination of the interval points of key variables, that is, the threshold value, the complex function or even the implicit function is established to solve, in order to get a more reasonable segmentation scheme and interval.In the process of establishing the model, Many of the scale factors Ri are selected according to existing regulations and try to match the real data.In the final model, there are still parts that need to be improved, for example, when determining the advertising cost I_4, its threshold $N = \phi \bullet n \bullet f(n) + \sigma$, in which the implicit function of influence $f(n)$ and error correction σ need further verification and calculation, so as to obtain more accurate quantitative calculation results.

7 The establishment and solution of the model of Question 3

7.1 overall analysis

By the question, the data of 1/4 bus and subway mobile payment equipment installed after trial operation phase data, because the data can't distinguish between public transit and subway when payment, therefore, this question is no longer consider the specific differences between subway and bus.If it is necessary to estimate all the public transport in the city and realize the profit after payment by the third-party platform of public transport, the following procedures shall be followed: Full coverage Profitability Full

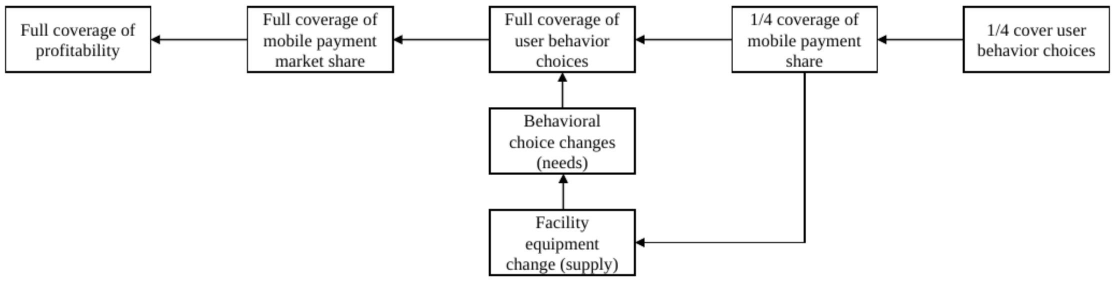

Figure 7.1: Problem three analysis flow chart

coverage Mobile payment share Full coverage User behavior choice 1/4 Covered user behavior choice 1/4 covered Mobile payment share Behavior choice Change (demand) Change of facilities and equipment (supply).

If want to know all the cover under the condition of profit, you need to learn the whole mobile payment under the condition of share.Mobile payment share is closely related to user behavior choice, which is one of the forms of demand.The change of coverage rate is reflected by the change of facilities and equipment, which is the supply part of the system, and the change of supply will affect the demand.Therefore, we need to establish a model to describe the change of behavior choice through the data of mobile payment occupancy and occupancy under the coverage condition of the existing problem no. 14, so as to predict the mobile payment occupancy under the full coverage condition, and then obtain the profitability under the full coverage condition through the model established under the second problem.

7.2 Analysis of the current situation of the problem-occupancy rate

From the data analysis results of question 1, it can be seen that in the case of 1/4 of the mobile payment device, the ratio of the number of mobile payments to the number of bus card payments is about 1, that is, without considering other payment methods, mobile payments account for about 50%. Therefore, when considering only vehicles with installed equipment, mobile payments must account for more than 50% of these vehicles. To determine the specific share of mobile payment devices on installed devices, it is necessary to estimate the proportion of passenger traffic of 1/4 covered vehicles to total passenger traffic. By assuming that a quarter of the buses and subways installed with mobile payment devices are the most popular routes in the city, taking Zhengzhou as an example, the passenger flow of the bus lines is sorted from small to large, and the daily passenger flow distribution curve of the line is drawn. After correction, the curve is shown in the Figure 7.2 and Figure 7.3.

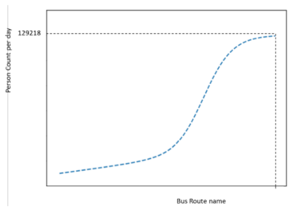

Figure 7.2: Cumulative distribution of bus passenger flow

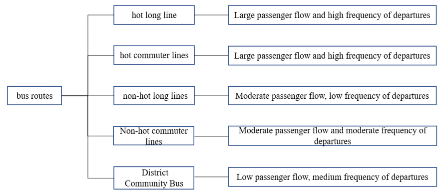

Figure 7.3: Schematic diagram of bus classification

In the Figure 7.2, the horizontal axis represents the bus routes in the city, and the vertical axis is the corresponding daily average passenger flow. After calculation, the bus passenger flow with the top 1/4 passenger flow accounts for about 74.86% of the total passenger flow. Here it is calculated as 75%. This is mainly because bus lines can be divided into five types according to coverage and popularity: hot long-distance lines, hot commuter lines, non-hot long-term lines, non-hot commuter lines and community buses in the area. , but the breadth of line distribution is indispensable, resulting in a situation where a small number of lines share a large amount of passenger flow.

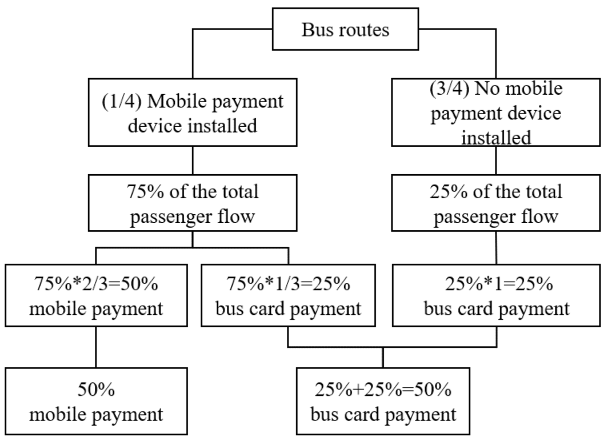

Figure 7.4: Mobile payment-bus card payment ratio

In Figure 7.4, it can be seen from the above analysis that in 1/4 of the buses with mobile payment devices installed, mobile payment accounts for 66.6%, and bus card payment accounts for 33.3%.

Due to the influence of the supply-demand relationship, the above proportions will change. The supply-demand change relationship is shown in the following Figure 7.5:

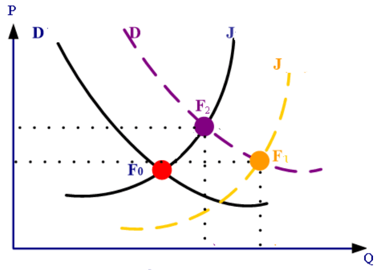

Figure 7.5: Schematic diagram of changes in supply and demand curves

In the initial state, supply and demand are shown by the black curve in the figure, F_0 is in equailibium, as the supply increases (the black J curve moves to the right of the yellow dotted line), the demand also changes (the black D curve moves to the right to the purple curve). Therefore, next, the user's choice after full coverage of the device is analyzed from the perspectives of aggregate and non-aggregate.

7.3 Aggregate Method — Innovation Diffusion Model

The innovation diffusion model is based on the innovation diffusion theory, which was proposed by E.M.Roger. Innovation is defined as: an idea, time, or thing considered novel by an individual or other unit of adoption. [1] And innovation has five elements of relative convenience, compatibility, complexity, reliability and perceptibility. The adopters of innovation can be divided into five types: innovators, early adopters, early followers, late followers and laggards. The diffusion pattern of innovation is shown in the following Figure 7.6 and Figure 7.7.

In Figure 7.7, the curve shows that in the process of innovation diffusion, about 2.5% of the people are innovators, 13.5% are early adopters, 34% are early followers, 34% are early followers, and 16% are early adopters. belong to the laggards.

The process of mobile payment equipment installation and promotion itself is an innovative diffusion process. Using this aggregate model to estimate the full coverage state, the ratio of mobile payers is used. Since the estimation stage is the ratio within a period of time after the equipment is fully covered, so Laggards are not considered here. It is estimated that under the condition of full coverage, 84

7.4 Disaggregated Methods — Discrete Choice Models

Discrete choice model belongs to one of the methods of multivariate analysis, which is a common method of statistical empirical analysis in sociology, biostatistics, quantitative psychology, marketing and so on. This contains: four elements, a decision maker, a finite number of decision options, the attributes of the options, and the preferences of the decision maker. The discrete choice model is based on utility theory, which holds

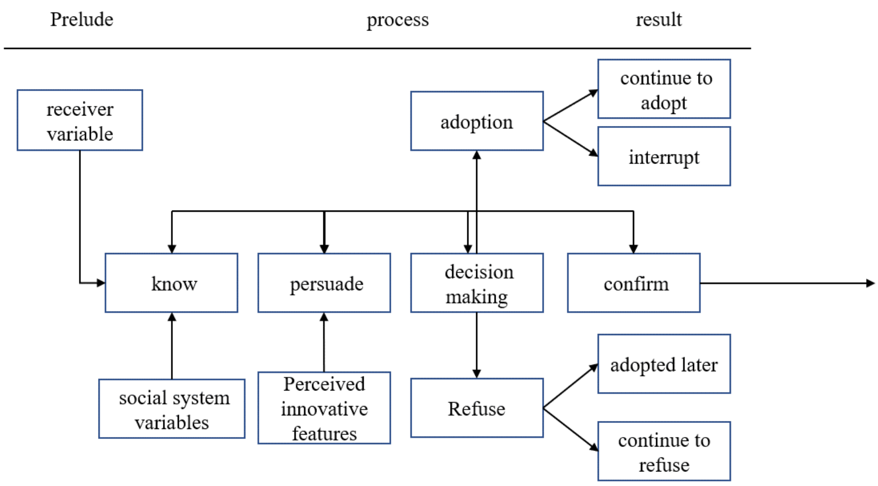

Figure 7.6: Roger innovation diffusion model

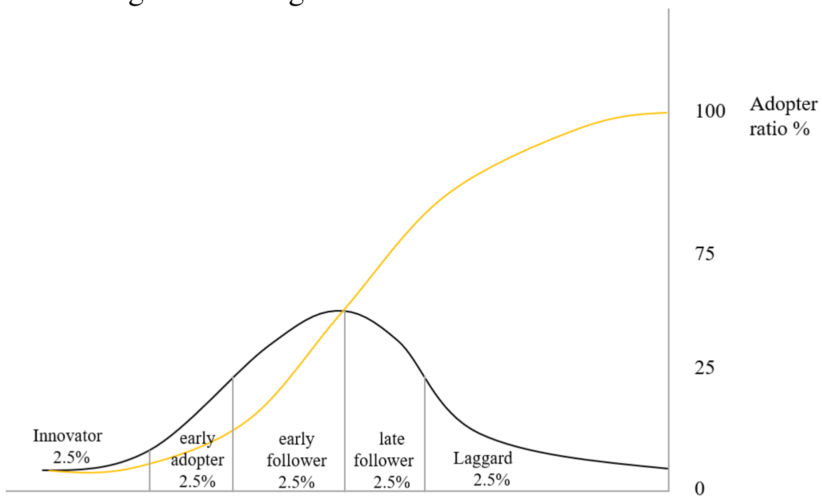

Figure 7.7: Roger innovation diffusion model

that: **Model 2** a decision maker chooses a certain option will get a certain utility **Model 2**assuming decision maker rationality and always chooses the option with the greatest utility **Model 3** the utility of a certain option is jointly determined by the attributes of that option and the preferences of the decision maker **Model 4** the utility has uncertainty, which arises from incomplete knowledge of the decision maker's preferences Incomplete knowledge of the properties of the options.

For this problem, the decision makers, decision options, option properties of this problem are analyzed as follows:

- Population: young and middle-aged, elderly.
- decision options: mobile payment, bus card payment.
- Options Properties: actual cost, time of use, equipment coverage, portability, functional breadth, difficulty of use

First, analyze the young and middle-aged population, assuming that the utility of each option is a weighted linear combination of attributes, there are:

$$u_1 = \widehat{u_1} + e_1 = \beta_6 x_6^1 + \beta_5 x_5^1 + \beta_4 x_4^1 + \beta_3 x_3^1 + \beta_2 x_2^1 + \beta_1 x_1^1 + \beta_0 + e_1 \tag{7.4.1}$$

$$u_2 = \widehat{u_2} + e_2 = \beta_6 x_6^2 + \beta_5 x_5^2 + \beta_4 x_4^2 + \beta_3 x_3^2 + \beta_2 x_2^2 + \beta_1 x_1^2 + \beta_0 + e_2 \tag{7.4.2}$$

Among them, μ_1, μ_1 represent the utility of young and middle-aged people to choose mobile payment and bus card payment respectively. x is an attribute, the subscript 1,2,3,4,5,6 corresponds to 6 attributes, and the superscript 1,2 Corresponding to two ways of mobile payment and bus card payment; β is a preference parameter, e is a random variable, representing the uncertainty of utility.

According to the theoretical assumptions in the utility theory, the condition for decision makers to choose mobile payment is that the utility of mobile payment is greater than that of bus card payment:

$$\begin{gathered} u_1 > u_2 \\ \widehat{u_1} + e_1 > \widehat{u_2} + e_2 \end{gathered} \tag{7.4.3}$$

Arranged:

$$\begin{gathered} e_1 - e_2 > \widehat{u_2} - \widehat{u_1} \\ P_1 = P(u_1 > u_2) = P(e_1 - e_2 > \widehat{u_2} - \widehat{u_1}) \end{gathered} \tag{7.4.4}$$

Assuming e is a logistic function, there are:

$$\begin{gathered} P_1 = \frac{e^{\widehat{u_1}}}{e^{\widehat{u_1}} + e^{\widehat{u_2}}} \\ P_2 = \frac{e^{\widehat{u_2}}}{e^{\widehat{u_1}} + e^{\widehat{u_2}}} \end{gathered} \tag{7.4.5}$$

Under the condition that the equipment coverage is 1/4, it is known from the previous analysis that $P_1 = 66.6\%, P_2 = 33.3\%$,quanlity value of x_1 to x_6 under this condition, and then standardize, the standardization formula is:

$$x^* = \frac{x - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}} \tag{7.4.6}$$

Using the survey method, preliminarily calculate the preference parameters (ratio between preference parameters) for the young and middle-aged, and bring the calibrated x value, β value, and P value into the P value calculation formula, and further adjust the preference parameters to meet the requirements, etc. formula condition.

During the process of expanding the device coverage from 1/4 to 1, the actual cost, access time, portability, functional breadth, and difficulty of use $x_1, x_2, x_3, x_4, x_5, x_6$ attributes do not change, but the device coverage x_3 changes. Using the discrete choice model, calculate the probabilities of the young and middle-aged and the elderly choosing two payment methods after expansion, in Table 1.

Using the survey results(Figure 7.8) of the characteristics of bus passengers in Zhengzhou City, it can be seen that the elderly (¿60 years old) account for about 4.1%, the young and middle-aged (¿10 years old) account for about 93.3%, and the rest of the people younger than 10 years old account for less. Here Not be considered. The statistical results are

Table 1: Selection probability under full coverage

decision options	crowd	selection probability
mobile payment	young and middle-aged	92.17%
	old age	25.88%
bus card payment	young and middle-aged	7.83%
	old age	74.12%

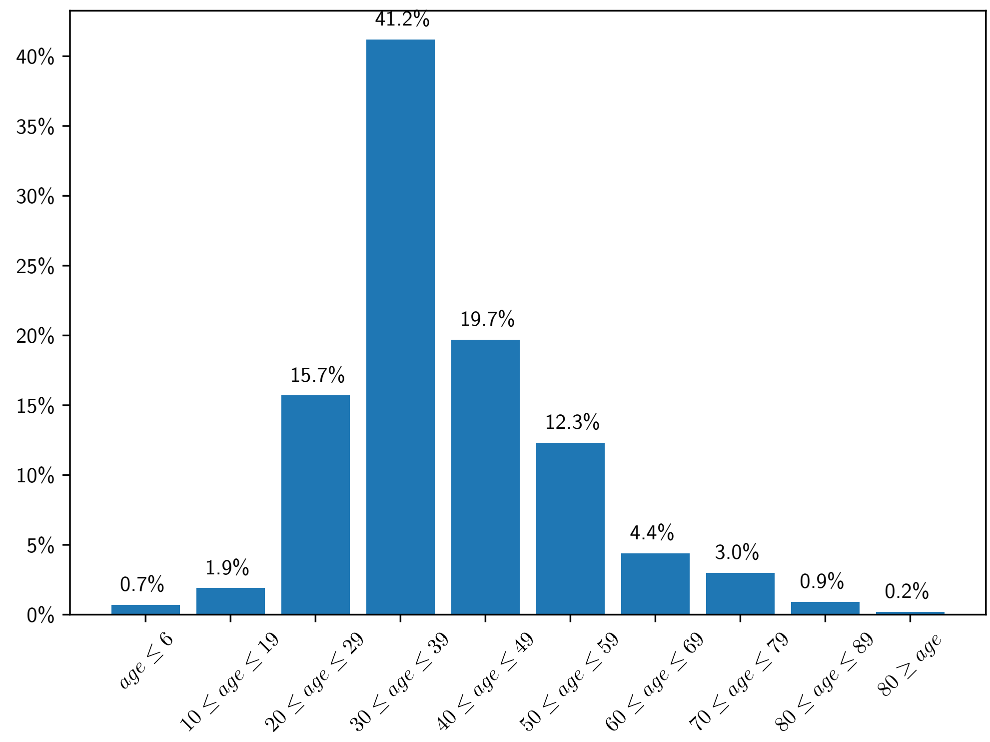

Figure 7.8: Age distribution of Zhengzhou bus survey

shown in the figure below. After revision, the elderly accounted for 4.2% and the youth accounted for 95.8%.

Therefore, under the condition of full coverage, the probability of choosing mobile payment is:

$$\begin{aligned} P_1 &= \frac{P_{1y}P_y + P_{1o}P_o}{P_{1y}P_y + P_{10}P_o + P_{2y}P_y + P_{2o}P_o} = 89.50\% \\ P_2 &= \frac{P_{2y}P_y + P_{2o}P_o}{P_{1y}P_y + P_{10}P_o + P_{2y}P_y + P_{20}P_o} = 10.50\% \end{aligned} \tag{7.4.7}$$

The subscripts $\{1,2\}$ represent decision-making options (mobile payment, bus card payment), and $\{y,o\}$ represent groups (young and middle-aged, elderly).

7.5 Solving Results

The aggregate model (innovation diffusion model) and the disaggregated model (discrete choice model) probability results were integrated, and the mean value was calculated. Available: Under the condition of full coverage, the probability of choosing mobile payment is about 86.75%, and the probability of choosing bus card payment is about 13.25%.

The selection probability is brought into the second problem model. After calculation, the third-party platform will earn about 7,241,790 yuan per month after full coverage is achieved.

8 The solution for the fourth question

8.1 Business feasibility report of third-party mobile payment platform

With the continuous progress of industrial level and information technology, smart mobile terminal devices, i.e., smartphones, have entered thousands of households, and third-party mobile payment platforms relying on them have more business opportunities. Combining a third-party mobile payment platform with pre-existing entity magnetic cards, such as: bank cards, car drive cards, membership cards and so on, by partnering with an entity enterprise, and handling fees, service fees, advertising fees as well as precipitation of financial interest are charged for profit during the process of use. In this question, the third-party payment platform cooperates with the public transportation system to combine the functions of the recharge and use of the ride card with the platform. In the specific business process, the publicity in the early stage, the construction of infrastructure and the labor cost of employees are all increasing with the expansion of the scope of influence. However, the increase in the number of users also expands the profitability of the platform, especially the service fee and precipitation. The growth curve of interest on funds is much higher than the expenditure curve. There are profit models in this article: $W_0 = I_0 - O_0$, and $f'(I_0) > f'(O_0) \to W_n - O_n > 0 \to W_n - O_n > W_{n-1} - O_{n-1}$that is, the profit W is growing. In this question, it can be seen that when the platform share increases from 50% to 86.75%, the profit increases from 1.9 million to 7.2 million, which is extremely profitable.

Feasibility suggestions for the third-party payment platform:

- The third-party payment platform can expand financing and increase the commercial influence and scale of the platform.
- The third-party payment platform can seek multi-faceted cooperation with more entity enterprises.
- The third-party payment platform can appropriately reduce the handling fee and attract more customers.
- The third-party payment platform can add a variety of service directions and portable mobile payment channels.

9 Evaluation and promotion of the model

Question I analyzes the data given in attachment, presents the relationships between the payment characteristics in the form of graphs, enables an objective, visual measure of each factor's role in the data form, and analyzes the city's travel payment characteristics by car, and provides a foundational data support for the latter question.

Question two develops a mathematical model of a third-party mobile payment platform that is reliable and objective and comprehensive in incorporating factors influencing revenue and expenditure, and segments the profitability model into individual modules, with the resolution of re quantitation yielding profitability results that improve functional accuracy and precision.

Question three builds an innovation diffusion model that generalizes data from a quarter of applications to data when they are all applied. And the preconditions for the use of this model are explained using both the aggregate and non - aggregate models that address the supply-demand relationship, with the scientifically complete building of a new model and the profitability model incorporating the second question. To find the relationship between guest flows, coverage of third party payment platform payment, and corporate profitability of third party payment, we bring the data into the model to experiment.

The model used in this question is innovative and efficient, using expertise to complete the modeling process. The multiple models established in this paper are innovative and practically practical, make full use of all data and indicator factors attached, are analysed and evaluated in terms of their nature and quantity, provide good pricing schemes for different items and modes of operation, and have a wide range of applicability.

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