

## Research on the Electronic Commerce Market Survey Based on Normalization Kernel Principal Component Analysis

Cao Lijun<sup>1</sup> and Liu Xiyin<sup>2</sup>

<sup>1,2</sup>Hebei Normal University of Science & Technology, China  
<sup>1</sup>misscao6666@163.com, <sup>2</sup>liuxiyin2003@sina.com

### Abstract

*As a new kind of consumption mode, the online group buying is familiar to consumers and many consumers adopt this new consumption mode. We can conclude online consumption as one of the electronic commerce. Electronic commerce is known as utilization of computer technique, network technique and telecommunication technique to achieve the entire electronic commerce (business transactions) process electronically, digitally and networked. From the view of the consumption patterns, the online group buying (so called electronic commerce) can be divided into the simple online shopping mode and the mode which combine the online shopping and the entity shopping (that is, O2O mode). Though the domestic E-commerce industry starts later, it develops very quickly. However, the unbalanced development among the different regions results the imbalance of the online group buying market development. Therefore, it is necessary to survey the online group buying market. In this paper, we put forward an improved principal component analysis method- normalization principal component analysis method. This method transforms the negative index and the neutral index into the positive index. And it also transforms the positive index that the index value exists negative values into the index value that the positive indexes are all the positive values. Then it can score these indexes. The experimental results show that the method is feasible and effective.*

**Keywords:** *Electronic Commerce; Online Buying; Normalization Principal Component Analysis; O2O*

### 1. Introduction

At the end of twentieth century, with the explosion of the information technology, the network shopping has gradually become an important part of people's life. Hence, here comes electronic commerce. Electronic commerce is defined as under the internet available circumstances, widely using websites and other application servers as foundations to do business transactions or financial trades without seeing each other around the table in the big atmosphere of globally business trade. They use this mode to achieve the goals of internet consumption, internet trade between commercial tenants, electronic payment, and also variety commercial activities, trades, financial activities, and relevant combinations. Electronic commerce is a new commerce operating model. According to the notice that the Internet Information Center recently issues, Chinese online group buying market scale grows rapidly. To the end of 2010, the market transactions amounted to 52.31 billion. And the scale of online shopping user reached to 161 million [1]. The impact of these figures on the traditional retail industry is becoming more and more obvious. In 2009, the rapid development of America Groupon enterprises made "the online group buying mode" concerned around the world. From January 2010, China began to appear the similar online group buying website. Due to the low technology threshold, there are thousands of group websites appearing within 9 months. The O2O is a kind of business activity. That is, a certain number of users purchase the same product with a lower discount by the Internet channel.

Flanagan and Robert analyzed the impact of the collective bargaining system on the industrialized countries macroeconomic performance from the bargaining level and the coordinating etc. They thought that the power of the collective bargaining was more important than the individual bargaining. And they put forward the corresponding bargaining strategy [2]. Kauffman and Wang proposed three factors which influence the establishment of the network online group buying. These three factors were price, cycle and the external demand effect [3]. Krishnan and Ravi studied the price mechanism of the network online group buying in B2B and B2C modes. And they also compared the influence degree of different price mechanism on profit. In addition, they made the corresponding production and price strategy for enterprises [4]. Hsiangchu and Her-Sen analyzed the impact of the market price on the online group buying activity for the buyers. They thought that the price affected the willing that the consumers participated in the group buying directly [5]. However, the short of quantity of the group buying caused the consumers to have to wait. Aiming to this phenomenon, Kauffman put forward the corresponding online group buying motivation mechanism. The results showed that the price was not the only determinant factor that influenced the consumers to proceed the group buying. Equity was another important factor [6]. In the risk of the scale economies, by comparing the difference between the online group buying auction and the fixed price mechanism, they found that the optimal price of the online group buying auction and the fixed price mechanism were the same when the best discount ratio was zero. When considering the scale economy, the group buying auction was better than the price mechanism [7]. Gupta and Banpa pointed out that consumers online auction pricing process involved their investment strategies. And these strategies were very important to ensure the transaction price [8].

In China, Peng Liang evaluated the consumer trust for the online group buying website in Groupon mode. He thought that the core link of the online group buying mode was the online group buying website. However, the group website which was trusted by the consumers was the basis for the long-term success online group buying activities [9]. Zhou Jianni verified that the perceived risk of the consumer group buying behavior still existed 8 dimensions. The 8 dimensions were economic risk, functional risk, social risk, time risk, physical risk, psychological risk, privacy risk and service risk. In each dimension, the specific factor has the feature of the online group buying mode [10]. Wang Jing studies the effect of grouping-buying consumer perception to purchase decision under different price discount and time pressure. He thought that the perceived value was positively related to the purchase decision. And the perceived risk was negatively related to the purchase decision [11]. Bo Yang researched the influencing factors on customer satisfaction of college students' online group buying. He thought that the influence factors of the network online group buying customer satisfaction could be composed of multiple indexes. These indexes included network group buying characteristic factor, commodity information factor, evaluation and rating factor, service factor and logistics and payment factor. And each factor could also be subdivided into a number of factors. These factors (in addition to the network group characteristic factor) were significantly correlated to the customer satisfaction. The network group characteristic factor was negatively related to the customer satisfaction [12]. He Lefie researched the online group buying websites model of based on O2O mode. He analyzed the operation mechanism based on the online group buying website mode. Starting from the 9 elements of the business model, he combined the management theory and discussed the existing models in such group buying website operation mode. And he proposed the corresponding countermeasure. In addition, he used the public group as a sample. He also adopted the analysis method and the Potter five competitive forces analysis method to analyze the typical "O2O" business mode. Finally, he got the conclusion and enlightenment. And he gave the corresponding references [13]. According to studying the business mode, Liu Peng discovered the characteristic, trend, bottlenecks and the future of the business mode. His study promoted

the maturity and development of the service life of the electronic commerce market. Aiming for the transformational challenge which the current telecom operators faced, Liu Pneg analyzed the advantages for the telecom operators in the business mode. And we also analyzed the opportunities and challenges [14]. In addition, Shi Chunjia and Chi Kunpeng also studied deeply the O2O theory [15-16].

Although many scholars studied the online group buying strategy or the O2O mode, few people assessed the market condition of O2O. In addition, in order to solve the unformed evaluation index attribute, we put forward an improved principal component analysis method- normalization principal component analysis method. According to this method, we transformed the index into positive index in order to score the index. By using the experimental analysis, we proved the method is effective. The structure of this paper is as follows. The first part is the conclusion. The second part is the current status of the online group buying website. In this part, we introduce the current status of the network online group buying website. The third part is the algorithm process of the normalization kernel principal component analysis. In this part, we proposed the normalization kernel principal component analysis method. The fourth part is the numerical analysis and the last part is the conclusion.

## 2. The Current Status of the Online Group Buying Website

Firstly, we collect the online group buying website data. Then we analyze the current online group buying situation of the top 10 cities for the Chinese online group buying websites. These ten cities are Beijing, Shanghai, Guangzhou, Shenzhen, Tianjin, Nanjing, Hangzhou, Suzhou, Wuhan and Chengdu. We select 12 variables. They are the number of online group buying  $X_1$ , the number of the online group buying people  $X_2$ , the market turnover  $X_3$ , the number of the online group buying website  $X_4$ , the regional differences of the online group buying product  $X_5$ , per capita GDP  $X_6$ , the proportion  $X_7$  of the third industry in GDP, the per capita disposable income  $X_8$ , residents consumer price index  $X_9$ , the population flow  $X_{10}$ , passenger volume  $X_{11}$  and the total postal service  $X_{12}$ . The indexes and the types are shown in the table.1.

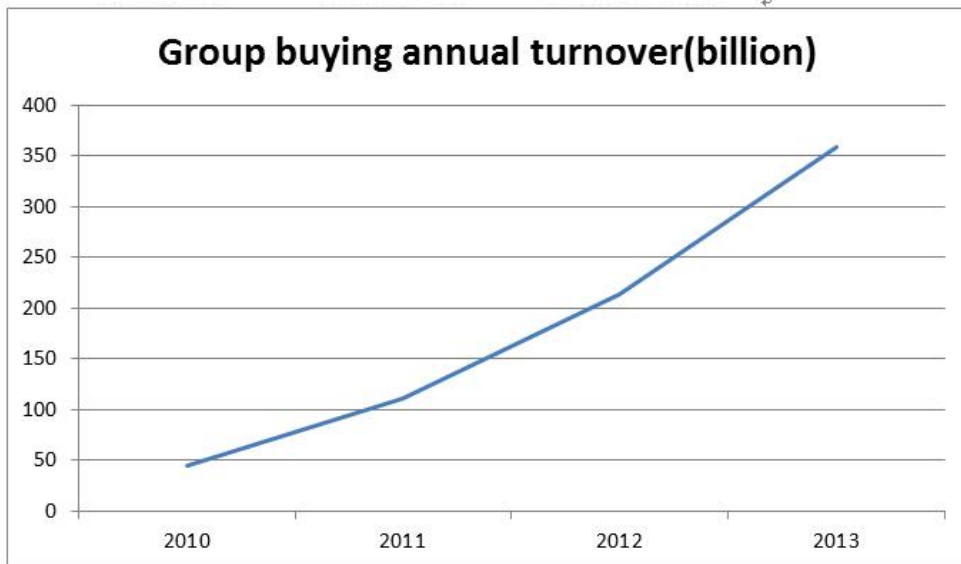
**Table1. The Indexes of the Online Group Buying Evaluation Model**

dimension	index	type
Online group buying market purchasing power	the number of online group buying	positive
	the number of online group buying people	positive
	the market turnover	positive
	the number of the online group buying website	positive
	the regional differences of the online group buying product	positive
The living standards of residents	per capita GDP	Positive
	the proportion of the third industry in GDP	positive
	the per capita disposable income	positive
	residents consumer price index	positive
Demographic factors	the population flow	positive
	passenger volume	positive
	the total postal service	neutral

Online group buying market purchasing power includes the number of online group buying, the number of online group buying people, the market turnover, the number of the online group buying website and the regional differences of the online group buying product. The living standard of resident includes per capita GDP, the proportion of the

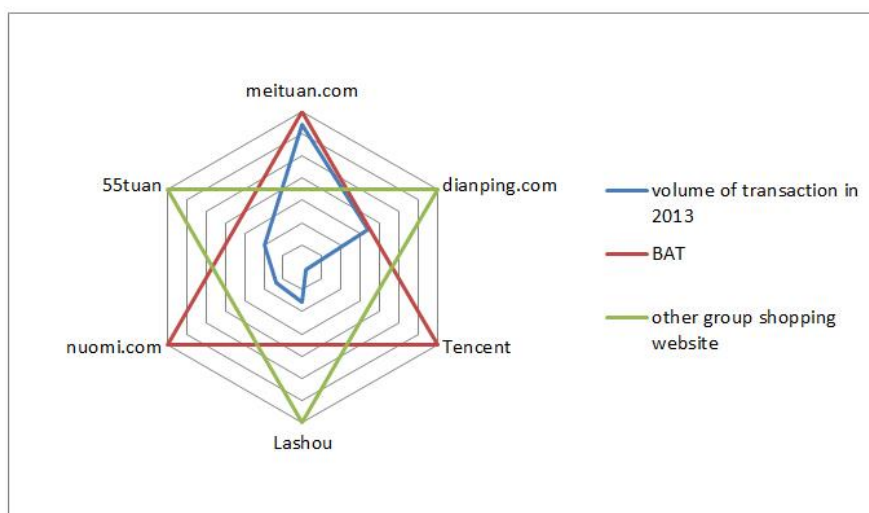
third industry in GDP, the per capita disposable income and resident consumer price index. Demographic factor includes the population flow, passenger volume and the total postal service. The reverse effect of the residents consumer price index on the consumer spending is conform to the mechanism of the residents consumer price index on the consumer spending

Now, we introduce the current status of the network online group buying website. Firstly, we show the online group buying turnover about 2010-2013 years. The online group buying turnover about 2010-2013 years is as follows.



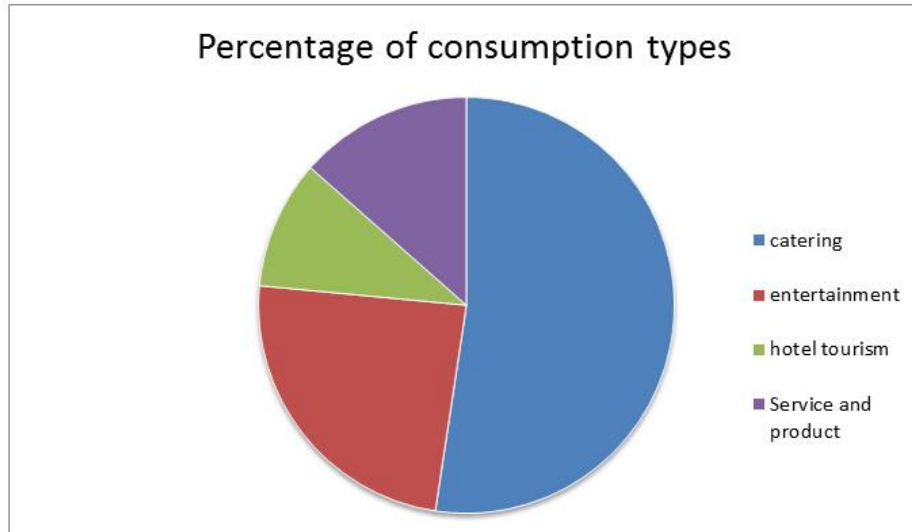
**Figure1. Online Group Buying Turnover from 2010-2013**

From figure.1, we can see that the online group buying transaction volume is 45 billion in 2010. In 2011, the online group buying transaction volume is 110 billion. In 2012, the online group buying transaction volume is 214 billion and the online group buying transaction volume is 358.8 billion in 2013. The online group buying transaction volume increased year by year and the growth is very fast. This shows that the online group buying market is in the golden period.



**Figure 2. Market Shares of Different Goupons in 2012**

Figure.2 shows the different online group buying websites market share. The major domestic online group buying websites included meituan.com, dianping.com, Tencent, Lashou, noumi.com and 55tuan. In this figure, we can see that meituan occupies most of the market share. The websites that the BAT (Baidu, Alibaba and Tencent) holds occupies the vast majority of the market share. Therefore, the competition of the online group buying market further intensifies.



**Figure3. The Percentage of Consumption Types**

From figure.3, we can see that the catering consumption is the mainly consumption, then is the entertainment consumption and the service and product consumption. The hotel tourism consumption occupies the least amount of share.

### 3. The Algorithm Process of the Normalization Kernel Principal Component Analysis

#### 3.1 The Kernel Principal Component Analysis

We assume that  $n$  sample data vector  $x_k (k = 1, 2, \dots, n), x_k \in R^p$  in the putting space  $R^p$ .

We assume

$$\sum_{k=1}^n x_k = 0.$$

Then the con-variance matrix is as follows.

$$C = \frac{1}{n} \sum_{j=1}^n x_j x_j^T \quad (1)$$

For the kernel principal component analysis, by solving the characteristic equation

$$\lambda v = Cv \quad (2)$$

Then, we can obtain the eigenvalue which has the larger contribution rate (corresponding to the largest eigenvalue) and the corresponding eigenvector.

Now, we introduce the nonlinear mapping function  $\phi$ . It makes the sample data vector  $x_k (k = 1, 2, \dots, n)$  in the putting space  $R^p$  transform the sample data vector  $\phi(k) (k = 1, 2, \dots, n)$  in the feature space  $F$ . And we assume

$$\sum_{k=1}^n \phi(x_k) = 0 \quad (3)$$

The con-variance matrix in the feature space  $F$  is as follows.

$$\bar{C} = \frac{1}{n} \sum_{j=1}^l \phi(x_j) \phi(x_j)^T \quad (4)$$

Therefore, PCA in the feature space  $F$  is the eigenvalue  $\lambda$  and the feature vector  $V \in F \setminus \{0\}$  in the characteristic equation

$$\lambda v = \bar{C}v. \quad (5)$$

Then we have the equation as follows.

$$\lambda(\phi(x_k) \cdot v) = \phi(x_k) \cdot \bar{C}v, (k=1, 2, \dots, n) \quad (6)$$

Among them,  $v$  can be expressed linearly by  $\phi(x_i), i=1, 2, \dots, n$ . That is,

$$v = \sum_{i=1}^n \alpha_i \phi(x_i) \quad (7)$$

We get

$$\lambda \sum_{i=1}^n \alpha_i (\phi(x_k) \cdot \phi(x_i)) = \frac{1}{n} \sum_{i=1}^n \alpha_i \left[ \phi(x_i) \cdot \sum_{j=1}^n (\phi(x_j)) \right] (\phi(x_j) \cdot \phi(x_i)), k=1, 2, \dots, n \quad (8)$$

Defining the kernel function

$$K(x_i, x_j) = \phi(x_i) \phi(x_j) \quad (9)$$

Then we get

$$n\lambda K\alpha = K^2\alpha \quad (10)$$

That is,

$$n\lambda\alpha = K\alpha \quad (11)$$

According to solve the above formula, we can get the eigenvalue  $\lambda_k, k=1, 2, \dots, n$  and the corresponding eigenvector  $\alpha^k, k=1, 2, \dots, n$ .

Therefore, we get that the  $F$  space vector is

$$v^k = \sum_{i=1}^n \alpha_i^k \phi(x_i).$$

For the selection of the principal components, we only need to compute the projection of a test sample data vector  $\phi(x)$  in  $v^k$  of the space vector  $F$ .

$$(v^k \cdot \phi(x)) = \sum_{i=1}^n \alpha_i^k (\phi(x_i) \cdot \phi(x)) = \sum_{i=1}^n \alpha_i^k K(x_i, x) \quad (12)$$

The above formula is similar to the comprehensive index in PCA. We call it as the  $k$  principal component of KPCA. At the same time, the comprehensive evaluation function of KPCA can be defined as follows.

$$F(x) = \sum_{k=1}^r \sum_{i=1}^n \omega_k \alpha_i^k K(x_i, x) \quad (13)$$

Among them,  $r$  meets  $\sum_{i=1}^r \alpha_i / \sum_{i=1}^n \alpha_i \geq 85\%$ .  $\omega_k$  is the contribution rate of the  $k$  principal component. If the parameter selection of the kernel function is appropriate, it can make  $r=1$ . That is,

$$F(x) = \sum_{i=1}^n \omega_i \alpha_i^1 K(x_i, x) \quad (14)$$

If  $\sum_{i=1}^n x_i = 0$  is not established, then  $K$  needs to use  $\tilde{K}$  to instead of  $\tilde{K} = K - AK + AKA$ . Among them,

$$A_{ij} = \frac{1}{n}, i, j = 1, 2, \dots, n.$$

### 3.2. The Normalized Score in Kernel Principal Component Analysis

**3.2.1 The positive indexes score:** We assume that  $x_{ij}$  is the score of the  $j$  index in  $i$  city.  $V_{ij}$  Is the value of the  $j$  index of the  $i$  city.  $m$  Is the number of the evaluated city. And  $n$  is the number of evaluated index. The positive indicator evaluation formula that the index values are positive is as follows.

$$x_{ij} = \left( V_{ij} / \sum_{i=1}^m V_{ij} \right) \times n, (1 \leq i \leq m, 1 \leq j \leq n) \quad (15)$$

**3.2.2 The score of the positive indexes that the index values exist the negative values:** The scoring method is as follows.

According to the following formula (16), we transform them to the positive indexes that the index value is positive. Then according to the positive index evaluation formula (15) that the index value is positive, we score them.

We assume that  $V_{ij}'$  is the converted value of the  $j$  positive index of the  $i$  city.  $V_{ij}$  is the value of the  $j$  positive index in  $i$  city.  $m$  is the number of the evaluated city. And  $n$  is the number of evaluated index.  $v$  is a constant which cannot take zero. Its order of magnitude is the same to  $\min_{1 \leq i \leq m} (V_{ij})$ . Then,

$$V_{ij}' = V_{ij} - \min_{1 \leq i \leq m} (V_{ij}) + v, (1 \leq j \leq n) \quad (16)$$

The difference between type (16) and the existing research is that we add a constant  $v$  which cannot take zero. And for  $v$ , the order of magnitude is the same to  $\min_{1 \leq i \leq m} (V_{ij})$ .

That is, by shifting the normalized numerical, we can avoid that its minimum value is zero. According to the existing research results, we know that the evaluation index score of the minimum index value is zero. When the score is zero, the evaluation result of the  $m$  evaluated cities which include the minimum index value is the same to the evaluation result of the  $m-1$  evaluated cities which remove the minimum index value. However, it is not reasonable.

**3.2.3 The negative index score:** The scoring method is as follows.

By the following formula (17), we transform the negative index to the positive index. Then, according to the evaluation method type (15-16) of the positive index, we score them.

We assume that  $V_{ij+}'$  is the converted value of the  $j$  positive index of the  $i$  city.  $V_{ij}$  is the value of the  $j$  negative index in  $i$  city.  $V_j$  is the moderate value of the  $j$  moderate index.  $m$  is the number of the evaluated city. And  $n$  is the number of evaluated index. Then,

$$V_{ij+}' = \max_{1 \leq i \leq m} (V_{ij}) - V_{ij} + \min_{1 \leq i \leq m} (V_{ij}), (1 \leq j \leq n) \quad (17)$$

**3.2.4 The neutral index score:** We assume that  $V_{ij-}$  is the value of the negative index which is transformed by the  $j$  moderate index of the  $i$  city.  $V_j$  is the moderate value of the  $j$  moderate index.  $m$  Is the number of the evaluated city. And  $n$  is the number of evaluated index.

$$V_{ij}' = |V_j - V_{ij}|, (1 \leq j \leq n) \quad (18)$$

## 4. Numerical Analysis

### 4.1 Normalization Kernel Principal Component Analysis

We select ten cities to analyze. They are Beijing, Shanghai, Guangzhou, Shenzhen, Tianjin, Nanjing, Suzhou, Wuhan, and Chengdu. From the geographical position, this sample includes the coastal cities as Shanghai, Guangzhou, Shenzhen, Tianjin and the developed cities as Beijing, Nanjing, Hangzhou, and Suzhou. It also includes the inland cities as Wuhan and Chengdu. From the angle of economic circle, this sample includes the bohai sea surrounding economic circle as Beijing and Tianjin, the Yangtse river delta economic area as Shanghai, Nanjing, Hangzhou and Suzhou, the Pearl River Delta economic circle as Guangzhou and Shenzhen. This sample also includes the inland cities as Wuhan and Chengdu.

**Table 2. The Ranking of the Online Group Buying Evaluation Model**

Number	City	Total ranking		Online group buying market purchasing power rankings		The living standards of residents rankings		Demographic factors rankings	
		Evaluation coefficient	Ranking	Evaluation coefficient	Ranking	Evaluation coefficient	Ranking	Evaluation coefficient	Ranking
1	Beijing	5.71	1	6.47	1	-0.05	6	1.86	2
2	Shanghai	5.69	2	6.28	2	-0.07	7	1.79	3
3	Guangzhou	2.11	3	4.35	3	0.01	5	1.53	4
4	Shenzhen	1.97	4	3.76	4	1.78	4	2.71	1
5	Tianjin	0.48	5	1.89	5	-0.34	8	0.78	5
6	Nanjing	0.31	6	0.02	6	2.03	3	0.00	7
7	Hangzhou	-0.46	7	-0.37	7	3.47	2	-0.32	8
8	Suzhou	-0.55	8	-0.51	8	3.62	1	0.06	6
9	Wuhan	-0.97	9	-0.86	9	-0.09	9	-0.56	9
10	Chengdu	-1.32	10	-1.12	10	-0.12	10	-1.84	10

Through the ranking of the principal component analysis, we find that the comprehensive ranking is very close to the online group buying market purchasing power ranking. This shows that the development of the online group buying market is closely related to the purchasing power. The bigger market purchasing power can have enough online purchasing market capacity. However, the market purchasing power can also reflect the economic development level of the city. The domestic and international research shows that the regional difference of the Internet development is the interaction result of many factors. However, the role of the economic development for the development of the area network should be not ignored.

Secondly, the comprehensive ranking is related to the living standards of the residents ranking. The index can reflect the living standard of the residents. Therefore, we add to the per capita GDP and the per capita disposable income in this index. The ranking of some cities that have the large gap between poor and rich are not high. The per capita GDP and the per capita disposable income are higher, intense for the sprint need of Internet access is more. It promotes the development of the online group buying.

Finally, the comprehensive ranking is also related to the city population factors. If the city passenger volume is bigger, the type of the merchandise is more abundant. The



updated speed of the online group buying information is faster; the range of the online alternative group buying products is wider. At the same time, the bigger city passenger volume reflects the advantages of the traffic location. To a certain extent, it promotes the development of the local logistics industry. And it also promotes the development of the online purchasing.

From the ranking, the best cities for the development of the O2O online group buying market are Beijing and Shanghai. On the one hand, Beijing and Shanghai is the birthplace of the online group buying network in China. It starts early. On the other hand, these two cities are international metropolises. One is the capital. The other is the economic center. The two cities have the broad online group buying market. And the resident consumption level is higher. The technical personnel also have a great advantage. After that, the second best cities are in three major economic regions (the Pearl River Delta Economic Zone, BoHai Economic Zone and the Yangtze River Delta Economic Zone). They include Guangzhou, Shenzhen, Tianjin, Nanjing, Hangzhou and Suzhou. These areas have the location advantages. The economic development is in leading position in the domestic. The market capacity is bigger. The purchasing power is stronger. And the consumption level of the residents is higher. At the same time, due to the developed transportation logistics, the development scale of the online group buying is larger. The last is Wuhan and Chengdu which locate inland. The scale of these places is not large and it is in embryonic stage. However, the market potential is bigger. Now, the group website, the inland areas and the two or three line cities will be as the focus of the future development. The successful experience of the first-tier cities can quickly expanded to the two or three line cities. The ability to win the market scale and the share increases rapidly. Therefore, the development space of these cities is bigger.

#### 4.2 Clustering Analysis

Then we cluster these ten cities. The hierarchical cluster analysis in 10 cities is shown in the table.3. The first kind is Beijing and Shanghai. The second kind is Guangzhou, Shenzhen, Tianjin, Nanjing, Hangzhou and Suzhou. The third kind is Wuhan and Chengdu.

**Table 3. The Hierarchical Cluster Analysis in 10 Cities**

Clustering Hierarchy	City
1	Beijing, Shanghai
2	Guangzhou, Shenzhen, Tianjin, Nanjing, Hangzhou, Suzhou
3	Wuhan, Chengdu

Beijing and Shanghai is international metropolis. And they are wombs of online group buying markets. Guangzhou, Shenzhen, Tianjin, Nanjing, Hangzhou and Suzhou are developed cities. The capacity markets in these cities are huge and the purchasing power in there cities are strong. Wuhan and Chengdu are inland city. The online group buying markets in these cities start late. But potential in these cities are big.

#### 5. Conclusion

With the increasing number of people who use Internet, it is much more popular that people use online buying consumption and use credit to make online payment (electronic payment). Market share is also increasing rapidly. Therefore the models of electronic commerce are appearing continuously. O2O is short for Online to Offline. It is the combination between the offline business opportunities and the Internet. It makes the Internet become the offline trading desk. The online group buying is a typical form of O2O. Internet technology makes the online group buying consumption situation has a

huge market space. Aiming to the market condition, this paper surveys the O2O market. And we did some work as follows. (1)Firstly, aiming to the market survey of O2O, we established the evaluation index system of O2O. (2)Secondly, we put forward an improved principal component analysis method- normalization principal component analysis method. (3)Thirdly, we use normalization principal component analysis method to evaluate the O2O online group buying market. And we point out that the group market exist a large difference in different regions. The experimental results show that the method is effective and feasible.

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