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CHALLENGES AND OPPORTUNITIES PREVAILING IN CHINESE MOBILE MARKET THROUGH THE ANALYTICS OF GREY MODEL

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Abstract

This research paper points out the existing problems and potential business opportunities in the elderly mobile phone consumption market by analyzing data obtained from the interviews with experts and marketing strategies of operators. Through the design of this research, this paper fills the conceptual and empirical gap in the discovery of the behavior of elderly consumer groups in China, and shows the changes and influences brought by the aging society from a new perspective, providing new perspectives, research methods and research ideas for future research on the elderly. The main innovations of this paper are that the research methods are relatively innovative that focuses on the basis of the description of the general statistics, using clustering and grey model to meaningfully and deeply demonstrate the data owing to its particularity odd data. It can provide new thoughts, new perspectives, new methods and new paths for related elderly research by analyzing generality and individual characters of the behavioral activities of the elder cell phone users.

Key words: Grey Model, Mobile Utility, Challenges and Opportunities

1. Introduction

Under the vast circumstance of a worsen aging society in China，the proportion of the elderly will maintain a stable rising tendency therefore the elderly, as a consuming objective, is becoming to play an important role (Law et al. 2019a; AJ Greco, 1987). The main research domains are focused on curing the diseases of the elderly, exploring the body functions, improving current medical care situation and researching on psychological features of the elderly (Czaja et al., 2019; Kossek et al., 2019; Gelderblom et al., 2010). In the meanwhile, scholars began to keep their eyes on the elderly-oriented economic market, a gold mine to be mined，to research on consumer behavior of the elderly, to put forward segmented marketing strategy, and provide reference to help companies make marketing decisions (Hirano et al., 2019; Valliappan Raju et al., 2019; Muhammad Tanveer, 2020). In the recent years, specific marketing research related to the elderly mainly focused on the fields of tourism, pension

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consumption, healthy products, however, information consumption still lagged behind others mentioned above (Muhammad Tanveer et al., 2020; Goot et al., 2016).

1.1. Research Background

In the past twenty years, the domestic media environment has gone through dramatic change. With the emergency and popularity of new media such as the computer and mobile phone, people's using habits have greatly transformed. As the Internet society developed, the audience of new media has extended from teenagers to the middle-aged the elderly, which, as a new born consumption object, has great marketing value in the respect (Furlong M, 2007; Grajczyk et al., 1996; Law et al., 2019b). With the improvement of life quality of the elderly and spiritual pursuit, more elderly begin to use electronic products, in which way they could get more access to obtain information, and that is why Grey Market has become a vital potential market for mobile devices.

1.2 Research Significance

Through this research paper, the authors attempt to introduce the grey system theoretical model and spatial statistical model in detail. It mainly combines the relevant researches at home and abroad, deduces the grey system theoretical model and spatial statistical model, and applies relevant practices, etc., to lay the theoretical model foundation for the prediction and analysis of the future elderly mobile phone user behavior. On this basis, grey system model and spatial statistical model were used to conduct empirical research on the data and analyze the use preference of mobile APP of the elderly population. On the one hand, spatial statistics are used to study whether the use of mobile phones by the elderly is spatially correlated in terms of fees and App use, and whether there is spatial clustering effect. On the other hand, this paper modifies and improves the grey model appropriately, and calculates the grey relational degree of all the data collected and preprocessed. The correlation between the number of phone calls, the duration of cell phone, the number of phone calls, the duration of the phone APP, the duration of the phone APP, the duration of the phone APP, the duration of the phone APP, and the amount of time that the phone APP used to use the duration of the phone, and the amount of the time that the phone APP used to use it to analyze the correlation between these factors.

1.3 Research Method

Through the comparative study mode this research paper selects TV as a representative of traditional media and as a comparative object with mobile phones. By comparing the usage of computer and mobile phone would analyze the possibility of alternation of traditional media, by comparing preferences of TV shows and app would show the differentiations on different social media platforms. This paper utilizes Grey Prediction Model to analyze the latest five-quarters' monthly average usage time, usage flow and call duration of the elderly and to propose the predictive analysis for the next quarter. At the same time, Spatial Statistical Model is also utilized to see if there exists spatial aggregation effect on elder users' behavior in Chengdu, namely spatial correlation effect. Finally experts interview was conducted. After obtaining data prediction of next stage, interviewing the top managers and professors in the field of marketing would be conducive to conclude and refine the experts' analysis of status quo and to propose suggestions for further decision-making for reference.

2. Literature Review

The aging of population in China presents a staged attribution in a way from the aspect of historical data (Law et al., 2019d; Law et al., 2020d; Law et al., 2020f). Which comes first is the embryo stage that appeared between the year of 1982 and 1990. At that time the proportion of aged group at or above 60 wasn't high with an instance of 4.9% in 1982 during the time of the third Chinese National Population Census. The second stage is the

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germinating and transition stage, since then the ratio of citizens at or above 60 to total population went up, the type of China's population age framework transmitted from adult to elder society thus heralded the forthcoming of a time of nationwide age of aging. In terms of the data from millennium's Chinese National Population Census, 10.33% of the total population are those at or above 60 therefore manifested officially that China had become an aging society in early 21 century. The third one is the stage of accelerating development during which the aforementioned proportion will increase rapidly from about 10%, the age structure has already transmitted into a typical aging one, and the transition of society type from adult to elder will then be completed. The fourth is the stage of rapid development. UN forecasts that in the future, every 100 active labor force will have to burden about 10 people of the age at or above 65, and this ratio will rise up to 100 to 30 in 2050. Research on social and economic activities cannot be achieved without information. Later, the academia called the partially explicit and partially ambiguous information system Grey System. In 1982, Professor Julong Deng published two papers on Grey Control System in *Systems & Control Letters* and Journal of *Huazhong University of Science and Technology*, which marked the advent of Grey System Theory. In the era of big data, there are still a large number of uncertain systems of "small data" and "poor information" in the real world, which provide abundant research resources and broad development space for the development and application of Gray System Theory. According to the theory of Grey System, random quantity can be regarded as grey quantity changing within a certain range. For the Grey System with poor information, the value of grey variable is very limited, and the data changes irregularly (Carlo, 2009; Valliappan et al., 2020). Through the generation and operation of these gray variables, the gray prediction model makes the data change after processing have certain rules.

Compared with the original data, the gray prediction model increases the certainty of data change. On the basis of the generated data, the gray system model is established for prediction. Grey prediction model is one of the most widely used models in grey system model. Naiming Xie et al. (2005) firstly put forward the discrete grey model and studied its nature. Chirwa (2006) used GM (1, 1) model to study the British and American data and estimate the risk of traffic accident. Xueyuan Zhang et al. (2006) used GM (1, 1) model to study the change rules of emotional state of robots, and proposed an emotional robot interaction system based on it. Yanyang Wang (2010) established a nonlinear online prediction model of operational risk of civil aviation in China by using the gray model. Wu et al. (2013) solved the perturbation problem of grey model solution by proposing discrete grey model through accumulation of fractional order; Jie Yang et al. (2014) modified the unbiased gray model and used the improved model to predict the gas supply of a city. Nelson (2014) through simulation experiment, such as to determine the four kinds of basic model GM (1, 1), the average GM (1, 1) model and discrete GM (1, 1) model, the mean difference GM (1, 1) model and the original difference GM (1, 1) model, at the same time, the sequence of different model applicable conditions and types. The grey prediction system starts from small data, integrates statistical test and the original model test method of grey system, and has wide applicability. Grey correlation analysis is a quantitative description and comparative method for a system development situation based on similarity of changing curve geometry of various factors, the basic idea is determined by the reference data series and several comparative data column geometry similarity degrees to judge whether the contact is intimate, it reflects the correlation degree between the curves. Through the quantitative analysis of the development trend of the dynamic process, this method completes the comparison of the geometric relationship of the relevant statistical data of the time series in the system, and obtains the gray correlation degree between the reference series and each comparison series. The larger the correlation degree between the reference series and the reference series, the closer the development direction and speed of the comparison series is to the reference series, and the closer the relationship between the comparison series and the reference series is. The appearance of grey correlation analysis

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method made people change from the traditional method of dealing with practical problems based on experience to a more scientific and accurate method for exploration (Yunlong et al., 2019; Shuai, 2019; Mansouri et al., 2019).

3. Research Framework

The data analyzed in this paper are operational data extracted from the data system of an operator, averting systematic errors caused by questionnaire surveys. The data are highly reliable and objective. Based on the existing literature research results and combined with the existing data types and modes of the operator database, the following variables were selected as the research objects:

(1) User's age. The age information of users is obtained by utilizing the data of the operator's database, and divided into different age sections to form the age information of each section which the user belongs to.

(2) User's gender. Attaining the gender information of users through the data base of the operator.

(3) Region that the user resides. The regions where mobile phones are most frequently used are the areas for users. According to the administrative divisions, the areas were divided into rural and urban areas. Users are sorted to different blocks within the Qingyang district

(4) User's phone numbers. One user may have more than one mobile phone number, and the data generated by different mobile phone numbers were combined, and the main mobile phone number was perceived as the corresponding mobile phone number of that user. It is worth noting that in real life, the user's mobile phone number may be in the state of shutdown but keeping the number or other abnormal use, that is, it failed to produce effective raw data for analyzing. In this case, the data will be cleaned and screened, and such users will be deleted.

(5) User's phone models. In real life, the same user may have more than one mobile phone model, and the mobile phone model adopted in the research was corresponding to the user's major mobile phone number which was also used by the user most frequently, in other words, the mobile phone model corresponding to the mobile phone number with the highest activity was taken as the model of phone used by that user.

(6) Level of user's expenditure. Calculating the average value of mobile communication consumption of the same user in different quarters as the user's expenditure level of phone charge, and the range of fee of all users is divided to determine the section of expenditure level that the user belongs to, then regarding it as the mobile communication consumption level of the user.

(7) User's call duration. The average call duration of the same user in different quarters was calculated as the call duration of the user, and the interval of all users' call duration was hence divided to decide which interval the user belongs to and taking it as the evaluation of the phone call duration of the user.

(8) The frequency of the user's calls. The average call frequency of the same user in different quarters was calculated as the call frequency of the user, and the call frequency interval of all users was divided to determine their call frequency intervals, which was used as the evaluation of the phone call frequency of users'.

(9) The list of Apps installed by the user. Sorting out the APP list used by the user, classifying these Apps via their fundamental or major functions, they are mainly divided into social networking applications, life and consumption applications, online payment applications, query tools, map and navigation applications, beautifying and photo-taking applications, video players, news information applications, book reading applications, enterprise customizations and other types of mobile Apps, the study was carried out through these classifications

(10) Duration of App use. After classified the above Apps, user's average monthly use time of each type of App was counted as the user's App-using time.

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Table 3.1 Variable Definitions

Variable Names	Variable Types	Other Remarks
Gender	Dummy Variable	Female = 0, Male = 1
Age	Continuous Variable	80 and above = 0, 75-79 = 1, 70-74 = 2, 65-69 = 3, 60-64 = 4
Region	Dummy Variable	Rural = 0, Urban = 1
Phone Number	Continuous Variable	
Phone Model	Dummy Variable	IPhone = 0, Samsung = 1, Huawei = 2, Xiaomi = 3, OPPO = 4, vivo = 5, other Chinese brands = 6, other non-Chinese brands = 7
Phone Type	Dummy Variable	Non-smart phone = 0, Smartphone = 1
Level of Phone Charge	Dummy Variable	0-20 CNY = 0, 20-40 CNY = 1,40-60 CNY = 2, 60 CNY and above = 3
Call Duration	Dummy Variable	0-1 hour = 0, 1-10 hours = 1, 10-20 hour = 2, 20 hours and above = 3
Call Frequency	Dummy Variable	0 time = 0,1-10 times = 1,10-20 times = 2,20 times and above = 3
App List	Dummy Variable	Social Networking = 0, Life and consumption = 1, online payment = 2, query tools = 3, map and navigation = 4,beautifying and photo-taking = 5,video players = 6, news information = 7, book reading = 8, enterprise customization = 9, others = 10
App-using Duration	Dummy Variable	0-1 hour = 0,1-10 hours = 1,10-20 hours = 2,20 hours and above = 3
App-using Data Traffic	Continuous Variable	
App-using Frequency	Dummy Variable	0 time = 0,1-10 times = 1,10-20 times = 2, 20times and above = 3

4. Data Analysis

As for the selection of mobile phone models, it can be found that at present, most of the elderly choose domestic mobile phones, and statistics showed that only 8.3% of the elderly choose mobile phones from non-Chinese brands. Among Chinese domestic mobile phone models, OPPO and vivo account for the highest proportion, which were 32.2% and 27.5% respectively, followed by Huawei, Xiaomi and other mobile phone models. Among the non-Chinese mobile phone models, Samsung, Apple and other mobile phone models have the highest proportion, followed by Nokia and SONY. Considering that Chinese brand mobile phones possess relatively perfect offline layouts and high advertising frequency, it can be considered that the selection of mobile

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phone models of the elderly is significantly affected by the offline sales policy.

From the perspective of mobile phone type, there are conspicuous age and gender discrepancies in the choice of smart phones among the elderly. 37.2% of the elderly women choose smart phones, and most of them still use feature phones. In comparison, the penetration rate of smartphone amid the elderly men reached 57.4%, much higher than females. The higher the urbanization degree was, the higher the proportion of elderly people's using of mobile Apps was. Only 10.3% of the elderly in rural areas used mobile Apps, whilst nearly half of the elderly in urban areas (47%) used mobile Apps. In the author's opinion, the place where the elderly live is not only a symbol of social status but also a symbol of cultural level to some extent. The higher the urbanization level is, the higher the cultural level of the elderly in the place where they live is, and the higher the ability and demand of using mobile phones is.

Variable Name	B	S.E,	Wals	df	Sig.	Exp(B)
Gender	0.269	0.203	1.752	1	0.186	1.308
Age	0.183	0.091	4.005	1	0.045*	1.201
Region	0.390	0.173	5.072	1	0.024*	1.477
Phone Number	0.368	0.219	2.820	1	0.093	1.445
Phone Model	0.198	0.099	4.016	1	0.045*	1.219
Phone Type	2.613	0.481	29.514	1	0.000*	13.643
Level of Charge	0.032	0.187	0.029	1	0.866	1.032
Call Duration	-0.595	0.389	2.338	1	0.126	0.551
Call Frequency	0.258	0.127	4.118	1	0.042*	1.294
App List	-0.438	0.300	2.126	1	0.145	0.645
App- using Duration	0.220	0.491	0.201	1	0.654	1.246
App-using Traffic	0.144	0.254	0.321	1	0.571	1.155
App-using Frequency	-0.345	0.217	2.531	1	0.112	0.708
Constant	-4.819	0.863	31.192	1	0.000*	0.008

* indicates that the change is significant when the confidence is 0.95

Multiple linear regression model summary

Logarithm	-2Log Likelihood Value	Cox & Snell R-squared	Nagelkerke R-squared
1	614076[a]	.239	.355

Note: a. since the change of parameter estimation is less than.001, the estimation stops at 6 iterations.

4.1 Analysis of Experimental Results

We tried different kernel functions when training the user attribute classifier and finally found the best result came from gaussian kernel function. The number of positive samples for some attributes is much smaller than the number of negative samples, especially the attributes obtained through 10 niche applications. For the unbalanced attributes of both positive and negative samples, we increased the penalty weight of positive samples in the penalty function when training the corresponding model accordingly. In the training of classifier, we adopted the method of cross validation for five times. The sample points were randomly divided into five parts as evenly as possible. In each round, four parts were used to train the classifier, and the remaining part was used to verify the classifier. Therefore, any data sample will not appear in the training set and the test set at the same time. We repeated the

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process for five times.

4.2 Grey model

With the development of scientific technologies, information has been an important resource which is quite influential to economy, scientific research and people's daily life in modern society and relevant technologies attached to it has also been created and developed rapidly. But facing massive and sophisticated information, how to effectively select out and process useful information has become a key question for the socio-economic and scientific technologies. Beneath the theoretical research of information technology, the degree of unequivocal external and internal characteristics in this system are marked by the depth of colors. Therefore, authors can split the system into three colors – white, grey and black. Entirely cleared information is so-called white system, in which authors already grasp all of its characteristics both internally and externally; Black system refers to the system that authors know nothing about, information in this system is completely unclear, and it is also named the black box system. The grey system indicates all of the rest information which is partly clear and partly unclear except the white and black. The grey system theory has been proposed earlier in 1980s, this notion has been developing and expanding for over two decades ever since it was established, and now it has founded a relatively sophisticated theoretical constructive system. The peculiarity of it is taking advantage of grey mathematics to handle and qualify uncertainty and making fully use of given data to seek for systematical laws. Over thirty years' development and perfection, the constructional system of grey system theory is fundamentally established. The Grey System covers many aspects of theory, methodology, analysis and modeling, it is gradually acknowledged and given attention by scholars worldwide and has been successfully applied to industrial engineering, economy, agriculture and other areas, offering effective help to solve problems whose information are partly clear in production and livelihood. Quite a few scholars have applied the grey model successfully into fault diagnose, image recognition, reliability analysis, correlation analysis, security analysis, energy forecast and early warning, gaining fruitful results when putting into use. Prediction model based on the Grey System theory has many advantages such as simple modeling, reduced requirement for historical data, high precision of prediction and no need to take regularities of distribution into account. The Grey System theory is a new method for researching questions with sparse data and inadequate information, this theory takes research objectives of uncertain system which is "partly known partly unknown" with "small samples" and "insufficient information", it depends on the production, development and extraction of valuable information from given information so as to realize the purpose of precise cognition, description and valid surveillance towards the systematic operative behaviors and evolutionary regularities. Setting the component sequence of time series after wavelet decomposition as follow, marked by upper "(0)":

$$X^{(0)} = [x^{(0)}(1), x^{(0)}(2), \dots, x^{(0)}(n)]$$

Wherein n stands for the amount of sequences. A new sequence is obtained by first order superposition of the sequence, represent it with upper "(1)", marked by 1-AGO:

$$X^{(1)} = [x^{(1)}(1), x^{(1)}(2), \dots, x^{(1)}(n)]$$

Wherein:

$$x^{(1)}(t) = \sum_{i=1}^{t} x^{(0)}(i), t = 1,2, \dots, n.$$

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The second order whitening equation of the grey GM (1, 1) model was established as:

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = b$$

The solution of the equation is:

$$x^{(1)}(t) = \left(x^{(0)}(0) - \frac{b}{a}\right)e^{-at} + \frac{b}{a}$$

Finally with x ^ ((1)) (t) b-b final prediction results are obtained.

$$x^{(0)}(t) = x^{(1)}(t) - x^{(1)}(t-1)$$

To bear it in mind, Since GM (1, 1) model only contains one exponential component and only one characteristic root, it is difficult to simulate the time series with large fluctuation and oscillation characteristics, while GM (2, 1) of the second-order grey model has two characteristic roots, which can reflect monotonic and non-monotonic changes and then simulate perfectly.

Table 4.2.3 Various forms of model's predicted values and residuals

Accuracy requirement.	Index critical point			
	Relative error α	Correlation degree ε_0	Value of mean square error ratio C_0	Little probability of residual p_0
1	0.01	0.90	0.35	0.95
2	0.05	0.80	0.50	0.80
3	0.10	0.70	0.65	0.70
4	0.20	0.60	0.80	0.60

5. Discussion of Research Suggestion

At present, the international community actively responds to the concept of aging and advocates maximizing the elderly to stay at home. Although in the developed countries where social pension is already high, family care is still the preferred way of old-age care for the majority of the elderly, and it still plays an important role. Families are encouraged and supported in many ways to provide care for the elderly and institutional pension would be the last choice (Law et al., 2020a; Law et al 2020e). In Sweden, for example, it uses a variety of professional care to enable the elderly to extend their life in their homes as much as possible, and encourages families and children to take up some of the work of caring for the elderly (Marcusson et al., 2019; Songur, 2019; Berglund-Snodgrass et al., 2019). In China, there has always been a tradition of family pension, and there is a saying of filial piety. For the majority of the elderly, the family pension is still their first choice (Ho, 2019; Wang et al., 2018; Cao, 2018). This is still the case in the international metropolis like Shanghai. According to the survey results of the Shanghai general investigation team of the National Bureau of Statistics in 2013, 67.3% of respondents prefer "traditional family pension", 21.2% prefer "community-based housing support", other 11.1% and 0.4% prefer "institutional pension" and "other ways to support the elderly". The great inertia of the traditional concept of old-age care and the reality of the family as the main place and institution for the elderly make people still place great hopes on their children when facing the problem of the aged (Law et al., 2019c; Perseguino et al., 2017; Baozhong et al., 2020). The traditional concept of our country is "nurturing children to prevent old age".

6. Conclusion

Mobile App developers should formulate marketing strategies based on the spending power of the elderly. The purposes are to solve the difficulties caused by the inconvenient life of the elderly, to improve the quality of life of the elderly, to preserve the dignity of the elderly in old age, to help the elderly restore a healthy body and to help them face the elderly life with a happy mood (Law et al., 2020c; Yuan et al., 2020; van Rijckevorsel-Scheele et al., 2019). Marketing strategy is that the company take customer needs as the starting point, and according to its experience, it obtains the information of customer demand and purchasing power, then organizes all kinds of business activities in a planned way (Law et al., 2020b; Chaouali et al., 2019). This is the process of achieving corporate goals by providing customers with satisfactory products and services through product strategy, price strategy, channel strategy and promotion strategy (Yazeed Alkatheeri et al., 2020; Shirahada et al., 2019; Laperche et al., 2019). For mobile App developers, there are several suggestions: firstly, fully understand the current needs of the elderly for mobile application. The main purpose of marketing is to carry out volume marketing for low-end customers. The basic telephone charges are divided into two positions: 19 rmb and 39 rmb. They can add a sub-card, which sets voice time in the package as the main selling point. It provides a large number of voice minutes in the package, but the supply of mobile internet data is very small. Below table 5.1 depicts the basic package that are available in market.

Table 6.1 Operator's basic package

Monthly basic charge	Voice call within package	Traffic within package	Free incoming call	Rules of subsidiary cards	Voice call out of package	Traffic out of package	Return of red packets
19CNY	390 min (Domestic)	50M (Domestic)	Domestic	With a maximization of 1 subsidiary cards, the functional charge will be 10CNY/month/card	Long-distance roam within the city 0.15CNY/min	30CNY /500M	null
39CNY	390 min (Domestic)	50M (Domestic)	Domestic		Long-distance roam within the city 0.15CNY/min	0.3CNY/M	20CNY

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