

# The Research on Economic Development Based on Entropy Method and Grey Relational Analysis – from the Perspective of Residents' Consumption Level

Y Y Li<sup>1</sup>, B Y Tao<sup>1</sup> and D Y Si<sup>2</sup>

<sup>1</sup>Department of Industrial engineering, Sichuan University, Chengdu, 610065, China

<sup>2</sup>Department of Logistics engineering, Sichuan University, Chengdu, 610065, China

Email: 2016225025033@stu.scu.edu.cn

**Abstract.** This article is based on the consumption function theory, with the development of domestic economic, consumption is the main driver of the economic and the leading factor on the growth of GDP. Obviously, the residents' consumption level can represent the trend of consumption of residents. Finding the incentive and analysing the reasons can contribute to sustainable economy. Five influencing factors are selected including the per capita fiscal expenditure, the consumer price index, commodity retail price index, the urban and rural residents' per capita deposits, residents' per capita income. Then, the entropy method is adopted to evaluate each index and assign weight. Combining with the grey relational analysis, we prefer to use the entropy weight of each factor rather than use the average coefficient for more comprehensive and reasonable results. And the comprehensive correlation degree is calculated. Finally, we select the statistical yearbook of Chengdu from 2007 to 2015, and the empirical analysis is carried out on the factors which influencing the residents' consumption level. The results show that the residents' per capita income not only takes the most important role in these factors, but also develops a gap gradually. The fiscal expenditure promotes the improvement of the residents' consumption level and the economy has been boosted. However the consumption of rural residents is prevented by the high deposits and it has led to an economic depression in some areas. We combine the two methods and analyse from the perspective of macro and micro angle, the influence of consumption on sustainable economic growth has been analysed based on these five factors, and the comprehensive analysis and reasonable suggestions are given in order to promote sustained economic development.

## 1. Introduction

Since the reform and opening-up, it's a great growth on the gross domestic product (GDP) and the national fiscal revenue. The public services and the per capita income has been improved significantly. Even so, the rapid development of China's economy also has some disadvantages. For example, the domestic economy depends on external investment and exports excessively, and the domestic consumer market has not been realized. What's more, the urban and rural residents have burden heavier pressure than before such as housing, education and health care. The topics of narrowing the income gap between city and countryside and improving the residents' consumption level have become popular in recent decades.

Considering the researches on residents' consumption, the Keynesian theory of consumption is a starting point abroad and he elaborates the relationship between consumption and income. It means



that the consumers' consumption is determined by income [1-2]. Based on this, the overseas economists carry on it until now. Duesenberry puts forward relative income hypothesis of consumption function. Friedman propose the persistence of income hypothesis [3-5]. A variety of consumption function forms have been built, and the development of economy has been promoted by them. Otherwise, they also provide reference for the research of our country.

Based on the foreign researches, researchers consider the domestic consumption market in China such as population structure and regional difference etc. They constantly enrich the study of residents' consumption level. Here are researches that are mainly divided into the following several aspects:

1) In macro perspective of view, to explore the influencing factors of urban and rural residents' consumption level, Zhang focus on the influence of the social security expenditure and analyses 15 typical provinces. He holds the point that the level of social security status is also crucial in addition to the traditional concept of people's income [6]. Zhao combines static panel data model with dynamic panel data model, three influencing factors are provided include the income, the consumption and the price index. The reasonable suggestions are given for the regulation of macroeconomic too [7].

2) Discussing the different parts of the consumption level from the perspective of regional differences. Dang analyses the annual consumption of urban households in China, and explained the impact of regional differences on the consumption level [8]. Wu and Chen do surveys by using the data of 31 provinces based on the theory of consumption economics theory and economic convergence. The analysis focus on the country residents' consumption, and some rational proposals are put forward in order to narrow the gap of regional income and coordinate the geographic policies [9].

3) Some literatures merely refer to the urban or rural residents. Deng and Zhou have carried on the statistical analysis about the urban residents' consumption structure. Based on a data analysis model, the changing consumption structure has been analysed and the influencing factors of consumption level are presented [10-11]. Li and Yang discuss the rural residents' consumption structure. They adopt the method of principal component analysis and give suggestions to improve the rural consumption structure and the level of consumption [12-13].

From the perspective of literatures at home and abroad, many articles only consider the one-sided influence factors. They lack of comprehensive analysis on the urban and rural residents' consumption level. Otherwise, the single angle of view still has some limitations. In view of this, combining with macro and micro factors, we selects five influencing factors and makes a comprehensive analysis and evaluation. Through the analysis of comprehensive correlation degree, a new research perspective is provided and some referential suggestions are provided to improve the residents' consumption level.

## **2. The summarize of residents' consumption level**

### *2.1 The analysis of influencing factors*

With the rapid development of economy in recent years, the residents' income has been driven by the domestic economy. From the influencing factors of residents' consumption level, the per capita fiscal expenditure affects the construction of public service and the residents' consumption psychologically. The consumer price index reflects the changing purchase of family in the prices of consumer goods and services generally. In the same way, commodity retail price index reflects the degree of changes on retail prices of commodities in certain period of time. The consumer price index and commodity retail price index are based on the influence of consumer goods and services, and provide the consumer spending judgment and choice advice. The urban and rural residents' per capita deposits is planning for the future by saving process. It has to do with the current level of economic development, income status and the change rates of interest. The behaviours of residents' consumption are influenced by the fluctuation of deposits directly. Obviously, changing unilateral factor can cause the change of other factors. They all lead to the fluctuation of residents' consumption level.

### *2.2 Grey relational analysis*

Grey relational analysis is a quantitative analysis of the development trend in the research system. By comparing the characteristics of the statistical sequence curve, the relational grade is determined between each elements [14]. It takes the grey system with some uncertain information as the research object, and finds out the main influencing factors. The grey relational analysis can grasp the essential characteristics of things. The detailed calculation steps are as follows [15]:

1) Reference sequence and comparative sequence

In order to make a reasonable comparison and evaluation, the influencing factors of residents' consumption level are selected as the reference sequence as follow:

$$X_0 = \{X_{01}, X_{02}, \dots, X_{0n}\} \quad (1)$$

The comparison sequence has m comparison objects, each sequence has n measurement data:

$$X_m = \{X_m(1), X_m(2), \dots, X_m(n)\} \quad (2)$$

2) Data normalization

Because of the differences in the physical meaning and the unit of the evaluation index, it is necessary to do the dimensionless and normalization.

$$Y_0 = \{X_0(1)1/nk = 1/nX_0(k), \dots, X_0(n)1/nk = 1/nX_0(k)\} \quad (3)$$

3) The correlation coefficient

After transforming the data, in the k moment, the correlation coefficient of the residents' consumption level is calculated below:

$$\varepsilon_{0i} = \Delta_{\min} + \rho \Delta_{\max} \Delta_{0ik} + \rho \Delta_{\max} \quad (4)$$

In this formula,  $\rho$  is the resolution coefficient. The function is to improve the difference in the correlation coefficients. It is usually taking 0.5.  $\Delta_{0i}(k)$  is the absolute difference of the two sequence at k time.  $\Delta_{\min}$  and  $\Delta_{\max}$  are the minimum absolute difference and the maximum absolute difference.

4) Comprehensive relational grade

$$r_{0i} = i = 1m\varepsilon_{0i}(k)\omega_i \quad (5)$$

In this formula,  $\omega_i$  is named weight. Entropy weight method is used to determine the weight, instead of the average coefficient. The better relational grade can be calculated.

### 2.3 Entropy weight method

The entropy method is an objective weighting method. During the process of using the indicators, the information entropy and entropy weight can be calculated according to the data. By modifying the weight of each index, the objective weight of index is calculated. Otherwise, it can provide more reasonable reference for subsequent evaluation. The detailed steps are calculated as follows [16]:

Here are k evaluative indexes ( $X_1, X_2, \dots, X_k$ ). Each evaluation indexes contains m data.

1) Data standardization

$$Y_{ij} = X_{ij} - \min(X_j) / \max(X_j) - \min(X_j) \quad (6)$$

2) The contribution degree of index

$$P_{ij} = Y_{ij} / i = 1mY_{ij} \quad (7)$$

3) The information entropy

$$E_j = -1/n \sum_{i=1}^m P_{ij} \ln P_{ij} \quad (8)$$

$$\lim_{P_{ij} \rightarrow 0} P_{ij} \ln P_{ij} = 0 \quad (9)$$

4) Entropy weight

$$W_{ij} = 1 - E_j / m - i = 1mE_j \quad (10)$$

The grey relational analysis aims to calculate the relational grade ultimately. By optimizing the grey relational analysis, this article uses entropy weight instead of average coefficient in order to obtain the comprehensive relational grade. Sorting the size of the relational grade, Results can be analyzed analysed and some reasonable suggestions can be given.

### 3. Case analysis

The study of residents' consumption level includes the selection of influencing factors and the establishment of evaluation index. According to the above analysis, this article selects five influencing factors including the per capita fiscal expenditure ( $Y_1$ ), the consumer price index ( $Y_2$ ), commodity retail price index ( $Y_3$ ), the urban and rural residents' per capita deposits ( $Y_4$ ) and residents' per capita income ( $Y_5$ ). According to the residents' consumption structure, five indexes are selected as the indicators of grey relational analysis including food ( $X_1$ ), clothing ( $X_2$ ), housing ( $X_3$ ), transportation and communication ( $X_4$ ), health care ( $X_5$ ). The comprehensive data analysis is given below [17-21].

#### 3.1 Data analysis

According to the statistical yearbook of Chengdu from 2007 to 2015, the influencing factors and evaluation indexes of the residents' consumption level are counted. Through the screen of yearbook data, the original analysis data are obtained as Table 1 and Table 2.

**Table 1.** Relevant data of urban influencing factors and evaluation indexes

	2007	2008	2009	2010	2011	2012	2013	2014	2015
$Y_1$	6	8	9	1	1	1	1	1	1
	8	3	2	5	5	5	8	9	8
	1	3	2	3	5	1	2	4	2
	1	4	5	7	1	8	0	5	4
	.			7	0	6	7	2	7
0									
$Y_2$	1	1	1	1	1	1	1	1	1
2	0	0	0	0	0	0	0	0	0
	5	4	0	3	5	3	3	1	1
$Y_3$	1	1	9	1	1	1	1	9	9
	0	0	9	0	0	0	0	8	9
	4	4		2	4	1	1		
$Y_4$	2	2	3	4	5	6	6	7	8
	2	9	7	4	1	1	9	4	1
	2	1	3	3	7	2	0	8	3
	6	8	9	1	2	6	4	4	6
	3	6	1	7	3	0	2	8	8
$Y_5$	1	1	1	2	2	2	2	3	3
	4	6	8	0	3	7	9	2	3
	8	9	6	8	9	1	9	6	4
	4	4	5	3	3	9	6	6	7
	9	3	9	5	2	4	8	5	6
$X_1$	4	4	5	5	6	6	7	7	7
	5	8	2	7	5	7	1	5	5
	7	0	8	3	8	4	4	5	0
	6	6	3	9	4	5	7	5	8
$X_2$	1	1	1	1	1	1	2	2	1
	1	2	3	4	6	8	0	1	9
	1	4	1	8	3	6	5	9	4

	2	6	0	9	7	7	7	3	2
<b>X</b>	1	1	1	1	1	1	1	1	4
<b>3</b>	0	0	0	1	6	7	8	9	4
	0	5	4	1	1	3	5	9	0
	6	4	3	7	9	4	3	7	9
<b>X</b>	1	1	2	2	2	3	3	3	2
<b>4</b>	7	9	2	6	9	1	3	5	5
	2	4	9	5	7	8	6	8	5
	0	0	6	2	2	2	0	2	4
<b>X</b>	6	8	9	8	9	1	1	1	1
<b>5</b>	9	4	4	2	2	0	1	2	1
	0	8	4	2	5	2	2	1	5
						9	0	6	7

**Table 2.** Relevant data of rural influencing factors and evaluation indexes

	2007	2008	2009	2010	2011	2012	2013	2014	2015
<b>Y<sub>1</sub></b>	6	8	9	1	1	1	1	1	1
	8	3	2	5	5	5	8	9	8
	1	3	2	3	5	1	2	4	2
	1	4	5	7	1	8	0	5	4
				7	0	6	7	2	7
<b>Y</b>	1	1	1	1	1	1	1	1	1
<b>2</b>	0	0	0	0	0	0	0	0	0
	5	4	0	3	5	3	3	1	1
<b>Y</b>	1	1	9	1	1	1	1	9	9
<b>3</b>	0	0	9	0	0	0	0	8	9
	4	4		2	4	1	1		
<b>Y</b>	2	2	3	4	5	6	6	7	8
<b>4</b>	2	9	7	4	1	1	9	4	1
	2	1	3	3	7	2	0	8	3
	6	8	9	1	2	6	4	4	6
	3	6	1	7	3	0	2	8	8
<b>Y</b>	5	6	7	8	9	1	1	1	1
<b>5</b>	6	4	1	2	8	1	2	4	7
	4	8	2	0	9	5	9	4	6
	2	1	9	5	5	0	8	7	9
						1	5	8	0
<b>X</b>	1	1	2	2	2	3	3	3	4
<b>1</b>	8	8	0	3	9	3	5	8	8
	5	9	4	5	5	1	8	5	8
	1	0	5	9	4	3	2	9	1
<b>X</b>	3	4	4	5	6	7	8	9	1
<b>2</b>	3	2	4	1	8	9	6	5	2
	6	5	1	6	2	0	9	0	2
									0
<b>X</b>	4	5	6	6	7	7	8	9	1
<b>3</b>	3	3	1	2	2	9	6	5	9
	2	9	1	6	4	8	0	0	9

										6
<b>X</b>	5	6	6	8	1	1	1	1	1	1
4	4	6	9	2	1	3	4	6	5	5
	8	2	7	3	1	3	7	0	3	3
					1	8	2	0	8	8
<b>X</b>	2	2	3	3	4	5	5	6	7	7
5	0	4	0	2	3	0	9	8	8	8
	4	7	6	5	6	0	4	8	8	8

Note: the data of table 1 and table 2 are selected from the statistical yearbook of Chengdu from 2007 to 2015.

1) The original data is used by entropy weight method and the weight of each evaluation index is determined. The corresponding information entropy and entropy weight are obtained.

**Table 3.** Information entropy and entropy weight of urban and rural evaluation indexes

	city					countryside				
	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>
<b>information entropy</b>	0.870	0.871	0.671	0.888	0.903	0.799	0.847	0.788	0.853	0.846
<b>entropy weight</b>	0.163	0.161	0.413	0.140	0.122	0.232	0.177	0.244	0.170	0.178

2) Looking at the Table 3, the high proportion of information entropy shows that entropy weight can be used instead of the average coefficient. Combining with the method of grey relational analysis and entropy method, the comprehensive relational grade can be calculated between the influencing factors and the evaluation indexes.

**Table 4.** Comprehensive relational grade of urban residents' consumption level

	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	comprehensive relational grade	rank
<b>Y<sub>1</sub></b>	0.824	0.843	0.749	0.842	0.781	0.793	2
<b>Y<sub>2</sub></b>	0.836	0.802	0.735	0.820	0.847	0.788	3
<b>Y<sub>3</sub></b>	0.831	0.797	0.731	0.817	0.842	0.784	4
<b>Y<sub>4</sub></b>	0.741	0.810	0.708	0.768	0.740	0.742	5
<b>Y<sub>5</sub></b>	0.870	0.938	0.763	0.882	0.860	0.837	1

**Table 5.** Comprehensive relational grade of rural residents' consumption level

	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	comprehensive relational grade	rank
<b>Y<sub>1</sub></b>	0	0	0	0	0	0.814	3
	.	.	.	.	.		
	8	8	7	8	8		
	2	5	2	6	3		
	4	6	9	4	4		
<b>Y<sub>2</sub></b>	0	0	0	0	0	0.711	4
	.	.	.	.	.		
	7	6	7	6	6		
	3	9	3	9	7		
	2	5	4	7	8		
<b>Y<sub>3</sub></b>	0	0	0	0	0	0.710	5
	.	.	.	.	.		
	7	6	7	6	6		
	3	9	3	9	7		

	1	5	2	6	9		
$Y_4$	0	0	0	0	0	0.826	2
	.	.	.	.	.		
	8	8	7	8	8		
	4	6	0	6	7		
	7	5	9	8	9		
$Y_5$	0	0	0	0	0	0.846	1
	.	.	.	.	.		
	9	9	7	8	8		
	0	1	4	1	7		
	5	0	4	8	2		

### 3.2 Result

From the perspective of table 4 and table 5, the rank of urban and rural comprehensive relational grade can be calculated above. We can draw the following conclusions:

1) Most comprehensive relational grades are the residents' per capita income compared with the urban and rural residents' consumption level. The income of residents still play a leading role currently. The rising incomes not only increases the consumer confidence, but also taps the potential consumption and stimulates consumer desire. The steady rise of residents' consumption level is contributed.

2) Compare with the income of urban and rural residents, the income has been increased yearly, while the gap is gradually expanding in less than ten years. The overall situation is not optimistic. Some obstacles still affect the rural residents' income level such as low technological level, laggard production mode. In contrast, urban residents could enjoy services and related goods expediently because of favourable location and higher income.

3) Considering the urban and rural residents' per capita deposits, the comprehensive relational grade of the rural areas is much higher than the urban areas. The deposits in rural areas have a lot to do with the food, clothing, transportation, communication and health care in the consumption structure. Compared to the consumption of urban residents, on the one hand, rural residents tend to make choices in order to solve the problem of life. On the other hand, the medical service and the facilities of transportation have not been prepared well. Residents are too worried to reserve deposits because of uncertainty. That's why the precautionary deposit is so high in rural residents.

4) In terms of the per capita fiscal expenditure, the rural areas with higher comprehensive relational grade are reflected in transportation and health care. It also reflects that the government construction plays an important role in countryside. The government will invest more fiscal expenditure on rural public services including the highway system and the rural cooperative medical. Excellent infrastructure promotes the development of rural areas and improve the residents' consumption level.

5) Comparing to rural residents, the consumption level of urban residents is much related to the consumer price index and commodity retail price index. On the one hand, the majority of rural residents have their own agricultural products, and they can be self-sufficient. However the city residents rely on consuming. On the other hand, the city's infrastructure construction is relatively perfect. It promotes urban residents to consume and enjoys better medical services.

### 4. Suggestion

With the development of China, investment, consumption and export have been the "three carriages" which stimulate the economy. The economy of China relies on investment and exports so much in the early period of economic development. However, the problem solving domestic consumption has not been solved until now even though it's vital. The residents' consumption could influence the economic growth radically by adjusting consumption structure. It also provides a powerful impetus to the sustainable development of the economy. The following suggestions are put forward:

1) Government should narrow the income gap between urban and rural areas and improve the income level of rural residents. The imbalance economic development has restricted the pace of rural development and the output of rural manpower. Measures should be taken to ensure stable income and drive consumption expenditure. The government appropriately adjust the structure of distribution and increase the proportion of workers' initial distribution. It also could encourage external investment to set up factories which can solve the problem of surplus manpower. Adjusting the structure of the agriculture, eliminating the limitation of the single agricultural products, strengthening professional agricultural production can improve the competitiveness of agricultural products too.

2) The positive behaviour of consumption should be guided normatively. The current market consumption is still faced with difficult to meet the supply of consumer demand. The government should organically consider the three effects of production, circulation and exchange. At the same time, the fair market environment is important particularly. It can not only guide consumers to rationally adjust the consumption structure, establish a scientific and healthy consumption, but also protect the rights of residents in the channel of consumption.

3) The fiscal expenditure should be inputted more than before and the government need to improve the social security system too. In addition to income, the expectations for the future still restrict consumption, and good expectations stimulate the residents' spending ahead of time. Otherwise, the inclination of fiscal expenditure on social security system aims to play the critical role. Social security system makes sure the basic living security. It eliminates uncertain worries in the future. It also helps the residents to form reasonable consumer expectations, and release the consumption potential.

## 5. Conclusion

The article focus on the evaluation of residents' consumption level and selects the statistical yearbook of Chengdu from 2007 to 2015. By using the methods, the curve of the sample data can be portrayed and the economic development trend can be predicted better. The results show that:

1) The influencing factors are selected integrally. The research of economic development has been enriched by analysing the residents' consumption level and consumption structure.

2) The article combines the entropy method and gray relational analysis, from the perspective of macro and micro angle, the comprehensive consideration of the influence factors and the consumption expenditure structure may provide comprehensive relational grade objectively. At the same time, it also provides a new perspective to stimulus economic growth.

3) On the evaluation of the consumption lever, the government should make reasonable control on consumptive goods and services. It provides complete public facilities and services and narrows the gap between city and countryside. The consumption ability of residents is released further.

Considering the macro and micro factors, the article refer to many literature. However the selection of factors is not comprehensive, and there are some limitations. Therefore, the more reasonable evaluation methods and influencing factors should be the focus of research in the future.

## References

- [1] D'Orlando F, Sanfilippo E 2010 *J. Behavioral foundations for the Keynesian consumption function. Journal of Economic Psychology.* **31(6)**:1035-1046.
- [2] Murota R, Ono Y 2010 *J. A Reinterpretation of the Keynesian Consumption Function and Multiplier Effect. Social Science Electronic Publishing.*
- [3] Sanders S 2012 *J. A Model of the Relative Income Hypothesis. Journal of Economic Education.* **41(41)**:292-305.
- [4] Park S 2016 *J. How to Consume and Invest for Retirement: Revisiting Friedman's Permanent Income Hypothesis. Social Science Electronic Publishing.*
- [5] Apostolou T, Jr V K 2011 *C. Permanent Income and Adaptive Expectations: Estimation of a EU Consumption Function. International Atlantic Economic Conference.* **33(23)**:2782-2797.
- [6] Zhang Q 2013 *J. Comparative Study of Expenditure Impact on the Level of Consumption in Urban and Rural Social Security --The empirical analysis of the 15 provinces Panel Data. Social*

- security studies.* **2** 71-82.
- [7] Zhao H C, Jeffrey F 2013 *J.* The influence of income, price and interest rate on the consumption level of urban residents in China -- Based on the static and dynamic panel data model analysis. *Mathematical statistics and management.* **32(2)** 211-220.
- [8] Dang Y J 2013 *J.* The influence of regional differences on the consumer level of urban residents in China. *China securities futures.* **3** 136-136.
- [9] Wu Y M, Chen Z J 2009 *J.* The spatial correlation and regional convergence of people's consumption lever. *World economic analysis.* **5** 76-89.
- [10] Deng X, Ge T T 2014 *J.* Panel Data analysis of the consumption structure of urban residents in China. *Economic system reform.* **1** 193-197.
- [11] Zhou H 2015 *J.* Influence factors and development trends of consumption structure of urban residents in China. *China market.* **21** 13-14.
- [12] Li C Y 2014 *J.* Analysis on the principal component of consumption structure of rural residents in China. *Commodity and quality: consumption research.* **5** 6-6.
- [13] Yang Q 2015 *J.* The analysis of consumption structure of rural residents in Sichuan Province Based on principal component analysis. *Jiangsu business theory.* **23** 105-106.
- [14] Liang B S 2009 *M.* *Applied mathematics.* Beijing: Meteorological Press.
- [15] Yi D S, Guo P 1992 *M.* *Grey system theory and method of solution, abstract, procedure and application.* Beijing: Petroleum Industry Press.
- [16] Feng Y Q, Li X M, Li X W 2014 *J.* Comprehensive evaluation of railway safety based on entropy weight method and grey relational analysis. *Journal of safety and environment.* **14(2)** 73-79.
- [17] Wang J H, Li M, Meng F 2012 *J.* The influencing factors of China's residents' consumption level. *Open herald.* **2** 44-47.
- [18] Miao Z 2013 *J.* The study on the influencing factors of per capita consumption level of Sichuan residents. *Wuhan Finance.* **8** 55-57.
- [19] Wang L C, Zhang N 2016 *J.* The consumption structure of urban and rural residents in Henan Province, the comparative analysis. *Chinese Agricultural Science Bulletin.* **32(1)** 193-199.
- [20] Zhang Z L, Song Q 2016 *J.* Trends and Countermeasures of residents' consumption structure change under the new normal. *Macroeconomic management.* **6** 68-71.
- [21] Ma H 2016 *J.* The consumption structure of rural residents China trend analysis. *Gansu theory.* **2** 135-139.