Changes in farmers’ income in Fuling District of Chongqing China from 2018 to 2028: A grey prediction method perspective

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Abstract. Urbanization development can have a great impact on farmers income structure. Through empirical analysis, the results of this paper show that with the development of urbanization the per capita disposable income of farmers in Fuling District will reach 70,890.69 yuan per person by 2028, nearly five times that of 2017. The influence of urbanization rate on various income sources of Fuling farmers are as follows: family business income, wage income, transfer income, and property income. The government should increase investment in rural education, promote the improvement of farmers' quality, accelerate infrastructure construction, increase support for agriculture, vigorously promote accurate poverty alleviation, promote the increase of farmers' family business income, and steadily increase farmers' wage income.

1. Introduction
In recent years, the development of urbanization in less developed areas is unprecedented. The incomes of urban workers in the second and tertiary industries grew rapidly, and the absolute incomes of rural residents increased significantly. However, compared with the growth rate of per capita income of urban residents, the growth rate of per capita net income of rural residents is slow. The increase of rural residents' income in underdeveloped areas is an important material prerequisite and foundation for solving the problems of agriculture, rural areas and farmers and building a moderately prosperous society in all respects. How to promote rural economic development, raise people's incomes, and optimize the income structure is very important.

Many scholars have done a lot of research on the relationship between urbanization and farmers' income: Brian C. Briggema thought government policies have a great influence on people's income [1] while Lerman, IddoKan, AyalKimhi and Zvi Lerma focused on affecting factors [2,3] and Liu Hongyuan, Liuke paid more attention on the impact of farmers' income structure in China [4]. Empirical studies also show that urbanization impact farmers' income [5-8]. Most of the literature analyzes the influencing factors of farmers' income growth in a general way. However, there are not many studies focusing on the changes in income structure and the actual development of regional development plans to promote farmers' income increase, and many suggestions are not operational.

This paper analyzes the changes in farmers' income and the impact of urbanization on rural residents' income structure in Fuling district, which has practical reference significance for less developed areas to promote urbanization and the improvement of rural residents' income level and the upgrading and optimization of income structure.
2. Characteristics of changes in farmers' income in the process of urbanization in Fuling District
Since 2000, with the rapid development of urbanization Fuling District, the urbanization rate increased from 38.3% in 2000 to 67.18% in 2017. Rural per capita disposable income increased rapidly, from 1892 yuan to 13,466 yuan. There are several characteristics:

2.1. The growth rate of urbanization rate is synchronized with the growth of the proportion of farmers' wages and incomes
In 2004, the urbanization rate of Fuling district was 47.46%, and the farmers' wage income was 789.66 yuan per person, accounting for 21.64% of the total income. While in 2017, these numbers are as follows: 67.18%, 3969 and 29.47%. Over the past decade, the urbanization rate has increased by 19.72 percent while farmers' income has increased (Table 1).

Table 1. Urbanization rate and rural per capita disposable income (yuan per person).

| year  | Urbanization rate (%) | Disposable income | Salary income | Household income | Transfer income | Property income | Income share (%) | Household operating income |
|-------|-----------------------|-------------------|--------------|------------------|----------------|----------------|------------------|--------------------------|
| 2004  | 47.46                 | 2528.52           | 789.66       | 2687.15          | 164.91         | 7.54           | 21.64            | 73.64                    |
| 2005  | 49.00                 | 2779.79           | 904.16       | 2872.21          | 181.12         | 10.91          | 22.78            | 72.38                    |
| 2006  | 50.36                 | 2853.95           | 1119.79      | 2448.50          | 262.51         | 53.20          | 28.83            | 63.04                    |
| 2007  | 51.80                 | 3499.26           | 1413.76      | 3725.22          | 337.10         | 57.36          | 29.78            | 64.79                    |
| 2008  | 53.30                 | 4168.43           | 1627.13      | 3938.43          | 338.85         | 58.74          | 28.3             | 61.91                    |
| 2009  | 54.20                 | 4651.13           | 2051.31      | 3715.34          | 517.81         | 57.20          | 28.3             | 58.58                    |
| 2010  | 55.80                 | 5548.80           | 2431.40      | 4597.30          | 514.30         | 75.90          | 31.91            | 60.34                    |
| 2011  | 57.56                 | 6858.30           | 2822.27      | 5440.55          | 799.76         | 147.58         | 30.64            | 59.08                    |
| 2012  | 59.28                 | 7941.92           | 3398.37      | 5683.10          | 1082.24        | 266.60         | 32.58            | 54.49                    |
| 2013  | 60.68                 | 8817.00           | 2602.22      | 6428.40          | 2533.53        | 260.74         | 22.00            | 54.37                    |
| 2014  | 62.18                 | 9963.00           | 3011.82      | 8620.35          | 2889.59        | 335.02         | 20.27            | 58.02                    |
| 2015  | 63.78                 | 11089             | 3338         | 9115             | 3260           | 380            | 30.10            | 82.20                    |
| 2016  | 65.45                 | 12253             | 3655         | 9646             | 3788           | 404            | 29.83            | 78.72                    |
| 2017  | 67.18                 | 13466             | 3969         | 10455            | 4451           | 438            | 29.47            | 77.64                    |

Data Source: "Fuling Statistical Yearbook 2018"

2.2. Urbanization has led to a slight increase in the proportion of household income
The family business income in Fuling District was 2,687.15 yuan per person in 2004, and in 2017, it was 10,455 yuan per person. The proportion of family business income to total income rose from 73.64% to 77.64%. In general, with the rapid development of urbanization, the total income of farmers' family business income has increased. Due to various entrepreneurship training, farmers have started their own businesses, which has led to an increase in family business income.

2.3. Increased transfer income and property income
The proportion of transfer income and property income in total income has increased. The property income was 164.91 yuan per person in 2004 and 4,451 yuan per person in 2017, accounting for 4.52% to 33.06%, an increase of nearly 30%. The property income accounted for 0.2% in 2004 to 3.30% in 2017.

3. Problems in the growth of farmers' income in the process of urbanization in Fuling District
3.1. Low growth rate of farmers' income
Although farmers' incomes have grown rapidly, the growth rate of farmers' income is still slow relative to the rate of economic growth. In 2017, the per capita disposable income of farmers in Fuling District reached 13,466 yuan, more than double the amount of 1,892 yuan in 2001. However, compared with the
growth rate of GDP per capita, the growth rate of farmers is still low. In 2017, the per capita GDP of Fuling District was 85,968 yuan per person, which was 10.2 times of the per capita GDP (8425 yuan per person) in 2001, with an average annual growth rate of 57%.

3.2. Large income gap between urban and rural areas
The income of farmers has increased rapidly, and the income gap between urban and rural areas has also improved. However, the gap between urban and rural incomes is still large. In 2017, the per capita disposable income of urban residents was 33,709 yuan per person, ranking 12 in Chongqing. At the same time, the per capita disposable income of rural residents was only 13,466 yuan per person, and the city ranked 22nd.

3.3. Uneven income structure of farmers
In horizontal comparison, the proportion of farmers' property income is still at a very low level. According to foreign research, property income generally accounts for about 30% of the disposable income of residents, and the income from property of the US agricultural industry accounts for nearly 40% of disposable income. By contrast, the property income of rural residents is seriously low, which was 3.43% in 2016 and 3.30% in 2017.

4. Grey theory prediction of farmers’ income changes in the process of urbanization in Fuling District

4.1. GM (1, 1) model
The grey system theory regards all random variables as the amount of gray that changes within a certain range. The method of data processing is applied to the gray quantity, and the unorganized raw data is sorted into a regular generation series and then a new model is established [9]. GM(1,1) represents a first-order, one-variable differential equation model, which is a commonly used grey prediction model in grey systems. It is a model consisting of a first-order differential equation containing only univariates. The test of the model generally adopts three kinds of test methods, namely the residual size test, the correlation test and the post-test difference test. In this study, the post-test difference method is used to test the accuracy of the model.

Assume \( x(t) \). For the original data sequence, there is

\[
x^{(0)} = (x^{(0)}(1), x^{(0)}(2), ..., x^{(0)}(n))
\]

among them: \( x^{(0)}(k) \geq 0 (k = 1, 2, ..., n) \), and \( x^{(i)} \) equals \( x^{(0)} \) after a cumulative sequence of data, there is

\[
x^{(i)} = (x^{(i)}(1), x^{(i)}(2), ..., x^{(i)}(n)), \text{ among them } x^{(i)}(k) = \sum_{j=1}^{k} x^{(0)}(j) (k = 1, 2, ..., n).
\]

\( z^{(i)} \) is immediate sequence of mean generation for \( x^{(0)} \)

\[
z^{(i)} = (z^{(i)}(2), z^{(i)}(3), ..., z^{(i)}(n))
\]

Then get the GM(1,1) model as

\[
x^{(0)}(k) + az^{(i)}(k) = b
\]

Substituting a and b into the gray GM (1,1) model, and there is

\[
\hat{x}^{(i)}(k+1) = (x^{(i)}(0) - \frac{b}{a}e^{-ak} + \frac{b}{a}, k = 1, 2, ..., n
\]

Finally, get the gray prediction model

\[
\hat{x}^{(i)}(k+1) = \hat{x}^{(i)}(k+1) - \hat{x}^{(i)}(k), k = 1, 2, ..., n
\]

When \( k \leq n \), it is the original data simulation value; \( k > n \) is the model prediction value.

In this paper the use of a difference test method for testing the accuracy of the model, which is
generally used after posterior error ratio c and a small error probability p comprehensive evaluation index. Standard deviation of the original sequence \[ S_1 = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (x^{(0)}(t) - \bar{x}^{(0)})^2} \], the standard deviation of the residual sequence \[ S_2 = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (e^{(0)}(t) - \bar{e}^{(0)})^2} \]. Posterior variance ratio \[ c = \frac{S_1}{S_2} \], and small error probability \[ p = p(\varepsilon(k) - \bar{\varepsilon} < 0.6745n) \]. In general, the smaller c is, the better, the larger p is the better.

4.2. Forecast of farmers' income in the process of urbanization in Fuling District
According to the data from "Fuling Statistical Yearbook 2007-2017," GM (1,1) model can be established and related parameters are as follows: \( S_1 = 2593.103, S_2 = 206.5335, c = 0.0796, p = 1 \). According to the model accuracy evaluation standard, the accuracy of the GM (1, 1) model is rated as one level, which indicates that the model has good prediction accuracy and can be predicted by the model.

The results are shown in table 2.

| Year | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|------|------|------|------|------|------|------|------|------|------|------|------|
| Actual value | 3499.26 | 4168.43 | 4651.13 | 5548.8 | 6858.3 | 7941.92 | 8817 | 9963 | 11089 | 12253 | 13466 |
| Forecast value | 3588.74 | 4168.08 | 4856.93 | 5636.19 | 6541.36 | 7591.91 | 8811.17 | 10226.2 | 11029.2 | 12566.8 | 14296.1 |
| Relative error (%) | 0.0256 | 0.0001 | 0.0408 | 0.0133 | -0.046 | -0.04 | -0.06 | 0.026 | -0.005 | 0.024 | 0.062 |

According to formula (5), the model equation is:

\[ x^{(1)}(k + 1) = 16480.45276e^{0.149653k} - 13951.93276 \quad k = 1,2,\ldots,n. \]

As shown in table 2, per capita disposable income model predictions and actual disposable income average error is relatively small, the maximum relative error, 0.062 (2017), and were below 0.1%. The prediction results are quite good. According to the same method, the predicted value of per capita disposable income from 2018-2028 is obtained (Table 3). All the data can be described in Figure 1.

| Year | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
|------|------|------|------|------|------|------|------|------|------|------|------|
| Predictive value | 1861 | 2162 | 2511 | 2916 | 3387 | 3934 | 4569 | 5306 | 5983 | 6108 | 7089 |
| Relative error (%) | 0.00 | 0.33 | 0.51 | 4.12 | 2.11 | 0.11 | 0.82 | 6.73 | 1.20 | 1.08 | 0.69 |
Figure 1. Comparison of predicted and actual value of per capita disposable income from 2007 to 2028 (yuan per person).

4.3. Grey correlation analysis of urbanization and farmers’ income structure

Grey correlation theory is an analysis method to judge the degree of correlation between factors according to the similarity degree of development and change of various factors. Grey correlation analysis tries to seek the main relationship between various factors in the system, find out the important factors affecting the target value, and then master the main characteristics of things.

The urbanization rate of Fuling District from 2004 to 2017 is selected as the reference sequence: \(X_0(k) = (X_0(1), X_0(2), \ldots, X_0(10))\); The family business income, property income, and transfer income are comparative sequences as a comparison sequence: \(X_i(k) = (X_i(1), X_i(2), \ldots, X_i(10))\), where \(k = 1, 2 \ldots 10;\ i = 1, 2, 3, 4\). Then through the calculation of initial value standardization, absolute difference, maximum value and minimum value, the correlation coefficient and the correlation between farmers’ income sources and urbanization rate are obtained (see table 4).

| year | \(X_1\) wage income | \(X_2\) family business income | \(X_3\) transfer income | \(X_4\) property income |
|------|----------------------|-------------------------------|------------------------|------------------------|
| 2004 | 1.00000              | 1.00000                       | 1.00000                | 1.00000                |
| 2005 | 0.99604              | 0.99872                       | 0.99768                | 0.98558                |
| 2006 | 0.98756              | 0.99474                       | 0.98162                | 0.82539                |
| 2007 | 0.97593              | 0.99993                       | 0.96747                | 0.81305                |
| 2008 | 0.96798              | 0.99080                       | 0.96817                | 0.80953                |
| 2009 | 0.95114              | 0.99158                       | 0.93414                | 0.81472                |
| 2010 | 0.93706              | 0.98147                       | 0.93583                | 0.76119                |
| 2011 | 0.92308              | 0.97215                       | 0.88626                | 0.60683                |
| 2012 | 0.90270              | 0.97035                       | 0.84210                | 0.45379                |
| 2013 | 0.93356              | 0.96218                       | 0.66799                | 0.45973                |
| 2014 | 0.91881              | 0.93723                       | 0.63609                | 0.39655                |
| 2015 | 0.90765              | 0.93259                       | 0.60599                | 0.36616                |
| 2016 | 0.89712              | 0.92763                       | 0.56756                | 0.35185                |
| 2017 | 0.88698              | 0.91967                       | 0.52562                | 0.33333                |
| Correlation | 0.87040              | 0.96993                       | 0.82261                | 0.64126                |

The results are as follows: family business income, wage income, transfer income and property income. Among them, the relationship between urbanization rate and family business income, wage income, and transfer income is extremely strong, and the correlation with property income is strong.

From the above analysis, the following conclusions can be drawn: (1) In the process of urbanization, the sources of income of farmers have been developed to varying degrees. (2) The growth of wage income of farmers is basically synchronized with urbanization; the proportion of family business income to total income has decreased year by year. (3) The influence of urbanization rate on farmers’ income was: family business income, wage income, transfer income, and property income.

5. Suggestions on improving farmers’ income structure and promoting farmers’ income increase

5.1. Promoting an increase in family business income
Increasing investment in rural education and promoting the quality of farmers. Since family business income is highly correlated with urbanization rate, family business income is still a major component of farmers’ income; therefore, it is essential to improve the quality of farmers: First, training for rural adult education. Continue to promote the new farmers' poverty alleviation and entrepreneurship training in Fuling District, the Three Gorges immigrant training, the new professional farmers training, and the management of professional farmers. The second is the training of rural teachers, through training to improve the overall business quality; rural teachers can be regularly exchanged in urban areas to implement urban and rural educational resources sharing. Third, accelerate infrastructure construction and increase support for agriculture. Strengthen financial support for rural areas and provide strong guarantee for agricultural intensification;

5.2. Steadily increasing the wage income of farmers
Adjust and optimize the industrial structure and increase farmers' income. The proportion of farmers' wage income in the income of farmers is gradually increasing, and the role of wage income in farmers' income is becoming more and more important. Urbanization construction can solve the absorption of peasant surplus labor; it should promote the employment of peasants through the project, revolve around regional characteristic industries and products, vigorously develop the township economy, support township enterprises to absorb employment, and increase wage income.

5.3. Promoting property income and transfer income
First, Promoting precision poverty alleviation. Promoting the dynamic management mechanism of poor households, and use poverty alleviation and development as the main way to get rid of poverty. The second is to increase the financial transfer payments to rural public goods. Improve the rural production environment, promote the development of agricultural mechanization, increase the subsidies for the purchase of agricultural machinery, effectively reduce the burden on farmers and increase the income of farmers.

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