Hindawi
Journal of Mathematics
Volume 2021, Article ID 4869135, 10 pages
https://doi.org/10.1155/2021/4869135

Research Article

Prediction of Farmers' Income in Hebei Province Based on the Fractional Grey Model (1,1)

Yongqiang Xu,[1,2] **Lim Thien Sang**,[1] **and Kun Wang**[3]

[1]*Faculty of Business, Economics and Accountancy, University Malaysia Sabah, Kota Kinabalu, Sabah 88400, Malaysia*
[2]*School of Management Engineering and Business, Hebei University of Engineering, Handan 056038, China*
[3]*Department of Management, Handan Polytechnic College, Handan 056000, China*

Correspondence should be addressed to Kun Wang; uthz2013@163.com

Received 17 June 2021; Accepted 6 November 2021; Published 29 November 2021

Academic Editor: Efthymios G. Tsionas

The problem of increasing farmers' income has been a hot issue of social concern. Understanding the farmers' income and the overall development trend is conducive to the rational layout of the social economy and promotes the steady development of a well-off society. Based on this, the paper selects the per capita disposable income (PCDI) of farmers' households from 2012 to 2019 in 11 cities of Hebei Province as the research object and applies the fractional grey model (FGM (1,1)) to predict farmers' income from 2020 to 2024. The results show that the farmers' income will increase in the next five years. However, the growth rate of farmers' income is slow in the areas with a large base of farmers' income and strong in the areas with a small base of farmers' income. The area with the highest trend in the growth rate of farmers' income is Zhangjiakou and the lowest place is Handan. Only Shijiazhuang's income growth rate is on the rise. Finally, suggestions are given to promote farmers' income in Hebei Province.

1. Introduction

In recent years, the government has been focusing on "three rural issues: agriculture, rural areas, and farmers" in rural work and "how to increase farmers' income" has been a long-term work to tread. Only by understanding the development trend of farmers' income can the government better formulate economic plans and achieve a well-off society [1]. Hebei, as a province in China, should also consider the importance of predicting farmers' income to promote the rural economy. As of 2020, the urbanization level of Hebei Province was 45%. It means that the rural population still has an absolute advantage. The precondition for the rapid economic development of Hebei Province is that farmers' income needs to increase substantially. Meanwhile, some studies expressed that increasing farmers' income is also the key step in solving the urbanization and the dual economy between urban and rural areas. In Hebei, farmers' absolute income is increasing, but at a slower rate, wage income is the main income factor. In addition, the PCDI of farmers' households in Hebei Province has no advantage across the country. So, it was necessary to evaluate and predict the future farmers' income, investigate the income channels, and formulate relevant rural policies. The paper takes Hebei farmers' income as the research object, the basic data are obtained from the PCDI of farmers in different cities from 2012 to 2019, and FGM (1,1) is used to predict the farmers' income from 2020 to 2024. Then, the paper analyses the results and gives suggestions of promoting farmers' income in Hebei Province. Meanwhile, the prediction model of farmers' income and the experience of increasing farmers' income also have some guiding significance for other provinces in China.

2. Literature Review

There have been many related studies on farmers' income, which can be divided into the analysis of factors influencing farmers' income and the prediction research of farmers' income. In terms of influencing factors of farmers' income, the agricultural industrial structure had an impact on farmers' income and not all agricultural structures were useful to the growth of farmers' income [2, 3]. In addition, agricultural technology and the degree of agricultural

intensification also affected farmers' income; advanced agricultural technology saved resources and reduced costs, which increased farmers' income [4]. The scale of the agricultural industry and agricultural mechanization would also raise farmers' income [5]. Some researchers introduced the quality of farmers in their studies and found that there was a positive relationship between income and education years, so it was necessary to guide farmers to receive vocational skills training [6]. And, the government support and urbanization development levels had a certain influence on farmers' income [7]. Both national policies and measures to support agriculture could affect farmers' income. The development of industries increased the level of nonagricultural employment and directly promoted the increase of farmers' income [8, 9].

Researchers have also done a lot of work on income prediction. Backpropagation neural network has strong nonlinear mapping ability, and it has high accuracy in farmers' income prediction [10]. The autoregressive integrated moving average model was applied to time-series data, which could accurately reflect the interdependence of dynamic data and provide an effective reference for the prediction of farmers' income in the short term [11]. The "quasi-stepwise regression" method had high accuracy, and the average relative error of farmers' income obtained was around 1%, which had a good validity [12]. Compared with the previous model, the support vector machine model, which had the nonlinear time-series prediction characteristic, greatly improved the prediction accuracy of farmers' income [13]. The advantage of the rough set theory and partial least squares regression method was that both can eliminate the influence of redundant factors on farmers' income and improve the prediction accuracy [14, 15]. To sum up, the above models were able to consider the variables' time variation and structural differentiation and supplied gaps of sectional data or time-series data, which had strong advantages in predicting farmers' income [16].

With the deepening of research, the studies have discovered that many factors affect the farmers' income and it was difficult to screen the main factors. The fuzziness and uncertainty of farmers' income prediction were more consistent with the grey theory [17]. The grey system theory and prediction model originally proposed by Professor Deng can accurately predict the future development trend with "small sample and poor information" data in the real world, which has been widely applied in many fields [18]. The grey model GM (1,1) was a basic predictive model [19, 20]. The advantage of the GM (1,1) model was that it can deal with grey information and poor data, but the model was mainly applicable to the sequence with strong exponential law and could only describe the monotone change process, and it had a big error in some specific fields [21]. In view of the shortcomings of the traditional GM (1,1) model, the fractional grey model (FGM (1,1)) was proposed [22]. In the process of FGM (1,1), the matrix perturbation theory was used to prove that the traditional integer-order cumulative generating operator violated the new information priority principle of grey system theory. Under certain conditions, the FGM (1,1) had a higher accuracy than the GM (1,1) model [23]. The FGM (1,1) was able to effectively reduce the error and obtain a better prediction by choosing the appropriate fractional order. Therefore, in this paper, the PCDI of farmers' households in various cities of Hebei Province from 2012 to 2019 was used as the measurement of farmers' income, the FGM (1,1) model was used to predict farmers' income, and suggestions were put forward to promote farmers' income.

3. Model Introduction of FGM (1,1)

The sequence with the nonnegative samples is $X^{(0)} = \{x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n)\}$. The FGM (1,1) model is constructed as follows.

Step 1. The R-order accumulation generation sequence is

$$X^{(r)} = \left\{x^{(r)}(1)\ ,\ x^{(r)}(2)\ ,\ \ldots\ ,\ x^{(r)}(n)\right\}. \tag{1}$$

Among them,

$$x^{(r)}(k) = \sum_{i=1}^{k} C_{k-i=r-1}^{k-i} x^{(0)}(i), \quad k = 1, 2, \ldots, n,$$

$$C_{r-1}^{0} = 1, C_{k}^{k-1} = 0, \tag{2}$$

$$C_{k-i+r-1}^{k-i} = \frac{(k-i+r-1)(k-i+r-2), \ldots, (r+1)r}{(k-i)!}.$$

We establish the average generation sequence of $X^{(r)}$:

$$Z^{(r)} = \left\{z^{(r)}(2), z^{(r)}(3), \ldots, z^{(r)}(n)\right\}. \tag{3}$$

Among them,

$$z^{(r)}(k) = \frac{1}{2}\left(x^{(r)}(k) + x^{(r)}(k-1)\right), \quad k = 2, 3, \ldots, n. \tag{4}$$

Step 2. We establish the whitening differential equation:

$$\frac{\mathrm{d}x^{(r)}(t)}{\mathrm{d}t} + ax^{(r)}(t) = b, \tag{5}$$

where a is the developmental grey number and b is the grey action.

Since the least squares method can minimize the error of the solution, we use the least squares method to solve $\hat{a}$ and $\hat{b}$:

$$\begin{bmatrix} \hat{a} \\ \hat{b} \end{bmatrix} = \left(B^T B\right)^{-1} B^T Y. \tag{6}$$

Among them,

$$B = \begin{bmatrix} -z^{(r)}(2) & 1 \\ -z^{(r)}(3) & 1 \\ \vdots & \vdots \\ -z^{(r)}(n) & 1 \end{bmatrix}, Y = \begin{bmatrix} x^{(r)}(2) - x^{(r)}(1) \\ x^{(r)}(3) - x^{(r)}(2) \\ \vdots \\ x^{(r)}(n) - x^{(r)}(n-1) \end{bmatrix}. \tag{7}$$

The time response formula is as follows:

$$\hat{x}^{(r)}(t) = \left(x^{(0)}(1) - \frac{\hat{b}}{\hat{a}}\right) \cdot e^{-\hat{a}(t-1)} + \frac{\hat{b}}{\hat{a}}. \tag{8}$$

Using the time response formula, $\hat{X}^{(r)}$ is solved:

$$\hat{X}^{(r)} = \left\{\hat{x}^{(r)}(1), \hat{x}^{(r)}(2), \ldots, \hat{x}^{(r)}(n)\right\}. \tag{9}$$

Step 3. The inverse accumulation generating operator is used to obtain

$$\hat{x}^{(1)} = x^{(r)}x^{(1-r)} = \left\{\hat{x}^{(r)(1-r)}(1), \hat{x}^{(r)(1-r)}(2), \ldots, \hat{x}^{(r)(1-r)}(n)\right\}. \tag{10}$$

Then, the predicted value can be obtained by the following reduction formula:

$$\hat{x}^{(0)}(k) = \hat{x}^{(1)}(k) - \hat{x}^{(1)}(k-1), \quad k = 2, 3, \ldots, n. \tag{11}$$

Step 4. Model Testing. There are many testing methods for grey prediction models. And, the average absolute percentage is a commonly used testing method in grey prediction. The paper uses this method for model testing. Grey systems are often evaluated by using the mean absolute percentage error (MAPE).

$$\text{MAPE} = \frac{1}{n}\sum_{k=1}^{n}\left|\frac{x^{(0)}(k) - \hat{x}^{(0)}(k)}{x^{(0)}(k)}\right| \times 100\%. \tag{12}$$

The evaluation criteria of MAPE are shown in Table 1. When MAPE < 10%, it means that the model fitting effect is better and the prediction result is more reliable. When 10% < MAPE < 20%, the model fit has a certain degree of credibility. When MAPE > 20%, the fitting effect of the model is average and the prediction result has little reference value.

Especially in the FGM (1,1), when $r = 1$, the FGM (1,1) is equivalent to the GM (1,1). The GM (1,1) can be regarded as a special case of the fractional grey model.

Table 1: MAPE evaluation criteria.

MAPE (%)	Predictive performance
<10	Excellent
10~20	Good
20~50	General
>50	Difference

4. Prediction and Result Analysis of Farmers' Income

4.1. Data Sources. The data came from Hebei Statistical Yearbook from 2013 to 2020. From Table 2, the PCDI of farmers in all cities showed an upward trend from 2012 to 2019. In combination with the trend chart of farmers' income in Figure 1 and the average growth rate in Figure 2, it can be concluded that there is a large gap in the income level of farmers in the different areas of Hebei Province. The PCDI of Tangshan farmers is twice that of Chengde farmers. From the average growth rate of farmers' income in different cities, the growth rate of farmers' income in Hebei Province is more than 8%. In addition, income in Zhangjiakou, Hengshui, Chengde, Xingtai, Cangzhou, and Baoding all grew by more than 10% and even income in Zhangjiakou and Hengshui both grew by almost 12%. However, it cannot be ignored that the average growth rate is relatively low in areas with higher farmers' incomes, such as Tangshan and Langfang. This might have a certain relationship with the economic background of the new normal of China's economic growth rate from high-speed growth to medium-high growth [24]. But overall, under the premise of stable development of the economic environment, the slowdown of farmers' income growth in some cities is temporary and it will still keep the rising trend in the future.

4.2. Testing the Validity of FGM (1,1). The FGM (1,1) was established according to the PCDI of farmers' households in different cities of Hebei Province from 2012 to 2019. The FGM (1,1) process was as follows.

Due to the duplication and similarity of calculations, the paper only gives the process of predicting farmers' income in Handan City from 2020 to 2024. The income prediction process of farmers in other cities is omitted.

PCDI of farmers' households in Handan City from 2012 to 2019 as follows:

$$X^{(0)} = (8447, 9307, 10343, 11247, 12153, 13151, 14307, 15695). \tag{13}$$

In MATLAB software, particle swarm optimization was used to calculate the optimal order r of the prediction model, $r = 0.95$, and then the 0.95-order accumulation generation sequence was

$$X^{(0.95)} = (8447.0, 17336.5, 27021.1, 37409.3, 48526.2, 60474.4, 73412.8, 87566.3). \tag{14}$$

We established a first-order one-variable differential equation about t for $X^{(0.95)}$:

$$\frac{\mathrm{d}x^{(0.95)}}{\mathrm{d}t} + ax^{(0.95)} = b. \tag{15}$$

Then, the least squares method was used to solve a and b:

$$\begin{bmatrix} a \\ b \end{bmatrix} = \left(B^T B\right)^{-1} B^T Y_n = \begin{bmatrix} -0.076 \\ 7914.332 \end{bmatrix}, \tag{16}$$

Table 2: PCDI of farmers' households in various cities of Hebei Province from 2012 to 2019 (unit: yuan).

City	Year							
	2012	2013	2014	2015	2016	2017	2018	2019
Shijiazhuang	8993	9682	10691	11442	12345	13345	14518	15853
Tangshan	10698	11674	12867	13935	15023	16229	17656	19316
Handan	8447	9307	10343	11247	12153	13151	14307	15695
Baoding	7696	8649	9704	10558	11612	12779	14108	15618
Cangzhou	7514	8470	9442	10389	11340	12363	13516	14854
Xingtai	6601	7446	8342	9152	10006	10999	12287	13798
Langfang	10447	10985	12115	13159	14286	15487	16865	18467
Chengde	5546	6031	7163	7923	8736	9682	10804	12101
Zhangjiakou	5564	6583	7462	8341	9241	10293	11531	12973
Hengshui	6167	7182	8104	9030	10069	11194	12493	13917
Qinhuangdao	8315	9007	9964	10782	11621	12563	13719	15035

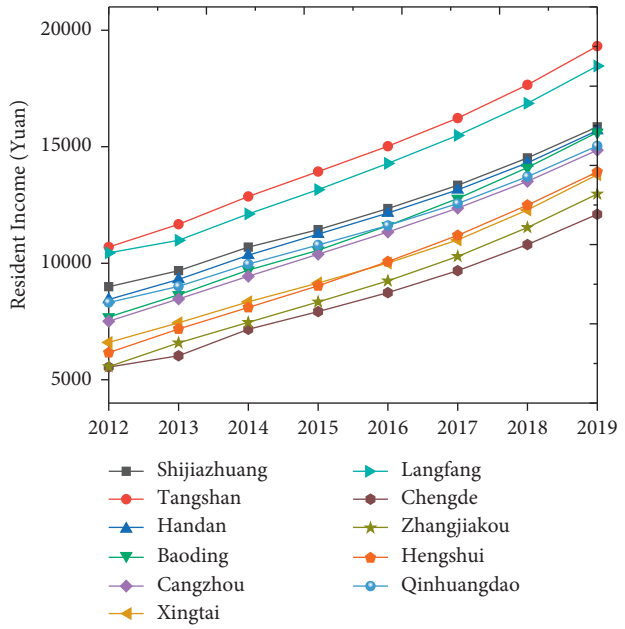

Figure 1: The farmers' income trend of Hebei Province from 2012 to 2019.

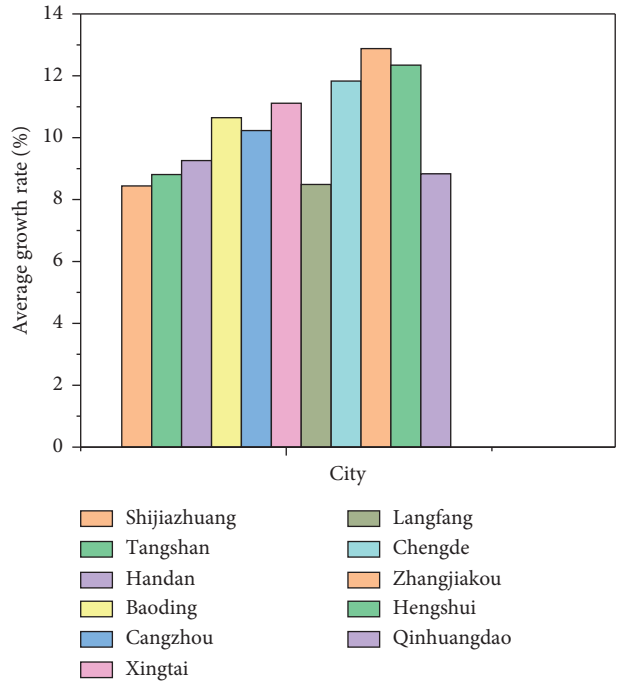

Figure 2: Average growth rate of farmers' income in Hebei Province from 2012 to 2019.

where

$$B = \begin{bmatrix} -12891.8 & 1 \\ -22178.8 & 1 \\ -32215.2 & 1 \\ -42967.8 & 1 \\ -54500.3 & 1 \\ -66943.6 & 1 \\ -80489.6 & 1 \end{bmatrix}, \quad Y_n = \begin{bmatrix} 8889.53 \\ 9684.61 \\ 10388.20 \\ 11116.89 \\ 11948.18 \\ 12938.40 \\ 14153.53 \end{bmatrix}. \tag{17}$$

Table 3: Prediction results of the GM (1,1) model and FGM (1,1) model for Handan data.

Year	PCDI	GM (1,1)	Growth rate	FGM (1,1)	Growth rate
2012	8447	8447		8447	
2013	9307	9417	0.114	9307	0.102
2014	10343	10246	0.088	10250	0.101
2015	11247	11149	0.088	11203	0.093
2016	12153	12132	0.088	12197	0.089
2017	13151	13201	0.088	13249	0.086
2018	14307	14364	0.088	14370	0.085
2019	15695	15630	0.088	15570	0.083
MAPE (%)		0.62		0.52	

We used the corresponding formula of time, and we obtained

$$\widehat{X}^{(0.95)} = \left(\widehat{x}^{(0.95)}(1), \widehat{x}^{(0.95)}(2), \ldots, \widehat{x}^{(0.95)}(13)\right) = \begin{pmatrix} 8447.0, 17336.5, 26927.8, 37326.1, 48441.4, 60488.0, 73485.5, \\ 87509.0, 102639.5, 118964.4, 136577.9, 155581.8, 176085.9 \end{pmatrix}. \tag{18}$$

Then, the 0.95-order reverse accumulation generation operation was performed on $\widehat{X}^{(0.95)}$ to obtain $\widehat{X}^{(1)}$:

$$\widehat{X}^{(1)} = \alpha^{(0.95)} X^{(0)} = \begin{pmatrix} 8447.0, 17754.0, 28003.6, 39206.2, 51403.1, 64652.3, 79022.5, \\ 94952.3, 111448.5, 129686.8, 149411.2, 170735.1, 193781.4 \end{pmatrix}. \tag{19}$$

Finally, the fitting value sequence and the predicted value sequence of $X^{(0)}$ were obtained.

The fitted value sequence of $X^{(0)}$ is

$$\{8447.0, 9307.0, 10249.6, 11202.5, 12197.0, 13249.1, 14370.3, 15569.8\}. \tag{20}$$

The predicted value sequence of $X^{(0)}$ is

$$\{16856.2, 18238.2, 19724.4, 21323.9, 23046.3\}. \tag{21}$$

When $r = 1$, the FGM (1,1) model became the GM (1,1) model. The MAPE of the GM (1,1) model and FGM (1,1) model is shown in Table 3. It can be found that the MAPE of the FGM (1,1) model and GM (1,1) model both meet the requirements, but the MAPE of the FGM (1,1) model was significantly lower than that of the GM (1,1) model. In other words, the FGM (1,1) model had a higher accuracy than the GM (1,1) model. Excluding the second data, the growth rate of GM (1,1) is a constant. But, the growth rate of FGM (1,1) is mutable and data-driven. The growth rate of FGM (1,1) is very consistent with the actual situation. This is an important property. Thus, we used FGM (1,1) to fit the other data. The results are listed in Table 4; the FGM (1,1) model and GM (1,1) model both meet the requirements, but the MAPE of the FGM (1,1) model was significantly lower than or equal to that of the GM (1,1) model. In other words, the FGM (1,1) model had a higher accuracy than the GM (1,1) model.

4.3. Prediction Results of Farmers' Income in Different Cities. Based on the data of farmers' income from 2012 to 2019, the FGM (1,1) model was used to predict farmers' income from 2020 to 2024. The predicted results are shown in Table 5.

Table 4: Prediction results of the GM (1,1) model and FGM (1,1) model.

	Shijiazhuang			Tangshan			Qinhuangdao		
Year	PCDI	GM (1,1)	FGM (1,1)	PCDI	GM (1,1)	FGM (1,1)	PCDI	GM (1,1)	FGM (1,1)
2012	8993	8993	8993	10698	10698	10698	8315	8315	8315
2013	9682	9730	9701	11674	11752	11674	9007	9068	9007
2014	10691	10544	10498	12867	12756	12759	9964	9855	9857
2015	11442	11427	11377	13935	13846	13884	10782	10711	10741
2016	12345	12383	12343	15023	15029	15075	11621	11641	11677
2017	13345	13420	13402	16229	16313	16346	12563	12652	12679
2018	14518	14543	14563	17656	17706	17710	13719	13751	13755
2019	15853	15761	15835	19316	19219	19176	15035	14945	14912
MAPE (%)		0.52	0.49		0.50	0.47		0.59	0.56
	Baoding			Cangzhou			Xingtai		
Year	PCDI	GM (1,1)	FGM (1,1)	PCDI	GM (1,1)	FGM (1,1)	PCDI	GM (1,1)	FGM (1,1)
2012	7696	7696	7696	7514	7514	7514	6601	6601	6601
2013	8649	8694	8685	8470	8578	8470	7446	7430	7430
2014	9704	9579	9579	9442	9399	9401	8342	8222	8222
2015	10558	10553	10558	10389	10298	10350	9152	9098	9098
2016	11612	11628	11633	11340	11283	11347	10006	10067	10067
2017	12779	12811	12815	12363	12362	12410	10999	11139	11139
2018	14108	14115	14116	13516	13545	13551	12287	12326	12326
2019	15618	15552	15547	14854	14841	14781	13798	13639	13639
MAPE (%)		0.39	0.38		0.49	0.29		0.80	0.80
	Langfang			Chengde			Zhangjiakou		
Year	PCDI	GM (1,1)	FGM (1,1)	PCDI	GM (1,1)	FGM (1,1)	PCDI	GM (1,1)	FGM (1,1)
2012	10447	10447	10447	5546	5546	5546	5564	5564	5564
2013	10985	11053	10985	6031	6265	6057	6583	6622	6583
2014	12115	12034	12035	7163	6990	6973	7462	7401	7401
2015	13159	13101	13134	7923	7799	7885	8341	8272	8289
2016	14286	14262	14304	8736	8701	8824	9241	9245	9267
2017	15487	15527	15558	9682	9707	9890	10293	10332	10349
2018	16865	16904	16908	10804	10830	10857	11531	11547	11550
2019	18467	18403	18364	12101	12083	11978	12973	12905	12885
MAPE (%)		0.39	0.32		1.28	1.06		0.47	0.44
	Hengshui								
Year	PCDI	GM (1,1)	FGM (1,1)						
2012	6167	6167	6167						
2013	7182	7235	7182						
2014	8104	8067	8067						
2015	9030	8996	9019						
2016	10069	10031	10061						
2017	11194	11186	11209						
2018	12493	12473	12476						
2019	13917	13908	13880						
MAPE (%)		0.32	0.16						

Table 5: Prediction results of farmers' income from 2020 to 2024.

City	Year				
	2020	2021	2022	2023	2024
Shijiazhuang	17227	18752	20421	22247	24247
Tangshan	20754	22454	24287	26265	28399
Handan	16856	18238	19724	21324	23046
Baoding	17123	18857	20767	22869	25184
Cangzhou	16108	17545	19100	20785	22611
Xingtai	15092	16699	18478	20446	22624
Langfang	19938	21640	23481	25474	27631
Chengde	13184	14486	15894	17419	19073
Zhangjiakou	14369	16020	17858	19904	22182
Hengshui	15434	17158	19070	21191	23544
Qinhuangdao	16161	17507	18961	20532	22228

4.4. Result Analysis. The farmers' income has been predicted, combining the actual values of farmers' income from 2012 to 2019 and the predicted values from 2020 to 2024 (as shown in Figure 3); obviously, farmers' income in Hebei Province is generally increasing by years and the growth rate of farmers' income in cities with a small income base is higher than that in cities with a large income base (as shown in Figure 4). In particular, 2021 is a turning point for farmers' income. Later, the growth rate tends to stabilize, which is closely related to the economic environment such that the whole country enters a well-off society and the productive forces are fully released. For the convenience of analysis, the farmers' income in 11 cities is divided into three ranges based on the income growth rate. The first growth range: Zhangjiakou and Hengshui (income growth rate > 11%), the second growth range: Baoding, Xingtai and Chengde (10% < income growth rate < 11%), and the third growth range: Shijiazhuang, Tangshan, Handan, Cangzhou, Langfang, and Qinhuangdao (income growth rate < 10%).

In the first range, as shown in Figure 5, the income growth rate of Zhangjiakou and Hengshui is in the leading position in the province. This is inseparable from the local government support and farmers' motivation. In particular, Zhangjiakou's growth rate is the first; it takes the "2022 Winter Olympics" as an opportunity to increase the "ice and snow economy," promoting the development of tertiary industries. Meanwhile, Zhangjiakou actively guides the transfer of rural surplus labor to cities, creates a lot of rural wealth, and increases the farmers' income. Hengshui takes advantage of its proximity to the Xiong'an New District, and it develops characteristic agriculture, such as pears and peaches, uses modern science and technology, optimizes the structure of agricultural industries, and builds modern agricultural parks. At the same time, Hengshui relies on the advantages of the Internet to carry out e-commerce cooperation with large agricultural enterprises. All these have laid a solid foundation for increasing farmers' incomes.

Baoding, Xingtai, and Chengde are in the second range (as shown in Figure 6), where farmers' incomes are growing at a medium speed. Based on the actual situation, Baoding cultivates characteristic and advantageous agricultural products, builds industry-leading enterprises, helps agricultural product clusters, mixes the development of primary, secondary, and tertiary industries in rural areas, and promotes "agriculture and industry," "agriculture and Internet," "agriculture and tourism," and other models to increase farmers' employment and income. While increasing the development of agricultural planting industries in Chengde and Xingtai, two cities take advantage of geographical and labor cost advantages to export rural surplus labor to Beijing and Tianjin, the purpose of which is to increase farmers' income through multiple channels.

The third range is the slower increase in farmers' income, as shown in Figure 7, including Shijiazhuang, Tangshan, Handan, Cangzhou, Langfang, and Qinhuangdao. From the existing statistical yearbook of Hebei Province, it can be found that the farmers' income in the six cities is higher than that in the other five cities, but the growth rate is slow. In particular, Handan and Xingtai have the slowest income

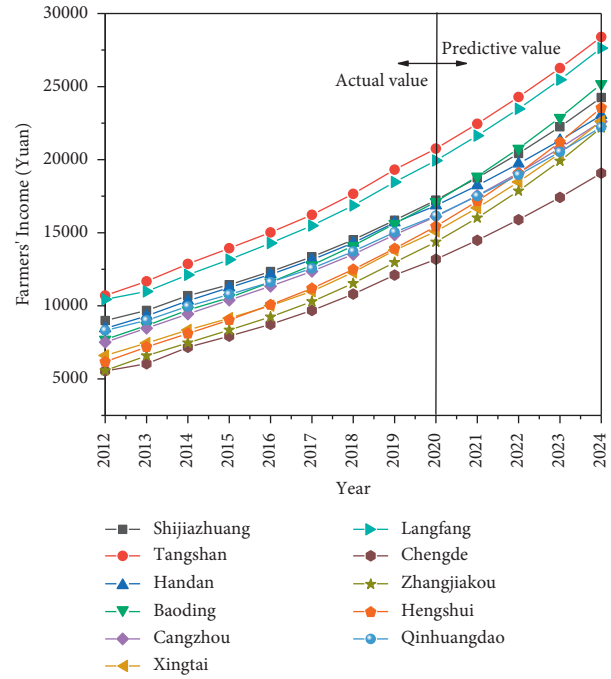

Figure 3: The actual and predicted values of farmers' income in Hebei Province from 2012 to 2024.

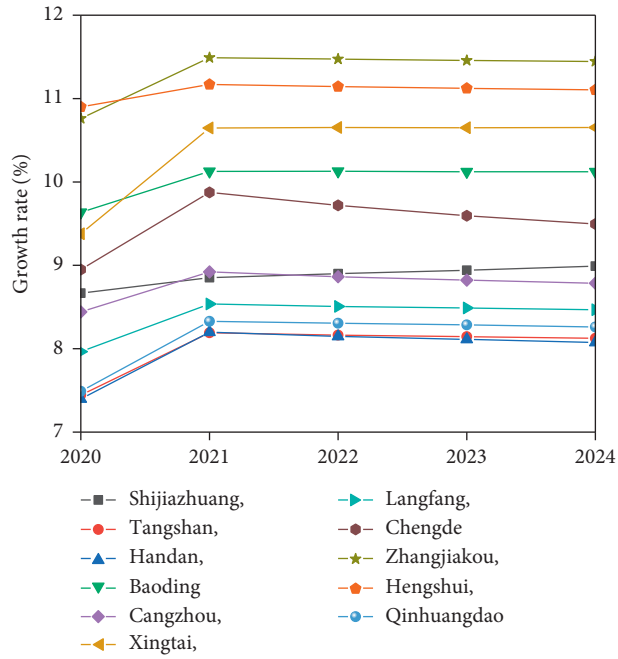

Figure 4: The growth rate of the predicted value of farmers' income from 2020 to 2024.

growth rates in the province. They are both heavy industrial cities, and their development models are in a transitional period; this influences economic development, but the impact is temporary. Langfang is next to Beijing, and its economic development is inseparable from Beijing. However, the phenomenon of economic and talent "siphoning" is inevitable. Although Qinhuangdao has increased its

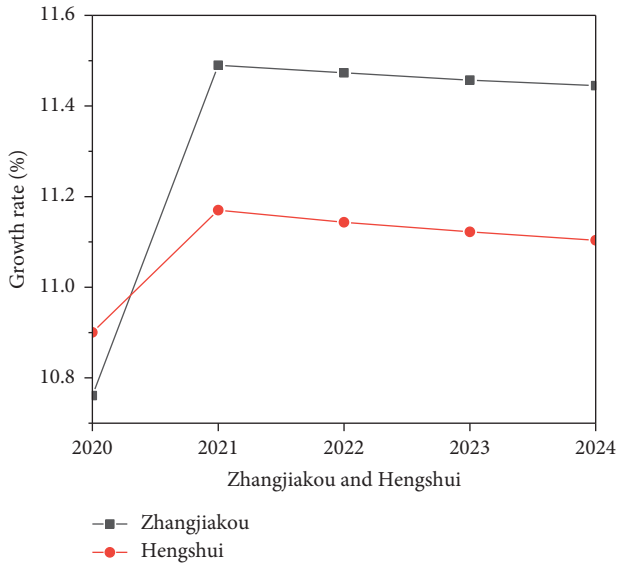

Figure 5: Farmers' predicted income growth rate in the first range.

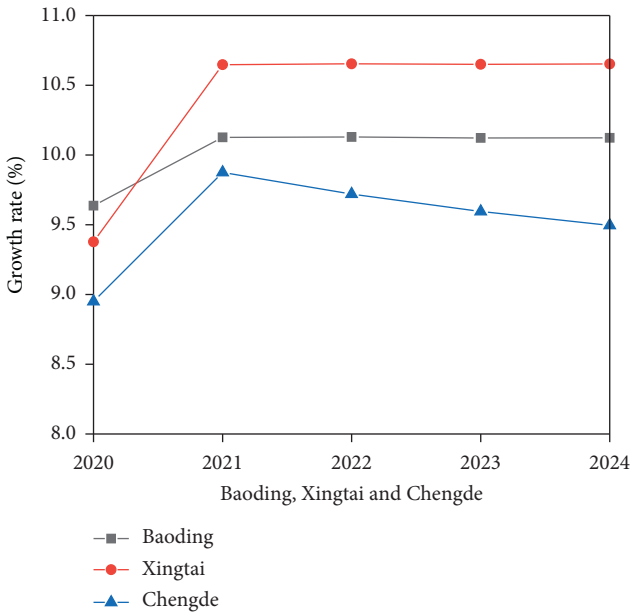

Figure 6: Farmers' predicted income growth rate in the second range.

investment in rural infrastructure construction, the unreasonable structure of agricultural industrialization, backward education, and ecological environmental governance still disturb farmers' income. Cangzhou promotes the cultivation of characteristic agriculture and strengthens the construction of the fruit market such that behaviors have been useful in promoting farmers' income. Shijiazhuang is the capital of Hebei Province, and it is the only city where farmers' income growth rate has been growing steadily. However, it has a slow growth rate, which is completely inconsistent with the characteristics of capital cities. It also proves that the development of urban and rural areas is relatively unbalanced, the economic growth force is still focused on cities, and there is lack of management of rural development.

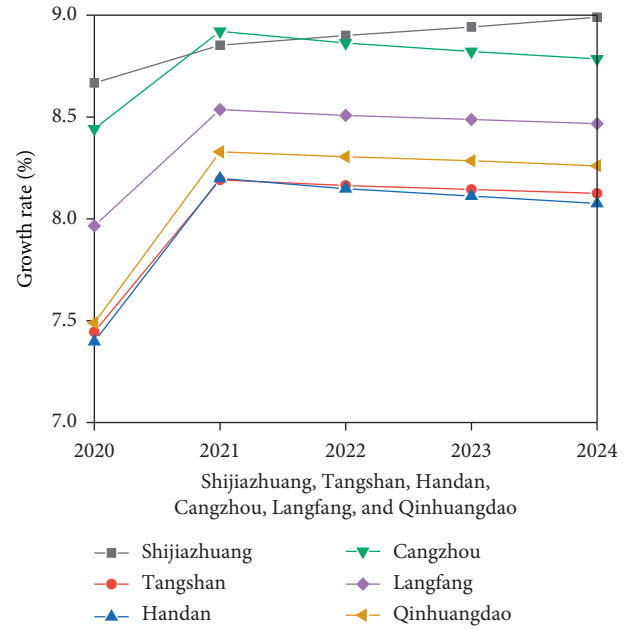

Figure 7: Farmers' predicted income growth rate in the third range.

5. Conclusions and Suggestions

By using the FGM (1,1) model to predict the farmers' income in Hebei province, it can be concluded that the FGM (1,1) model can better predict farmers' income and the FGM (1,1) model has certain advantages over the GM (1,1) model in predicting accuracy. The prediction results show that the farmers' income in Hebei province will continue to increase in the next five years, and from the perspective of the growth rate of farmers' income, the growth rate is slow in the areas with a large base of farmers' income and strong in the areas with a small base of farmers' income. The area with the highest trend growth rate of farmers' income is Zhangjiakou, and the lowest place is Handan. Only Shijiazhuang's income growth rate is on the rise.

According to the prediction results of farmers' income in Hebei Province, combined with national policies, the core of solving the rural issue is to increase farmers' income. Meanwhile, increasing farmers' income is also the basic requirement of a well-off society [25]. Hence, the paper makes the following suggestions for increasing farmers' income:

(1) Strengthen rural infrastructure construction and improve rural production efficiency.

Rural infrastructure is an important material foundation for enhancing rural productivity, developing modern agriculture, increasing farmers' income, and building a new socialist countryside. The government needs to increase capital investment in rural infrastructure. Farmers are the main body of new rural construction, and the government should take various measures to mobilize farmers' enthusiasm, initiative, and creativity so that farmers consciously participate in rural construction.

(2) Improve the quality of farmers and guide the transfer of rural surplus labor.

The low quality and ability of the farmers are the main factors affecting the increase in income. The government has the responsibility to improve the quality of farmers in rural areas. In addition, it is necessary to strengthen rural vocational and technical education based on market demand and promote the transfer of rural labor to cities, to ensure stable employment for farmers and increase income.

(3) Promote the combined development of rural revitalization strategy and new urbanization.

The coupled development of rural revitalization and new urbanization is conducive to promoting the extension of urban public resources and public services to the rural areas, encouraging the flow of urban capital, technology, and talents to the rural areas. Then, the new industrialization, information technology, urbanization, and agricultural modernization are developed simultaneously.

Finally, the prediction of farmers' income is a complex issue. In the next step, the paper will analyze the influencing factors of farmers' income in Hebei Province, establish the GM (1,N) model, and put forward more targeted methods to increase farmers' income.

Data Availability

The research data come from Hebei Statistical Yearbook from 2013 to 2020, available at (http://tjj.hebei.gov.cn/hetj/tjsj/jjnj/).

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

This work was supported by the Humanities and Social Science Research Project of Higher Education Institutions in Hebei Province (No. SQ2021127) and Handan City Philosophy and Social Science Planning Project (No. 2020074). Meanwhile, this paper was also partially supported by Dr. Lim and Ms. Wang. Dr. Prof. Li also provided a lot of research suggestions for the paper.

References

[1] D. X. Song, X. Z. Feng, and Y. M. Zhu, "The forecast analysis of rural residents' income in shanxi province based on the GM (1,1) model," *Agriculture and Technology*, vol. 40, no. 009, pp. 142–144, 2020.

[2] Y. H. Gao and S. Zhao, "Study on the influence of county agricultural structure adjustment on farmers' income in gansu province based on fixed effect model," *Journal of Lanzhou University of Finance and Economics*, vol. 36, no. 02, pp. 24–33, 2020.

[3] J. Y. Jing, "Study on adjustment of agricultural industrial structure and farmers' income in changzhou city," *Food Science and Economy*, vol. 44, no. 07, pp. 112–118, 2019.

[4] Z. Zeng and P. M. He, "Study on the influence of food price and agricultural technology progress on farmers' income," *Price Monthly*, vol. 07, pp. 21–26, 2019.

[5] Y. Hu, J. S. Zhang, and M. Miao, "Study on the impact of large-scale land management on urbanization and farmers' income," *World Agriculture*, vol. 08, pp. 47–55, 2018.

[6] S. T. Li and X. Zhou, "Differences in the effect of farmers' education levels on their wage income Based on CH IP2013 Data of Shandong Province," *Journal of Hunan Agricultural University (Social Sciences)*, vol. 19, no. 04, pp. 41–46, 2018.

[7] H. J. Guan, "Characteristics and cause of wage income fluctuation in Chinese farmers," *Journal of Hebei University of Engineering (Social Sciences)*, vol. 31, no. 03, pp. 15–21, 2014.

[8] X. L. Wu and Z. Y. Liu, "Study on impact factors in China based on provincial panel data 2002-2011," *Contemporary Economic Sciences*, vol. 36, no. 01, pp. 46–54, 2014.

[9] X. Y. Mao and T. L. Cheng, "Empirical analysis of the structure of fiscal agriculture consumption and farmers ' income based on 2010 ~ board data of 13 cities in jiangsu province in 2012," *Public Finance Research*, vol. 12, pp. 68–71, 2014.

[10] D. X. Song, X. Z. Feng, and Y. M Zhu, "Prediction analysis of rural residents in shanxi province based on GM (1,1) model," *Agriculture and Technology*, vol. 40, no. 09, pp. 142–144, 2020.

[11] R. Zhou and X. Y. Chen, "Analysis of adjustment factors of engineering price based on grey system theory," *Friends of Accounting*, vol. 01, pp. 61–66, 2021.

[12] Z. H. Han and C. Qi, "Analysis of the impact factors of energy consumption strength based on grey association degree," *Industrial Technical economy*, vol. 35, no. 10, pp. 155–160, 2016.

[13] L. Xu, "Comparative analysis of the main causes of consumption structure of urban and rural residents under grey correlation," *Development Research*, vol. 05, pp. 63–66, 2012.

[14] W. Shan, H. M. Xiao, and X. P. Geng, "Analysis of the impact factors of farmers' income based on the grey correlation model," *Henan Science*, vol. 23, no. 02, pp. 306–309, 2005.

[15] K. L. Lin, Q. L. Chen, and R. Zhao, "Study on classified management of rocky desertification area based on the perspective of farmers' income," *Forestry Economy*, vol. 35, no. 01, pp. 31–37, 2015.

[16] S. F. Liu, Y. J. Yang, and L. F. Wu, *Grey System Theory and its Application*, Science Press, Beijing, China, 2014.

[17] J. J. Li, W. M. Liu, and H. M. Fei, "The forecast of farmers' income in Jilin province based on the grey markov model," *Northeast Agricultural Science*, vol. 45, no. 06, pp. 106–109, 2020.

[18] S. Liu, Y. Yang, N. Xie, and J. Forrest, "New progress of grey system theory in the new millennium," *Grey Systems: Theory and Application*, vol. 6, no. 01, pp. 2–31, 2016.

[19] S. F. Liu, B. Zeng, and J. F. Liu, "Study on the centralized basic form and use scope of the GM (1,1) model," *Systems Engineering and Electronics*, vol. 36, no. 03, pp. 501–508, 2014.

[20] S. F. Liu and J. L. Deng, "Range of GM (1,1) model," *Theory and Practice of Systems Engineering*, vol. 20, no. 05, pp. 121–124, 2000.

[21] L. Pei and J. Liu, "A predictive analysis of the business environment of economies along the belt and road using the fractional-order grey model," *Journal of Mathematics*, vol. 2021, Article ID 3153731, 13 pages, 2021.

[22] L. Wu, S. Liu, L. Yao, S. Yan, and D. Liu, "Grey system model with the fractional order accumulation," *Communications in*

Nonlinear Science and Numerical Simulation, vol. 18, no. 7, pp. 1775–1785, 2013.

[23] H. Chen, Y. Tong, and L. Wu, "Forecast of energy consumption based on FGM (1, 1) model," *Mathematical Problems in Engineering*, vol. 2021, Article ID 6617200, 11 pages, 2021.

[24] D. X. Song, X. Z. Feng, and Y. M. Zhu, "Forecast analysis of the income of rural residents in shaanxi province based on the GM (1,1) model," *Agriculture and Technology*, vol. 04, no. 09, pp. 142–144, 2020.

[25] J. Ding, "Strategic integration and coordinating promotion of rural revitalization and new urbanization in the new era," *Socialism Studies*, vol. 05, pp. 74–81, 2019.