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Comparative Research on Prediction Model of China's Urban-rural Residents' Income Gap

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Abstract By using the data concerning China's urban-rural residents' income gap from 1978 to 2010, this paper mainly researches the application of several kinds of models in predicting China's urban-rural residents' income gap. By conducting empirical analysis, we establish ARIMA prediction model, grey prediction model and quadratic-polynomial prediction model and conduct accuracy comparison. The results show that quadratic-polynomial prediction model has excellent fitting effect. By using quadratic-polynomial prediction model, this paper conducts prediction on trend of China's urban-rural residents' income gap from 2011 to 2013, and the prediction value of income gap of urban-rural residents in China from 2011 to 2013 is 14 173.20, 15 212.92 and 16 289.67 yuan respectively. Finally, on the basis of analysis, corresponding countermeasures are put forward, in order to provide scientific basis for energy planning and policy formulation: first, strengthen government's function of public service, coordinate resources, and strive to provide an equal opportunity of development for social members, so as to promote people's welfare and promote social equality; second, breach industrial monopoly and bridge income gap between employees in monopoly industry and general industry; last but not the least, support, encourage and call for government to establish social relief fund, adjust residents' income distribution from the non-governmental perspective, and endeavor to promote the income level of low-income class.

Key words Urban-rural residents' income gap, ARIMA model, Grey prediction model, Quadratic-polynomial model, China

During the Eleventh Five-Year Plan period, the GDP per capita in China breaks through 1 000 US dollars. At this stage, China must pay close attention to the problems concerning income distribution gap of interest groups and avoid further expansion of income distribution gap of all classes. In 2010, the income growth rate of rural residents was greater than the income growth rate of urban residents for the first time since the year 1998, but the income gap between rural residents and urban residents in China at present is still large. The demerits of land system and register census system are unconquerable, and there is an enormous gap between urban management system and rural management system, therefore, the income gap between rural residents and urban residents in China still distends. Conducting analysis on income gap prediction of urban-rural residents in the future and providing scientific basis for energy planning and policy formulation, have significance theoretically and practically to maintaining healthy, continuous and steady development of society and economy in China. At home, there are many scholars who research income gap prediction of urban-rural residents in China, for example, on the basis of analyzing regional pattern of urban-rural residents' income gap, Wang Yahong's *Monitoring and Warning Research on Income Gap Prediction of Urban-rural Residents in China-on the Basis of Analysis of Key Regions* (2011) selects 12 key provinces to conduct analysis and early warning, in order to create pertinent conditions for solving problems and finally achieve coordinated development of urban areas and rural areas^[1]; through empirical analysis, Wang Licheng's *Countermeasures of Solving Income Gap Prediction of Urban-rural Res-*

idents in China (2010) holds that industrial bias policies, lagged level of urbanization, production of agricultural products and price are responsible for the increasing income gap^[2]; on the basis of classified income sources, Lai Wenyan's *Empirical Analysis of Income Gap of Urban-rural Residents in China* (2010) uses quantitative and qualitative method to analyze the impact of urban-rural residents' income gap and various income sources in China on urban-rural residents' income gap^[3]; by using fixed effects model, Mu Yueying's *Analysis of Cause and Astringent Trend of Income Gap of Urban-rural Residents in China* (2010) holds that rural residents' human capital level has most significant impact on urban-rural gap^[4]; by using co-integration, Granger causality test and auto-regression model, Jiang Nanping's *Deconstructional Analysis of Impact of Income Gap of Residents in China on Urban-rural Residents' Consumer Spending* (2010) conducts deconstructional analysis to research urban-rural gap from 1985 to 2007^[5]. They all conduct analysis on income gap of urban-rural residents in China in terms of structure, cause, warning, countermeasures and so on, and there are no scholars who try to use time sequence model to predict income gap of urban-rural residents in China. By using the data concerning China's urban-rural residents' income gap from 1978 to 2010 (the data are from State Statistics Bureau), this paper mainly researches the application of several kinds of models in predicting China's urban-rural residents' income gap, establishes ARIMA prediction model, grey prediction model and quadratic-polynomial prediction model, and conducts accuracy comparison. This paper also conducts preliminary discussion on some problems, such as the cause of formation of China's urban-rural residents' income distribution gap, and the approach of bridging urban-rural residents' income distribution gap and constructing harmonious society.

1 Data source and research method

1.1 Data source The data are from *China Statistical Yearbook*. According to *China Statistical Yearbook*^[6], we get urban residents' disposable income per capita and rural residents' disposable income per capita in China from 1978 to 2010. The difference of them is time sequence data of China's urban-rural income gap, denoted by Y_t (Table 1).

Table 1 China's urban-rural residents' income gap yuan

Year	Y_t	Year	Y_t	Year	Y_t
1978	209.8	1989	772.4	2000	4 026.6
1979	226.8	1990	823.9	2001	4 493.2
1980	286.3	1991	992	2002	5 227.2
1981	268.5	1992	1 242.6	2003	5 850
1982	256.5	1993	1 655.8	2004	6 485.2
1983	254.2	1994	2 275.2	2005	7 238.1
1984	295.9	1995	2 705.3	2006	8 172.5
1985	341.5	1996	2 912.8	2007	9 646.2
1986	475.8	1997	3 070.2	2008	11 020.18
1987	539.6	1998	3 263.1	2009	12 022
1988	636.5	1999	3 643.7	2010	13 190

1.2 Research method By using the data concerning China's urban-rural residents' income gap from 1978 to 2010 and conducting empirical analysis, this paper adopts multi-model method to establish ARIMA prediction model, grey prediction model and quadratic-polynomial prediction model and conduct accuracy comparison.

1.2.1 ARIMAM model. ARIMA model was a time sequence analysis method based on the theory of random advanced by Box and Jenkins in 1970, also known as "Box-Jenkins model". This model has been widely used in the prediction analysis of economic field. Time sequence is a group of random variables dependent on the time t . Although the value of single sequence which contributes to constituting time sequence has uncertainty, in terms of the whole time sequence, its change has certain regularity, which can be described approximately by corresponding mathematical model. ARIMA model has three basic types as follows: auto-regression model, moving average model, and integration auto-regression moving average model. The ARIMA model is as follows:

$$X_t = \varphi_0 + \varphi_1 X_{t-1} + \varphi_2 X_{t-2} + \cdots + \varphi_p X_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \cdots - \theta_q \varepsilon_{t-q}$$

1.2.2 Grey model^[7]. Grey prediction method is a method to predict the system containing uncertain factors. By using time sequence data, generally we establish GM (1, 1) model to conduct prediction.

According to the historical sequence data $x^{(0)}$, we conduct one accumulation on the sequence to generate sequence $x^{(1)}$.

For differential equation $\frac{dx^{(1)}}{dt} + ax^{(1)} = \mu$, we construct matrix B and data vector Y . Then we solve the differential equation, and get that $Y = BA$, where

$$B = \begin{bmatrix} -\frac{X^{(1)}(1) + X^{(1)}(2)}{2} & 1 \\ -\frac{X^{(1)}(2) + X^{(1)}(3)}{2} & 1 \\ \vdots & \vdots \\ -\frac{X^{(1)}(30) + X^{(1)}(31)}{2} & 1 \end{bmatrix}; Y = \begin{bmatrix} X^{(0)}(2) \\ X^{(0)}(3) \\ \vdots \\ X^{(0)}(31) \end{bmatrix}; A = \begin{bmatrix} \alpha \\ \mu \end{bmatrix}.$$

1.2.3 Quadratic-polynomial model. When the object of prediction takes on the trend of rise or fall along with the change of time, with no prominent seasonal fluctuation, and the trend of this change can be reflected by a suitable function curve, we can establish trend model by taking time t as independent variable and value of time sequence y as dependent variable as follows: $y = f(t)$. Quadratic polynomial prediction model is a common model amid trend extrapolation prediction models, this paper adopts quadratic polynomial model to conduct fitting.

2 Results and analysis

2.1 Analysis of Change trend^[8-9] Since The Third Plenary Session of the Eleventh Central Committee, China's urban-rural residents' income gap has been gradually widening. In accordance with the development trend, it can be divided into three stages as follows.

The first phase (1978 – 1997): the income gap of residents widens.

Before The Third Plenary Session of the Eleventh Central Committee, China is under the condition of planned economy, and the principle of egalitarianism dominates the distribution of income. The urban income development and the rural income development achieve a better balance, but due to base effect, China's urban-rural residents' income gap is around twofold. As in history, China always pays more attention to heavy industry and neglects agriculture, and scissors gap between the prices of industrial products and the prices of agricultural products is prominent, so China's urban-rural residents' income gap has been so for quite some time.

The second phase (1998 – 2003): the income gap continues to widen.

After 1998, China's continuous rapid economic growth brings substantial increase of income and the rural residents' income increases concurrently and steadily, but the growth rate is relatively slow. The urban-rural income gap widens rapidly, while the growth rate of urban residents' disposable income per capita is always prominently faster than the growth rate of rural residents' net income per capita, which causes the trend of widening of urban-rural income gap year by year after the year 1998, the ratio of urban income and rural income increasing from 2.51:1 in 1998 to 3.23:1 in 2003.

The third phase (2004 – 2010): urban-rural income gap continues to widen, and the income distribution system needs to be improved and perfected.

At this phase, urban-rural income gap continues to widen, the urban-rural income gap increasing from 4 026.6 yuan in 2000 to 13 190 yuan in 2005. The urban-rural income gap becomes more and more acute, and there is an urgent need to address the problem.

2.2 Estimated results of ARIMA model

2.2.1 Stationarization processing^[10]. The time sequence fitted by ARIMA model must be stationary. If it is not stationary, then we need to stationarize the sequence by difference and conversion of sequence. The time sequence figure of original sequence is drawn as shown in Fig. 1, according to Table 1.

We can directly find from Fig. 2 that the original sequence has obvious long-term trend of progressive increase and the o-

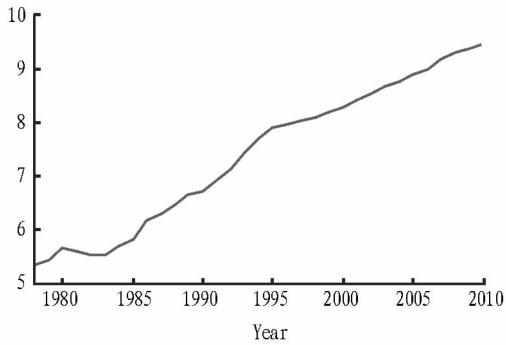


Fig. 1 ly time sequence

original sequence is not stationary. First take the logarithm of the sequence, assume $ly = \log(y)$ and conduct difference on ly . After conducting difference, get stationary sequence Δly . Test results of unit root can be seen in Table 2.

Table 2 Test results of unit root

	ADF value	P value	1% critical value	5% critical value	10% critical value
y	2.978 582	1.000 0	-3.699 87	-2.976 26	-2.627 42
ly	0.171 5	0.965 8	-3.679 32	-2.967 77	-2.622 99
Δly	-3.405 84	0.019 3	-3.689 19	-2.971 85	-2.625 12

From the table, we know that P value of ADF test of Δly after taking the logarithm of the sequence and conducting two differences on the sequence is 0.019 3, smaller than 0.05, therefore, it rejects the non-stationary null hypothesis of the sequence and accepts stationary alternative hypothesis of the sequence. The time sequence figure of Δly is drawn as shown in Fig. 2.

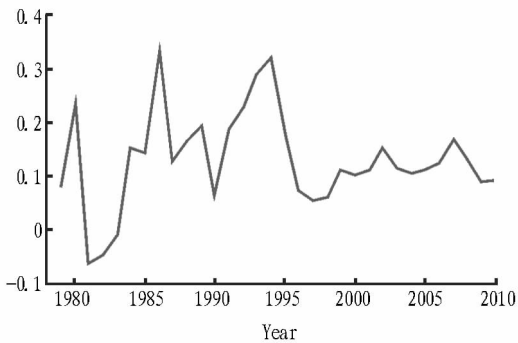


Fig. 2 Δly time sequence

2.2.2 Order determination. There are many methods to determine order. This paper selects the order determination methods of autocorrelation function and partial autocorrelation to determine the order of model^[11]. Firstly, we study the property of autocorrelation and partial autocorrelation of stationary sequence, in order to fit the order determination of model. Autocorrelation function (ACF) figure and partial autocorrelation function (PACF) figure are shown in Fig. 3.

From Fig. 3, we know that for the sequence which has been through processing, we can establish ARIMA(1,1,1) model, ARIMA(1,1,2) model and ARMA(1,1,4) model. We fit the ARIMA(1,1,1) model, ARIMA(1,1,2) model and ARMA

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	1	0.387	0.387	4.5190	0.034
2	0.189	0.046	5.6349	0.060	
3	-0.147	-0.276	6.3379	0.096	
4	-0.273	-0.176	8.6731	0.064	
5	-0.177	0.061	9.9938	0.075	
6	0.066	0.211	10.158	0.118	
7	0.042	-0.139	10.228	0.176	
8	0.142	0.018	11.059	0.198	

Fig. 3 Δly autocorrelation coefficient and partial autocorrelation coefficient

(1,1,4) model respectively, and get the results as shown in Table 3.

Table 3 Comparison of fitting results of models

Model	Adjusted R^2	AIC	SC
ARIMA(1,1,1)	0.171 79	-1.838 49	-1.742 88
ARIMA(1,1,2)	0.323 131	-2.266 54	-2.127 76
ARIMA(1,1,4)	0.434 966	-2.392 21	-2.160 92

From Table 3, amid ARIMA(1,1,1) model, ARIMA(1,1,2) model and ARMA(1,1,4) model, only the coefficients of ARIMA(1,1,4) model pass significance test. Moreover, the adjusted of ARIMA(1,1,4) is biggest amid ARIMA(1,1,1) model, ARIMA(1,1,2) model and ARMA(1,1,4) model, and AIC and SC of ARIMA(1,1,4) is very small, in comparison with ARIMA(1,1,1) model, ARIMA(1,1,2) model, so this paper choose ARMA(1,1,4) model, and the expression of model is as follows:

$$\Delta ly = (1 - B) \log(y) = (1 - 0.493\ 520B + 0.522\ 254B^2 - 0.775\ 257B^3 - 0.245\ 985B^4) \varepsilon_t$$

$$1 + 0.983\ 963B$$

2.3 Result analysis of grey model By using original data and the prediction method of grey model in "1.2.2", we conduct matrix calculation, so as to get development grey number $a = -0.123\ 312$, endogenous control grey number $\mu = 379.080\ 8$, thus we get the prediction model as follows:

$$X^{(1)}(k+1) = 3\ 283.96 e^{0.123\ 312k} - 3\ 074.16$$

2.4 Result analysis of quadratic polynomial model The model result is obtained, according to the quadratic-polynomial prediction method.

Table 4 Results of quadratic-polynomial prediction model

Variable	Coefficient	Standard deviation	T statistic	P value
Constant term	1 115.461	264.573 3	4.216 075	0.000 21
t	-275.045	35.877 35	-7.666 26	1.5E-08
t^2	18.517 81	1.023 675	18.089 53	1.1E-17

F statistic of the model is 992.869 8, Prob(F -statistic) is 0.00, smaller than 0.05, so it rejects null hypothesis, namely that the model is significant. In addition, P value of significance test of all coefficients is smaller than 0.05, passing significance test. The adjusted of model is 0.971 825, close to 1, indicating that the fitting effect of this model is good. So we establish quadratic polynomial model as follows:

$$y = 1\ 115.461 - 275.045x + 18.517\ 81x^2$$

2.5 Prediction results and accuracy comparison Generally, the trend model is the modeling and immobilization of phe-

nomenon. One of shortcomings of the trend model is that it cannot change along with the change of phenomenon. This raises a question: whether the trend described by the model can be identical with the future development trend, because the model is fixed but the phenomenon is always changing. One consideration is that we conduct analysis on the future probable manifestation of the model after establishing model. This kind of analysis can be carried out from many aspects, and here we use the analysis method of recent data. The so-called recent data refers to the sample data close to the prediction period. If the sequence fitted and generated by the model meshes with the recent sample data, there is great probability that the model is identical with the actual change of the sequence in the future. Table 5 is the table of prediction results and accuracy comparison of three prediction models on the basis of recent data.

Table 5 Prediction results and accuracy comparison of three prediction models

Year	Actual value	ARIMA model	Grey model	Quadratic polynomial model
2006	8 172.5	7 870.007 85	8 312.74	8 530.14
2007	9 646.2	8 901.357 38	9 403.69	9 884.68
2008	11 020.2	9 846.793 14	10 637.80	11 276.26
2009	12 022.0	10 784.929 55	12 033.87	12 204.87
2010	13 190.0	11 795.218 29	13 613.17	131 70.52

Note: MAPE of ARIMA model, grey model and quadratic polynomial model is 8.58%, 2.20% and 2.16% respectively.

From Table 5 Prediction results and accuracy comparison of three prediction models, we know that amid three prediction models, namely ARIMA model, grey model and quadratic polynomial model, the mean absolute percentage error (MAPE) of quadratic polynomial prediction model is lowest, with 2.16%, that is, the prediction accuracy of quadratic polynomial prediction model is highest amid ARIMA model, grey model and quadratic-polynomial model. That the prediction accuracy of quadratic polynomial prediction model is better than the prediction accuracy of ARIMA model and the prediction accuracy of grey model is judged by combining qualitative analysis and quantitative analysis. Therefore, this paper finally adopts quadratic polynomial model to conduct another prediction on the future trend of income gap between urban and rural residents in China.

We get the prediction value of income gap between urban and rural residents in China from 2011 to 2013 as follows: the prediction value of income gap between urban and rural residents in China in the year 2011 is 14 173.2; the prediction value of income gap between urban and rural residents in China in the year 2012 is 15 212.92; the prediction value of income gap between urban and rural residents in China in the year 2013 is 16 289.67.

3 Conclusion and countermeasures

3.1 Conclusion The investment and financing system and financial system impacted by China's non-agricultural conversion make the distribution of urban public resources and rural public resources irrational, which thus fundamentally determines the growing income gap between urban residents and rural residents in China. However, with the coming of economic transition period and social transition period, we should not

keep away from the actual situation that income distribution gap between urban residents and rural residents in China is increasingly widening. We should spare no efforts to pay attention to and analyze the specific income gap between urban residents and rural residents in China and the cause of formation of the income gap between urban residents and rural residents in China, understand correctly the major contradictions we are faced by, and formulate effective and pertinent policies and measures. These are of great significance to bridging income gap between urban residents and rural residents in China. We have to find optimal balance point between fairness and efficiency. That is to say, we should vigorously develop economy in order to unremittingly enhance the overall national strength, and in the mean time, we should pay close attention to fairness in the redistribution chains, in order to bridge income gap between urban residents and rural residents in China. By using the data concerning China's urban-rural residents' income gap from 1978 to 2010, conducting empirical analysis on income gap between urban residents and rural residents in China, and conducting accuracy comparison of ARIMA prediction model, grey prediction model and quadratic polynomial prediction model, it is not difficult for use to find that amid ARIMA prediction model, grey prediction model and quadratic polynomial prediction model which are used to predict income gap between urban and rural residents in China, the prediction accuracy of quadratic polynomial prediction model is highest. By using quadratic polynomial prediction model, we conduct prediction on the income gap between urban and rural residents in China in the future, in order to provide scientific basis for government departments' decision making, which will have significant value of reference for government.

3.2 Countermeasures On the basis of the aforesaid analysis, in order to bridge income distribution gap between urban residents and rural residents in China, promote fairness and efficiency and construct harmonious socialist society, corresponding countermeasures are put forward to provide scientific basis for energy planning and policy formulation as follows: first, strengthen government's function of public service, coordinate resources, and strive to provide an equal opportunity of development for social members, so as to promote people's welfare and promote social equality; second, breach industrial monopoly and bridge income gap between employees in monopoly industry and general industry; last but not the least, support, encourage and call for government to establish social relief fund, adjust residents' income distribution from the non-governmental perspective, and endeavor to promote the income level of low-income class.

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including spatial layout, industrial development, infrastructure construction, social undertakings development, employment and social security and ecological environment construction, will be completed. On the basis of the primary formation of developmental layout of regional urban-rural economic integration of Jiuquan City and Jiayuguan City, the urban-rural integrated infrastructure, industrialization of rural economy, urbanization of social management, and equalization of public services are realized basically^[6].

The first stage ranges from 2010 to 2011. On the first stage, the urban-rural integration development of core area (central cities in Suzhou District – Jiayuguan) should be further promoted. The overall urbanization level should achieve 70% or above (so far, the urbanization rate is 69.5%), the urban-rural integration process is promoted by urban civilization. The average net income of farmers should come to more than 7 000 yuan. The disparity coefficient of urban and rural residents' income has increased from 44% and 46% in 2008 to 46%. The nearby rural infrastructure construction and ecological environment should be further improved to let every villages get access to TV, broadcast, telecommunication and roads and materialize the perfect equipment of rural education, culture, hygiene and information network.

The second stage ranges from 2012 to 2015. In the stage, the urban-rural integration of central cities in Suzhou District – Jiayuguan City should be basically completed and each index should attain the evaluation standard of complete stage. At the same time, other two cities and four counties of Jiuquan City should be motivated to achieve the standard of later transitional stage from urban-rural dual structure to urban-rural integration.

The third stage ranges from 2015 to 2020. The development of Jiuquan City and Jiayuguan City should complete urban-rural integration to achieve the demand of "productive development, rich life, civilized village, clean village appearance and domestic management" to realize the overall development of rural economic construction, rural political construction, rural cultural construction and the overall ecological civilization development of rural social construction.

3.2 Major working highlights

3.2.1 Coordinating the construction of infrastructure. Coordinating urban-rural development of Jiuquan City and Jiayuguan City and accelerating urban-rural integration should adopt forceful measures and increase input to coordinate the integration construction of urban-rural infrastructure and public service according to the principals of urban-rural mutual construction, urban-rural network and urban-rural share of infrastructure con-

struction in the two cities. Through expanding urban and township infrastructure equipments to rural areas, rural areas will be covered in public services and the smooth flow of urban-rural elements should be ensured.

3.2.2 Promoting rural economic industrialization. The government should coordinate urban-rural integration development and take the development of distinctive agriculture as the breakthrough point and optimizing structure, improving quality, widening fields and increasing employment as targets to realize the concentration from industry to industrial park, from villages to central villages, from land to scale operation and from urban residents' leisure tourism to rural area. The intensity on taking industry to motivate agriculture and city to motivate village should be increased to materialize the agricultural scale production, intensive operation and try to improve the added value of agricultural and sideline production to form the industrial structure of distinctive agricultural of "one town, one industry, several villages, one brand".

3.2.3 Promoting the urbanization of social management. The government should intensify the agricultural supporting intensity on education, culture and hygiene and gradually establish the rural service mechanism led by urban resources. The employment service system should be unified and rural social security system should be perfected to accelerate urbanization of rural social management and realize the harmonious development of urban-rural social undertakings.

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