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Research on the mathematics model and its application on housing price problem

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ABSTRACT

The housing price is closely linked to national economy and people's livelihood, it also has a significant impact on the national economic development and social stability. As the housing price is increasing constantly, this problem has become a focus issue that draws public attention. This article will predict the house price and its rationality in the next few years. The question we are discussing can boil down to a binary linear regression problem. Per capita disposable income and building costs are two main factors that affect the housing price. Here we take Beijing, Anhui and Ningxia as research objects. By using data from China Statistical Yearbook which are attested to be normally distributed, we get the linear regression equations. In equations, local average house price is used as dependent variable, and the household disposable income and costs of construction are independent variables. Equation of average house price in Beijing: $y_1 = -8114.517 + 1.004x_{11}$. Equation of average house price in Anhui: $y_2 = 265.941 - 0.025x_{12} + 0.001x_{22}$. Equation of average house price in Ningxia: $y_3 = -2826.025 - 0.203x_{13} + 0.013x_{23}$. To predict house price in the next few years, we need to firstly identify per capita disposable income and building costs. Per capita disposable income has strict linear relationship with year. While linear relationship between building costs and year is unconspicuous with little data. In order to improve the accuracy of the prediction, we can use grey forecasting to predict building costs in the futur. We can make a judgment at the rationality of house price based on the Housing Price-to-Income Ratio of the 3 areas. It shows that house price in Beijing is quite unreasonable as it is beyond local people's burden level. As for Anhui and Ningxia, house price is also too high to be reasonable.

KEYWORDS

Normal distribution; Binary linear regression; Grey prediction; Housing-price-to-income ratio.

BACKGROUND

The house price is closely linked to national economy and people's livelihood, it also has a significant impact on the national economic development and social stability and is always drawing government's attention. Since the Chinese government cancelled the welfare housing distribution system, as house price surges day by day, house price problem has become a focus issue. Opinions on some key problems such as rationality of house price and the trends of future prices, have never reached a consensus.

To measure the rationality of house price, we use a data called Housing Price-to-Income Ratio. Housing Price-to-Income Ratio means the ratio of house price to yearly household income of urban residents. Generally, the data range of a reasonable Housing Price-to-Income ratio is 4-6. House price is regarded as high if the ratio calculated is higher than this range. Then there may be real estate bubble. The higher it is than the normal range, the more likely bubble comes into being, and the lager bubbles may grow[1].

Price of house = housing area × average selling price per unit area of house.

annual income of each household = average family population × annual per capital income of this family.

ESTABLISHMENT OF MODEL

MODEL 1

Firstly, search for data relevant to average house price, per capita disposable income and building costs for the recent 6 years of these 3 areas.

TABLE 1 : Relevant data of Beijing (2005-2010)

Year	Average price/yuan	HouseholdDisposable Income/yuan	Building costs/yuan
2005	6788	17652.95	7820466
2006	8280	19977.52	7592448
2007	11553	21988.71	8356115
2008	12418	26738.48	11019346
2009	13799	24724.89	12274686
2010	17782	29072.93	16432274

First, we test the normal distribution of data above:

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Household disposable income	.125	6	.200*	.979	6	.948

a. Lilliefors Significance Correction; *. This is a lower bound of the true significance.

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Building cost	.242	6	.200*	.874	6	.243

a. Lilliefors Significance Correction; *. This is a lower bound of the true significance.

From the table we can see the dependent variable data follows normal distribution. So we can make linear regression analysis on it. Household disposable income has some linearities with average house price, here we use SPSS to make a binary linear regression analysis,[2] then get the function after fitting data.

$$y_1 = -8114.517 + 1.004x_{11}$$

This function shows house price in Beijing is only strongly linked to household disposable income, while it has noting to do with building costs.

TABLE 2 : Relevant data of Anhui (2005-2010)

Year	Average price/yuan	Household Disposable Income/yuan	Building costs/ yuan
2005	2220	8470.68	2133943
2006	2320	9771.05	2658399
2007	2598.33	11473.68	2858245
2008	2948.27	14085.74	3246077
2009	3400.14	12990.35	3650267
2010	4211.74	15788.17	4608657

Data above, which has been tested, follows normal distribution. Use SPSS to make a binary linear regression analysis, then we get the function after fitting data.

$$y_2 = 265.941 - 0.025x_{12} + 0.001x_{22}$$

This data also follows normal distribution. We can also get the function after fitting data above:

$$y_3 = -2826.025 - 0.203x_{13} + 0.013x_{23}$$

TABLE 3 : Relevant data of Ningxia (2005-2010)

Year	Average price/yuan	Household Disposable Income/yuan	Building costs/ yuan
2005	2235.38	8093.64	492574
2006	2063.054	9177.26	527334
2007	2136.19	10859.33	552398
2008	2435.35	12931.53	598830
2009	3090.44	14024.70	653192
2010	3303.70	15344.49	705139

MODEL 2

We use year as dependent variable, per capita disposable income as independent variable, after fitting the data of TABLE 1,2 and 3 we get functions to make predictions.

Regression equation of Beijing:

$$x_{11} = -4572035.388 + 2289.113t$$

Regression equation of Anhui province:

$$x_{12} = -2790224.883 + 1395.926t$$

Regression equation of Ningxia:

$$x_{13} = -3020663.102 + 1510.536t$$

We can make predictions through the model established above. Here are the predicted values.

Region Area Year	Beijing City	Anhui Province	Ningxia Autonomous Region
2012	33659.968	18378.229	18535.33
2013	35949.081	19774.155	20045.866
2014	38238.196	21170.081	21556.402

MODEL 3

As building linear relationship between building costs and year is unconspicuous with little data. we use grey forecasting to predict building costs in the future.

Use MATLAB[3] to process raw data of building costs of Beijing in the period 2005-2010, then we get the GM (1,1) model as follows:

$$x^{(0)}{}_{21}(k+1) = 3187417\left[e^{0.201k} - e^{0.201(k+1)}\right]$$

Analysis:

Year	Actual data	Analog data	Relative error/%
2006	7592448	7096000	6.5329
2007	8356115	8677000	308356
2008	11019346	10609000	3.7270
2009	12274686	12971000	5.6719
2010	16432274	15859000	3.4878

Use MATLAB to process raw data of building costs of Anhui Province in the period 2005-2010, then get the GM (1,1) model as follows:

$$x_{22}{}^{(0)}(k+1) = 14262093.7\left[e^{0.1433k} - e^{0.1433(k-1)}\right]$$

Year	Actual data	Analog data	Relative error/%
2006	2658399	2493000	6.2075
2007	2858245	2878000	0.6789
2008	3246077	3321000	2.3125
2009	3650267	3833000	5.0056
2010	4608657	4424000	4.0131

Analysis:

Use MATLAB to process raw data of building costs of Ningxia in the period 2005-2010, then get the GM (1,1) model as follows:

$$x_{23}^{(0)}(k+1) = 6587033.1\left[e^{0.0758k} - e^{0.0758(k-1)}\right]$$

Analysis:

year	Actual data	Analog data	Relative error/%
2006	527334	518700	106438
2007	552398	559500	1.2824
2008	598830	603500	0.7818
2009	653192	651000	0.3352
2010	705139	702200	0.4122

Comparing the tables above we can see that this model has high accuracy, so the prediction on the 3 areas' building costs for the next few years also has certain accuracy.
Predicted values:

Year Region Area	Beijing City	Anhui Province	Ningxia Autonomous Region
2012	23708000	5892000	817100
2013	28987000	6800000	881400
2014	35442000	7848000	950800

Average house price of the 3 areas for the years to come:

Year Region Area	Beijing City	Anhui Province	Ningxia Autonomous Region
2012	25680.0909	5698.485	4646.881
2013	27978.3603	6571.556	5176.142
2014	30276.6318	7584.689	5771.703

Now we evaluate the rationality of house price. It can be estimated through housing-price-to-income ratio. Housing Price-to-Income Ratio means the ratio of house price to yearly household income of urban residents. Generally, the data range of a reasonable Housing Price-to-Income ratio is 4-6. House price is regarded as high if the ratio calculated is higher than this range.
Based on house price predicted in the year 2012-2014, we figure out the ratio as follows:

	Year	Housing-price-to-income ratio	Rationality
Beijing	2012	25	Highly unreasonable
	2013	26	Highly unreasonable
	2014	26	Highly unreasonable
Anhui Province	2012	10	Unreasonable, a bit higher
	2013	11	Unreasonable, a bit higher
	2014	12	Unreasonable, a bit higher
Ningxia	2012	8	Unreasonable, a bit higher
	2013	9	Unreasonable, a bit higher
	2014	9	Unreasonable, a bit higher

EVALUATION OF MODEL

This model is easy to understand and can accurately predict house price of the 3 areas for a short period. Grey prediction is widely used in industrial, agricultural and economic fields and also has broad applications in environment, society and military. In this model only a few data are required and it has a high computational accuracy with low error. In the evaluation on rationality of house price, we use Housing Price-to-Income Ratio to make judgment intuitively and reasonably.

SYMBOLIC ACCOUNT

y_1 : average house price in Beijing

y_2 : average house price in Anhui

y_3 : average house price in Ningxia

x_{11} : average household disposable income in Beijing.

x_{12} : average household disposable income in Anhui.

x_{13} : average household disposable income in Ningxia.

x_{22} : building costs in Anhui.

x_{23} : building costs in Ningxia.

t : years.

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