
Forecasting real estate index using grey forecasting: an application in Turkey

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Keywords

Grey Prediction, Grey Rolling, Real Estate Forecasting, Time Series

Abstract

Real Estates have always been a subject of investment decisions and thus literature provides various studies about house price and index forecasting studies. In this study a time series approach is applied using grey forecasting method to predict the real estate price index (REPI) of Turkey. Grey prediction with rolling mechanism (GPRM) models with different parameters are developed and compared with classical moving average and multiple regression models. The forecasting accuracy of the alternative models is compared using Mean Absolute Percentage Error (MAPE) and Normalized Root Mean Squared Error (NRMSE). The results show that GPRM model with $n=4$ outperform the other models.

Introduction

This study considers the dynamics of the Turkey's Real Estate Price Index (REPI) and the ability of grey prediction with rolling mechanism model (GPRM) and different models to forecast this index. The main focus, however, compares the relative effectiveness of the GPRM with various parameters and other models, including moving average and multiple regression models. The literature provides various forecasting studies about real estate prices. Brown et al. (1997) propose a model for UK housing prices using Time Varying Coefficient methodology and the results show that the model outperform the other three constant parameter regressions.

Pain and Westaway (1997) propose a new model for house prices in the UK using. The model incorporates consumers' expenditure as a determinant of housing demand rather than an output of the demand. Statistical comparisons with the more conventional models during the early 1990s provide additional evidence in favor of the proposed approach. Hannonen (2005) analyses spatio-temporal variation of land prices in two single localities by means of structural time series modeling and the results show that the proposed model offers a more viable alternative to the hedonic analysis of land prices than the conventional approach. Yan et al. (2007) propose a house price forecasting model based on TEI@I approach using 114 indicators.

Hannonen (2008) compares four different models, namely ordinary least squares estimation, robust MM-estimation, structural time series estimation and robust local regression, based on their ability to forecast the land prices. The test results indicate that more accurate predictions are obtained if the unorthodox methods are used instead of the conventional least squares estimation. Selim (2009) builds two models using multiple regression and artificial neural network to forecast house prices in Turkey based on 2004 Household Budget Survey Data. Rapach and Strauss (2009) investigate forecasts of state-level real housing price growth for the

period of 1995–2006 and generate a benchmark for different models including autoregressive models and models based some selected economic variables.

Meen (2010) examine the price determination in housing markets. Using different types of forecasting model namely, simple rules, univariate approaches, vector auto regressions, and vector error correction models. Chang (2010) proposes a Markov switching GARCH model to explore house price dynamics for US market between 1975 and 2007 period. Gupta et al. (2010) examine the impact of monetary policy on real house price growth in South Africa using a factor augmented vector auto regression using a data set of a period from 1980 to 2006. The results show that house price inflation responds negatively to monetary policy shock.

Gupta et al (2011) propose dynamic structural general equilibrium models to forecast the US real house price index and compare the results with Bayesian and classical time-series models. Clark and Coggin (2011) investigated the house prices in United States between 1975 and 2005 with a detailed time series statistical analysis. The authors also examined the relationship between house prices and some selected fundamental economic variables with regression analysis. Bourassa et al. (2011) investigate house prices and land leverage that is calculated by measuring the ratio of land to total value, in Switzerland over the period 1978 to 2008. Azadeh et al. (2012), propose a hybrid algorithm based on fuzzy linear regression (FLR) and fuzzy cognitive map (FCM) to forecast housing market fluctuations. In order to enable the decision-makers to make decisions with imprecise data fuzzy approach is used. Zhang et al. (2012) propose the Nonlinear Auto Regressive Moving Average with exogenous inputs, to investigate determinants of housing prices in China over the period 1999 and 2010.

In this study different from the previous studies real estate price index will be predicted using grey rolling mechanism.

Methodology

Grey Forecasting

Grey forecasting is established by Julong Deng in 1982. The model focuses on the study of problems that comprise poor information and samples are formed small. Grey Theory requires little effort to achieve result. The steps of Grey Forecasting are explained below (Liu and Lin, 2006).

Grey forecasting is comprised of three operations. The first operation is Accumulated Generating Operator (AGO). Original time series data with n samples is shown as:

$$X^{(0)} = (X^{(0)}(1), X^{(0)}(2), \dots, X^{(0)}(n)) \quad (1)$$

AGO operator creates new time series sequence using the equation as below;

$$X^{(1)} = \sum_{i=1}^k X^{(0)}(i) \quad (2)$$

From Eq.(2), a droningly serie, $X^{(1)} = (X^{(1)}(1), X^{(1)}(2), \dots, X^{(1)}(n))$, is obtained. The second operation is creating the Grey Model (1,1) by a first order grey differential equation.

$$X^{(0)}(k) + az^{(1)}(k) = b, \quad (3)$$

In this Eq.3, a , b and $z^{(1)}(k)$ are presented as follows;

$$\begin{bmatrix} a \\ b \end{bmatrix} = [B^T B]^{-1} B^T Y \quad (4)$$

Where

$$B = \begin{bmatrix} -z^{(1)}(2)1 \\ -z^{(1)}(2)1 \\ \dots \dots 1 \\ -z^{(1)}(2)1 \end{bmatrix}, \quad Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \dots \dots \\ z^{(1)}(2) \end{bmatrix}$$

and

$$z^{(1)}(k) = 0.5x^{(1)}(k) + 0.5x^{(1)}(k-1) \tag{5}$$

Here, a is named the development coefficient and b is named driving coefficient.

The last operation is Inverse Accumulating Operator performing. Grey forecasting equation (Eq.6) is obtained by grey differential equation.

$$\hat{x}^{(1)}(k+1) = \left[x^{(1)}(0) - \frac{b}{a} \right] e^{-ak} + \frac{b}{a} \tag{6}$$

Here, $\hat{x}^{(1)}(k+1)$ shows the forecasting of x at the time k+1. The initial condition is;

$$x^{(1)}(0) = x^{(0)}(1)$$

By applying the whole data in Grey Model (1,1), the forecasting is fulfilled.

Grey Prediction with Rolling Mechanism

Akay and Atak proposed an extended version of Grey forecasting and proposed Grey Forecasting Rolling Mechanism (GPRM) using electricity consumption data. In GPRM, $x^{(0)}(k+1)$ is forecasted by implementing Grey Model(1,1) to $X^{(0)} = (X^{(0)}(1), X^{(0)}(2), \dots, X^{(0)}(k))$ under rule $k < n$. In this method, the model finds first value. After that, the first data, $X^{(0)}(1)$ is removed from old series and a new entry $X^{(0)}(k+1)$ is added end of the series.

The forecasting accuracy of forecasting methods are determined using different indicators. Let A be the Actual value and F be the forecasted value the forecast error is calculated as

$$E_t = A_t - F_t$$

The aggregate error of a measurement method can be calculated using the following equations

$$\text{Mean Absolute Percentage Error (MAPE)} \quad MAPE = \frac{\sum_{t=1}^N \left| \frac{E_t}{A_t} \right|}{N} \tag{7}$$

$$\text{Normalized Root Mean Squared Error (NRMSE)} \quad NRMSE = \sqrt{\frac{\sum_{t=1}^N E_t^2}{\sum_{t=1}^N A_t^2}} \tag{8}$$

In Grey rolling, MAPE is designated as;

$$e(k) = \text{abs} \left(\frac{x^{(0)}(k) - \hat{x}^{(0)}(k)}{x^{(0)}(k)} \right) * 100\% \tag{9}$$

where $k < n$. Also, the Average Rolling Error of the model is

$$e = \frac{1}{n-4} \sum_{k=4}^{n-1} e(k+1) * 100\% \tag{10}$$

Application

The forecasting application contains the historical real estate index data. This index was initially developed in June 2007 with 100 as the first value. Later, based on the house prices demanded in the market was used to calculate the values of the following months.

Figure 1 represents the index values in the period of 2007 and 2013.

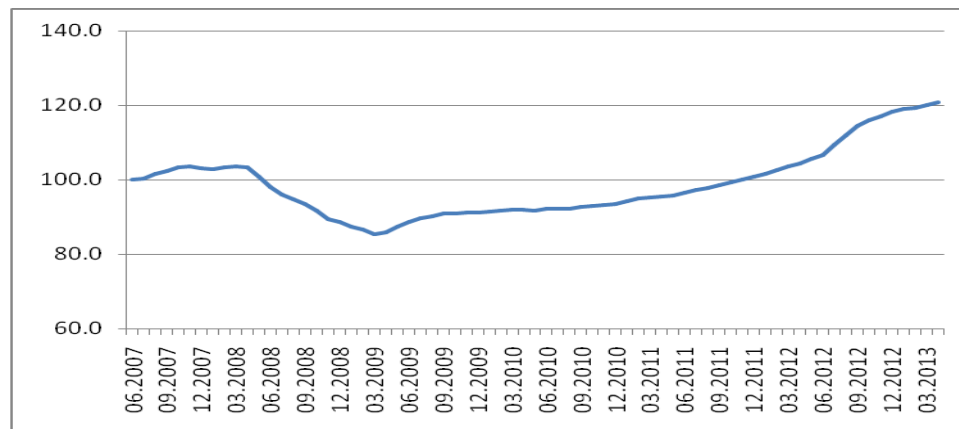


Figure 1: Real Estate Index Value (2007-2013)

The historical data is divided into 2 parts. First 55 months are evaluated as the training data to build forecasting models and the last 16 months are used as test data and the forecasting accuracy of the models are calculated. Basically three models are compared namely, grey prediction with rolling mechanism (GPRM), moving average and multiple regression. However, five different GPRM models are built using different parameter, $n=4,5,6,7,8$. As a basic model, moving average model is used with calculating the average for the last four months. In the final model, multiple regressions are used with a time series approach. In the model the index values of the last three months are behaved as independent variables and used to forecast the upcoming month's index value. The actual and predicted values of the alternative models are given in Table 1.

	Actual	Grey Rolling Predicted					Mov. Avg.	Mult. Reg.
		n=4	n=5	n=6	n=7	n=8		
Oca.12	101.7	101.6	101.6	101.6	101.5	101.4	99.6	101.3
Şub.12	102.5	102.5	102.5	102.5	102.4	102.3	100.4	102.1
Mar.12	103.5	103.4	103.4	103.3	103.3	103.3	101.2	102.9
Nis.12	104.3	104.4	104.3	104.3	104.3	104.3	102.1	104.0
May.12	105.5	105.3	105.3	105.2	105.2	105.2	103.0	104.7
Haz.12	106.7	106.5	106.4	106.4	106.3	106.3	104.0	106.1
Tem.12	109.3	107.9	107.8	107.7	107.6	107.5	105.0	107.4
Ağu.12	111.9	111.0	110.6	110.2	109.9	109.7	106.5	111.0
Eyl.12	114.5	114.6	113.9	113.4	112.9	112.5	108.4	113.5
Eki.12	116.0	117.2	117.2	116.7	116.2	115.6	110.6	116.0
Kas.12	117.1	118.2	118.7	118.9	118.7	118.3	112.9	116.4
Ara.12	118.3	118.5	119.2	119.7	120.2	120.1	114.9	117.2
Oca.13	119.1	119.5	119.6	120.2	120.8	121.3	116.5	118.5

Şub.13	119.3	120.2	120.3	120.5	121.1	121.7	117.6	119.0
Mar.13	120.1	119.9	120.3	120.5	120.8	121.4	118.4	118.5
Nis.13	120.9	120.5	120.6	120.9	121.1	121.4	119.2	120.0

Table 1: The actual and predicted values for the last 16 months

The performance of the forecasting models is calculated in terms of MAPE and NRMSE (Table 2). The results show that all Moving average shows the worst performance while GPRM model with $n=4$ outperform other models. GPRM ($n=5$) follows the leading model while Multiple regression model and GPRM($n=6$) takes the third place with nearly same forecasting performances.

	GR n=4	GR n=5	GR n=6	GR n=7	GR n=8	Mov. Avg.	Mult. Reg.
MAPE	0.0041	0.0054	0.0066	0.0079	0.0094	0.0281	0.0066
NRMSE	0.003%	0.005%	0.008%	0.011%	0.015%	0.095%	0.006%

Table 2: Forecasting performances of the alternative models.

Discussions and conclusions

Turkish Real estate index is developed in 2007 to show the trends in Turkish real estate market. This index is used by the different actors in the market for both investment and other managerial decisions. In this study, different forecasting models are used predict the index value and compared according to their performance. While GPRM model ($n=4$) outperformed other models, classical moving average model presented the worst performance. Thus, the results reveal that GPRM method is suitable model for REPI prediction.

In this study, the forecasting models are built with a time series approach, in other words it is assumed that the future value of the index can be forecasted by using the past index values. Thus in the future studies, advanced models that incorporate economical and global indicators can be used. Also computational intelligence techniques such as artificial neural networks, support vector machine and fuzzy prediction can be compared with the results of this study.

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