Housing Demand in Turkey: Application of Grey Forecasting Model

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Doi:10.5901/mjss.2016.v7n2p52

Abstract

One of the physiological needs of people is housing. The housing market is the market that meets this need and has a special place in the national economy. "Multiplier - accelerating" effect owned by housing sector, "economic - social" it includes and the experience of the global crisis in 2008 has made the sector the locomotive of economic development. Any movement formed in the housing sector identified as the driving force of economic growth also affects other sectors in a positive way. That being influenced of financial stability by housing sector both in direct and indirect way also took place among the reasons of global crisis in this sense and it is in a quality that may pose systemic risk require being monitored of supply demand indicators related to the system and making predictions for the future. In Turkey that is among the fastest growing economies in the world in recent years, housing sector showed quite strong performance. By making 1.165.381 house sales in Turkey in 2014 with an increase of 0.7% compared to the previous year, it was reached to the historical levels, while there was an increase of 173% in house sales between the years of 2008-2014. In this study, by using the house sales data in Turkey between the years of 2008-2014 in Turkey with Grey Forecasting model and Grey Verhulst model, it was made predictions for the future and these values were compared with actual data.

Keywords: *Housing sales, forecasting, grey system theory, grey forecasting, grey Verhulst model.*

1. Introduction

Housing production is one of the oldest producing fields in the history of mankind. Housing that is one of the most fundamental rights of people is not only a shelter but also a source of security for individuals and families in the community, an investment tool and a building block in the formation of living environment. Housing need of people is met by houses that are economic goods and it cannot be replaced with any other object. These features of housing that are different from the other goods affects the process of markets, so housing market is assumed to be different from the other markets.

Housing sector with the scope of labor intensive industries and with the structure which largely receives input from sub-industries and the related sub-sectors are among the most important dynamics of the national economies. Sector takes over the duty of leverage mostly with the value added it creates and the structure that keeps the economy vibrant, the feature of stimulating more than two hundred sub-sectors.

The requirement of close monitoring the developments of housing markets having dynamic features due to its structure and which have a strong relationship with economic activity has come to the agenda with the last global crisis experienced. Housing market containing systemic risks is affected directly by the macro and micro economic conditions, and has become one of the sectors feeling the changes to occur in the relevant conditions. Following closely the supply and demand indicators in housing market requiring a longer assessment period compared to the other sectors in terms of making both production and consumption decision is one of the most important subjects. Making predictions in order to make a proper analysis for "sensitivity" and "trends" in terms of supply and demand are predictions for the future to make a proper analysis becomes necessary for a sector in which such dynamics and movement will create a domino effect in the economies.

One of the sectors contributing to economic growth in Turkey that is one of the world’s fastest-growing economies in recent years is undoubtedly the housing sector. Although the great earthquake disaster occurred in 1999 in Turkey and then the economic crisis experienced in 2000 -2001 years caused postponement in housing demand, it is seen that the sector has slumped into a major process of change since 2005 with structural reforms and transmission programs. But in

2008, the global financial crisis that took the whole world under the influence and resulted from the housing loans in the US (mortgage) caused a significant contraction in the housing sector and increases the sensitivity on these sectors. With the experience of global crisis, while a decline was being experienced in demand for housing in Turkey in 2008 and 2009, housing demand has pursued a balanced growth in demand since 2010. While it was being reached to the historical levels with 1.165.381 house sales with an increase of 0.7% compared to the previous year in Turkey, an increase of 173% in house sales was observed between the years of 2008-2014.

The purpose of this study is to make predictions by using house sales data in ten provinces where house sales occurred most intensively and in all provinces in Turkey between 2008-2014 with Grey forecasting model (GM) and Grey Verhulst Model (GVM) and indicating whether these predictions are reliable models or not by comparing these predictions with the values occurred and in this context, it is the realization of house sales forecasts covering the years of 2015-2018. Grey System Theory was developed as an alternative theory for the quantification of the uncertainty in the early 1980s by Deng Ji-Long. The basic idea of the emergence of the theory is to predict the behaviors of uncertain systems that cannot be overcome with stochastic or fuzzy models with the help of a limited number of data. Grey forecast is an alternative prediction model in order to make forward predictions in weak data sets that are not complex, chaotic and imprecise. The model is different from the other prediction models with requiring a small number of data and high forecasting reliability and it is more useful compared to intuitive models such as artificial intelligence and fuzzy logic.

Grey forecasting model (GM) has been successfully applied over the last thirty years from the first day it raised until now in many sectors especially social, economic and industrial systems. In scientific literature about the model, it is seen to be applied in many sectors. Hsu (2003) indicated in his study comparing grey forecasting model to conventional models that grey model gave better results for the short-term forecasts in demand forecast for integrated circuit systems. In their study, Yao et al. (2003) developed a grey-based adaptive forecasting model for forecasting the electricity demand for very short terms. As a result, in businesses consuming high energy, they obtained a result protecting transaction costs. Akay and Atak (2007) indicated in their study in which they used electricity demand data in Turkey between 1970 - 2004 how healthy forecasts were made in the field of energy by the model. Kung and Chang (2003) made forecasts about sales by using the data between 1995 - 2001 in their study where they used grey forecasting model for China automotive industry. Kayacan et al. (2010) analyzed Euro and Dollar parity to cover the years 2005-2007 with grey-based system. Askari and Askari (2011) indicated in their study where they used grey forecasting model to estimate gold prices that the model gave successful results. In his study where he used the sales figures of a drug company, Wang (2007) made estimations by using grey forecasting model as well as grey Verhulst model and he compared the results of both models. In their study, Wang et al. (2007) developed a new model for grey Verhulst model and applied this model on traffic in the port motorway. In their study where they used phone subscription types and numbers as data, Kordnoori et al (2014) made estimations by using grey forecasting model, grey Verhulst model and grey Markov model of estimates in the study used the results in the comparison of the models they used. With a different study conducted by Wang et al. (2012), grey forecasting system has been proposed constituting early warning of food security. When it is examined in terms of scientific literature, it is possible to examine the studies done in the theory of grey system under six main headings as grey production, grey relational analysis, grey modeling, grey forecast, grey decision-making and grey control.

In this study, house sales data until 2018 in Turkey was estimated by using house sales data in all provinces in Turkey between 2008-2014 and in ten provinces where house sales took place most intensively with the grey forecasting model (GM). In the continuation of the study, grey forecasting model is described in detail in Chapter 2. In the 3rd section of the study, grey Verhulst (GVM) and new grey Verhulst (NGVM) of the estimation models within grey system theory have been examined. In the 4th part of the study, the data between 2008 – 2014 were estimated with GM, GVM and NGVM models and the relative errors was calculated and comparisons among the models were made by testing their reliability. In the 5th and last section of the study, the results obtained were evaluated and it was focused on the work to be developed prospectively.

2. Grey Forecasting Model (GM)

The grey system theory developed by Deng Ji-Long in the early 1980s as an interdisciplinary approach, focuses on uncertain, inadequate and incomplete data sets to analyze and understand the systems through condition analysis, forecasting and decision-making. Here, light colors refer to clarity and dark colors refer to the uncertainty. While black is expressing to have no knowledge about system characteristics and parameter, white means to access all the information about the system. Between black and white "grey", expressed as color indicate completely unspecified systems. Also in real life, it is made decisions under inadequate and incomplete information assumptions called as the main features of

GM. GM uses this part of grey system theory that is a basis.

Probability and statistics, fuzzy mathematics and grey system theory are the most common models used in studies for non-deterministic system. Different from the other two different theories, grey system theory was developed to find solution to the problems having small sample size and where poor information is located. The following table shows the differences between the three theories as summary.

Table 1. The comparison of the models that are not deterministic

	Grey System Theory	**Probability & Statistics**	**Fuzzy Mathematics**
Objects of Study	Poor information Uncertainty	Stochastic Uncertainty	Cognitive Uncertainty
Basic Sets	Grey hazy sets	Cantor sets	Fuzzy sets
Methods	Information coverage	Probability distribution	Function of affiliation
Procedure	Grey series generation	Frequency distribution	Mariginal sample
Requirement	Any distribution	Typical distribution	Experience
Objective	Laws of reality	Laws of statistics	Cognitive expression
Characteristics	Small samples	Large samples	Experience

On the other hand, the basic features of grey forecasting model that is one of the main field of occupation differ from traditional forecasting models is the requirement of the limited number of data in order to predict the behaviors of the uncertain system. Traditional forecasting models such as time series need large amount of past period data and known statistical distribution.

On the contrary to the traditional forecasting models, the basic feature of grey forecasting model is that it does not require strict assumptions about data set and it can be applied successfully in the analysis of the systems having limited data. The following table shows the comparison of traditional forecasting models.

Table 2. The comparison of traditional forecasting methods

Forecasting Method	**Required Min. Observation Number**	**Sample Type**	**Sample Range**	**Mathematical Necessity**
Simple Involutory Functions	5-10	Range	Short	Basic
Regression Analysis	10-20	Trend	Short	Middle
Random Regression	10	Any	Long	Developed
Grey Forecasting Model	4	Range	Long	Basic

GM uses a cumulative model to create differential equations and requires little data. GM (1,1) that is first-degree univariate model used commonly in literature within the scope of the study was used; GM (1,1) is a time-series having varying coefficients in time and hosting a group of differentiable equality. GM (1,1) is defined as follows.

Assume that $x^{(0)}$ Original time series with n sample number.

$$x^{(0)} = (x^{0}(1), x^{(0)}(2), x^{(0)}(3), \dots, x^{(0)}(n)) \tag{1}$$

Accumulated generating operator (AGO) turns $x^{(0)}$ series continuing as chaotic increasing monotonously into following $x^{(1)}$ series.

$$x^{(1)} = (x^{(1)}(1), x^{(1)}(2), x^{(1)}(3), \dots, x^{(1)}(n))$$

$$x^{(1)} = \left(\sum_{k=1}^{1} x^{(0)}(k), \sum_{k=1}^{2} x^{(0)}(k), \dots, \sum_{k=1}^{n} x^{(0)}(k)\right) \tag{2}$$

In order to reshape GM (1,1) and calculate coefficients, first degree grey differential equality is applied by using $x^{(0)}$ and $x^{(1)}$ series.

$$x^{(0)}(k) + az^{(1)}(k) = b, \qquad k = 2,3,\dots,n \tag{3}$$

Forming state for GM (1,1) is obtained as follows.

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

In equity (3), k; is described as time points, a; is as development coefficient and b; is as drive coefficient.

The least squares method over equity (2) and (3) is used and $\hat{a}$ coefficient is obtained.

$$\hat{a} = \begin{bmatrix} a \\ b \end{bmatrix} = (B^T B)^{-1} B^T Y_N \tag{4}$$

$$B = \begin{bmatrix} -z_1^{(1)}(2) & 1 \\ -z_1^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z_1^{(1)}(n) & 1 \end{bmatrix} \text{ and } Y_N = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix} \quad (5)$$

In order to find the solution of $x^{(1)}$ in equity (3), the following differential equity is used.

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = b \quad (6)$$

According to the predicted a and b coefficient, with placing $\hat{a}$ coefficient in equity (5), is obtained with GM as a result of first degree differentiable equity that is solved.

$$\hat{x}^{(1)}(k+1) = \left[x^{(0)}(1) - \frac{b}{a}\right] e^{-ak} + \frac{b}{a} \quad (7)$$

So, $\hat{x}(k)$ indicates the prediction at k time point of x and it is $x^{(1)}(1) = x^{(0)}(1)$. $\hat{x}^{(0)}(k)$ is obtained by Inverse – Accumulated generating operator (IAGO) on $\hat{x}^{(1)}(k+1)$.

$$\hat{x}^{(0)}(k) = \hat{x}^{(1)}(k) - \hat{x}^{(1)}(k-1)$$

$$\hat{x}^{(0)}(k) = \left[x^{(0)}(1) - \frac{b}{a}\right] e^{-a(k-1)}(1 - e^{a}) \quad (8)$$

In GM (1,1), all data set is used to make forecast. In case of having chaotic data using the data of recent period is suggested for increasing the forecasting accuracy. In GM $x^{(0)}(k+1)$, as far as k<n in GM(1,1) forecast is made by applying to $x^{(0)} = (x^{(0)}(1), x^{(0)}(2), \dots, x^{(0)}(k))$ data. After result is found $x^{(0)}(k+1)$ is added to the end of data and at the same time oldest data is removed from data set and operation is repeated. Forecast value of the next period $x^{(0)} = (x^{(0)}(2), x^{(0)}(3), \dots, x^{(0)}(k+1))$ is used to forecast $x^{(0)}(k+2)$ value.

In order to measure the efficiency of GM (1,1), mean absolute percentage error (MAPE) values are calculated by comparing the realized and forecasted values.

$$e(k) = \left|\frac{x^{(0)}(k) - \hat{x}^{(0)}(k)}{x^{(0)}(k)}\right| 100\%, \quad k = 2,3, \dots, n \quad (9)$$

The efficiency of MAPE values, expressing the average of sum of absolute values of percentage errors, in forecasts obtained by GM (1,1) are shown in below table.

Table 3. Comparison of MAPE value efficiencies in forecasts

MAPE (%)	Forecast power
>50	Weak and inaccurate forecasting
20-50	Reasonable forecasting
10-20	Good forecasting
<10	Highly accurate forecasting

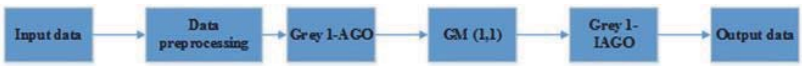

Figure 1. The forecast system based on GM (1,1)

3. Grey Verhulst Model (GVM)

Verhulst model was initially proposed by German mathematician – biologist Pierre Francois Verhulst in 1837. The main aim of the model is to limit all development for a real system. This non-linear model are effective in defining many increasing processes having saturation region or such as S shaped curve. GVM which is handled as a forecast model within grey system theory, anticipates that original data and raw data should be in S shaped curve form in order not to obtain weak forecast results. GVM is defined as below.

Let n be sample quantity and $x^{(0)}$ be original time series

$$x^{(0)} = (x^{0}(1), x^{(0)}(2), x^{(0)}(3), \dots, x^{(0)}(n))$$

Let n be sample quantity and $x^{(1)}$ be raw time series

$$x^{(1)} = (x^{(1)}(1), x^{(1)}(2), x^{(1)}(3), \dots, x^{(1)}(n))$$

Accumulated generating operator (AGO), converts chaotically continuing $x^{(0)}$ series to the monotonously increasing $z^{(1)}$ series below.

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), \; k = 1,2, \dots, n \quad (10)$$

$$z^{(1)} = (z^{(1)}(1), z^{(1)}(2), z^{(1)}(3), \dots, z^{(1)}(n)) \quad (11)$$

The series belonging to the consecutive neighbours of $x^{(1)}$ series and configurated form is obtained as below.

$$z^{(1)}(k) = \frac{1}{2}\left(x^{(1)}(k) + x^{(1)}(k-1)\right), \quad k = 2,3, \dots, n \quad (12)$$

In order to find the solution of $x^{(1)}$ below differential equation is used.

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = b(x^{(1)})^2 \quad (13)$$

$$x^{(0)}(k) + az^{(1)}(k) = b(z^{(1)}(k))^a \quad (14)$$

In equation (13) similar to GM (1,1), k is defined as time dots, a is defined as development coefficient and b is defined as driver coefficient. Through equation (10) and (13) $\hat{a}$ coefficient is obtained by using least squares method similar to GM (1,1).

$$\hat{a} = \begin{bmatrix} a \\ b \end{bmatrix} = (B^T B)^{-1} B^T Y_N$$

$$B = \begin{bmatrix} -z_1^{(1)}(2) & (z^{(1)}(2))^2 \\ -z_1^{(1)}(3) & (z^{(1)}(3))^2 \\ \vdots & \vdots \\ -z_1^{(1)}(n) & (z^{(1)}(n))^2 \end{bmatrix} \text{ and } Y_N = \begin{bmatrix} x^{(1)}(2) \\ x^{(1)}(3) \\ \vdots \\ x^{(1)}(n) \end{bmatrix} \quad (15)$$

As a result of solution of $x^{(1)}(t)$ for k time, GVM is obtained.

$$\hat{x}^{(1)}(k+1) = \frac{ax^{(0)}(1)}{bx^{(0)}(1) + (a - bx^{(0)}(1))e^{ak}} \quad (16)$$

Mean absolute percentage error (MAPE) obtained as a result of GVM is calculated by the formula below.

$$\Delta_k = \frac{|\varepsilon^{(1)}(k)|}{x^{(1)}(k)}, \quad \varepsilon^{(1)}(k) = x^{(1)}(k) - \hat{x}^{(1)}(k) \quad (17)$$

As seen in equation (16) if $a < 0$, $lim_{k\to\infty} x^{(1)}(k) \to \frac{a}{b}$, and at the same time if $a > 0$ $lim_{k\to\infty} x^{(1)}(k) \to 0$. This expression means the saturation point in equation (16) where the value limiting the forecast value is $\frac{a}{b}$. This expression at the same time means that when "k" is great enough $x^{(1)}(k)$ and $x^{(1)}(k+1)$ values will be very close. Due to this property, GVM is widely used in definition and forecasting of processes with saturation region.

Although GVM was initially proposed for modeling a living creature population in a limited area but it is also widely used in forecasting statistical and econometric models. However as statistical and econometric modellings are made with big samples an increasing GVM in S shaped curve form and suggesting usage of small samples had to be developed. In line of this requirement Wang et al. developed a new model for grey Verhulst model in a study they performed in 2007 and named it as “New Grey Verhulst Model (NGVM)”. NGVM aims to use trapezoid formula instead of difference model and differential equations for forecasting $\hat{a}$ coefficient in order to increase the accuracy of forecast. NGVM is defined as follows.

Let n be sample quantity and $x^{(0)}$ be original time series

$$x^{(0)} = (x^0(1), x^{(0)}(2), x^{(0)}(3), \dots, x^{(0)}(n))$$

Let n be sample quantity and $x^{(1)}$ be raw time series

$$x^{(1)} = (x^{(1)}(1), x^{(1)}(2), x^{(1)}(3), \dots, x^{(1)}(n))$$

The stages in GVM (10) - (14) are followed similarly and $\hat{a}$ coefficient is obtained. However formulation is differentiated during obtaining stage of B matrix.

$$\hat{a} = \begin{bmatrix} a \\ b \end{bmatrix} = (B^T B)^{-1} B^T Y_N$$

$$B = \begin{bmatrix} -\frac{1}{2}[x^{(1)}(1) + x^{(1)}(2)] & \frac{1}{2}[(x^{(1)}(1))^2 + (x^{(1)}(2))^2] \\ -\frac{1}{2}[x^{(1)}(2) + x^{(1)}(3)] & \frac{1}{2}[(x^{(1)}(2))^2 + (x^{(1)}(3))^2] \\ \vdots & \vdots \\ -\frac{1}{2}[x^{(1)}(n-1) + x^{(1)}(n)] & \frac{1}{2}[(x^{(1)}(n-1))^2 + (x^{(1)}(n))^2] \end{bmatrix} \quad Y_N = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix} \quad (18)$$

Similar to GVM, NGVM is obtained as a result of solution of $x^{(1)}(t)$ for k time.

$$\hat{x}^{(1)}(k+1) = \frac{ax^{(1)}(0)}{bx^{(1)}(0) + (a - bx^{(1)}(0))e^{ak}} \quad (19)$$

As seen in equation (19) if $a < 0$, $lim_{k\to\infty} x^{(1)}(k) \to \frac{a}{b}$, and at the same time if $a > 0$ $\lim_{k\to\infty} x^{(1)}(k) \to 0$. This expression means the saturation point in equation (18) where the value limiting the forecast value is $\frac{a}{b}$. The flowchart summarizing the stages in GVM and NGVM are shown below.

Figure 2. The forecast system based on GVM and NGVM

4. Forecasting of Housing Demand in Turkey by GM, GVM and NGVM

The main aim of this study is to forecast the housing demand in Turkey by using GM, GVM and NGVM and compare the mentioned models. All data used under the scope of the study were provided by Turkish statistical institute (TUIK). In the study house sales data in ten provinces of Turkey where house sales activity is most intensive between 2008-2014 were used and in below tables the data between years 2008-2014 were forecasted by GM, GVM and NGVM in order to calculate the mean absolute percentage error (MAPE) values and comparisons between models were made by testing their reliabilities.

Table 4. Actual and forecasted house sales in GM (1,1) (2008-2014)

	Provinces	House Sales Amount								MAPE (%)
		Years	2008	2009	2010	2011	2012	2013	2014	
1	Ankara	Actual	87087	104285	106006	117908	106019	137773	131825	
		Forecasted	87087	101885	107590	113614	119975	126692	133786	5.022
		$e(k)$ (%)	0	2.301	1.494	3.642	13.163	8.043	1.487	
		$1-e(k)$ (%)	0	97.699	98.506	96.358	86.837	91.957	98.513	
2	İstanbul	Actual	103503	140573	153897	169015	167110	234789	225454	
		Forecasted	103503	137030	152343	169367	188293	209335	232728	5.080
		$e(k)$ (%)	0	2.520	1.010	0.208	12.676	10.841	3.226	
		$1-e(k)$ (%)	0	97.480	98.990	99.792	87.324	89.159	96.774	
3	İzmir	Actual	26627	34828	39702	44876	46429	72421	71779	
		Forecasted	26627	33086	38878	45684	53681	63080	74123	6.777
		$e(k)$ (%)	0	5.003	2.076	1.801	15.621	12.899	3.265	
		$1-e(k)$ (%)	0	94.997	97.924	98.199	84.379	87.101	96.735	
4	Bursa	Actual	10244	14879	19966	24092	24724	40894	42437	
		Forecasted	10244	15371	18965	23399	28869	35618	43945	7.403
		$e(k)$ (%)	0	3.309	5.014	2.878	16.765	12.902	3.553	
		$1-e(k)$ (%)	0	96.691	94.986	97.122	83.235	87.098	96.447	
5	Mersin	Actual	11216	13692	15141	18464	18447	32393	31204	
		Forecasted	11216	12634	15729	18477	22345	27022	32679	8.524
		$e(k)$ (%)	0	7.724	0.912	0.072	21.131	16.579	4.727	
		$1-e(k)$ (%)	0	92.276	99.088	99.928	78.869	83.421	95.273	
6	Antalya	Actual	24821	30602	31419	35451	34555	59478	62227	
		Forecasted	24821	25857	30785	36652	43637	51953	61855	10.074
		$e(k)$ (%)	0	15.506	2.019	3.387	26.283	12.651	0.598	
		$1-e(k)$ (%)	0	84.494	97.981	96.613	73.317	87.349	99.402	
7	Eskişehir	Actual	9928	11077	14006	17325	19422	21292	19921	
		Forecasted	9928	12990	14443	16059	17855	19852	22072	8.889
		$e(k)$ (%)	0	17.274	3.122	7.310	8.070	6.765	10.796	
		$1-e(k)$ (%)	0	82.726	96.878	92.690	91.930	93.235	89.204	
8	Kayseri	Actual	10615	13015	15873	19040	18581	27109	28375	
		Forecasted	10615	13228	15470	18091	21156	24741	28934	5.621
		$e(k)$ (%)	0	1.637	2.542	4.985	13.860	8.734	1.969	
		$1-e(k)$ (%)	0	98.363	97.458	95.015	86.140	91.266	98.031	
9	Konya	Actual	10102	13963	14434	16838	17491	27724	29385	
		Forecasted	10102	12121	14476	17287	20645	24654	29442	7.574
		$e(k)$ (%)	0	13.189	0.289	2.667	18.030	11.073	0.196	
		$1-e(k)$ (%)	0	86.811	99.711	97.333	81.970	88.927	99.804	
10	Adana	Actual	9981	13057	14084	17412	15911	20928	20897	

		Forecasted	9981	13171	14518	16003	17640	19444	21433	5.428
		$e(k)$ (%)	0	0.870	3.081	8.092	10.866	7.089	2.567	
		$1-e(k)$ (%)	0	99.130	96.919	91.908	89.134	92.911	97.433	
11	**Turkey**	**Actual**	427105	555184	607098	708275	701621	1157190	1165381	
		Forecasted	427105	506381	600774	712761	845624	1003253	1190265	7.738
		$e(k)$ (%)	0	8.790	1.042	0.633	20.524	13.303	2.135	
		$1-e(k)$ (%)	0	91.210	98.958	99.367	79.476	86.697	97.865	

Table 5. Actual and forecasted house sales in GVM original data (2008-2014)

	Provinces	**House Sales Amount**								**MAPE (%)**
		Years	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	
1	**Ankara**	**Actual**	87087	104285	106006	117908	106019	137773	131825	
		Forecasted	87087	97977	107609	115756	122388	127623	131654	4.618
		$\varepsilon^{(1)}(k)$	0	6308	-1603	2152	-16369	10150	171	
		Δ_k (%)	0	6.049	1.512	1.826	15.440	7.367	0.129	
2	**İstanbul**	**Actual**	103503	140573	153897	169015	167110	234789	225454	
		Forecasted	103503	126995	150888	173685	194150	211538	225636	5.792
		$\varepsilon^{(1)}(k)$	0	13578	3009	-4670	-27040	23251	-182	
		Δ_k (%)	0	9.659	1.955	2.763	16.181	9.903	0.081	
3	**İzmir**	**Actual**	26627	34828	39702	44876	46429	72421	71779	
		Forecasted	26627	33359	40922	49051	57384	65520	73096	7.365
		$\varepsilon^{(1)}(k)$	0	1469	-1220	-4175	-10955	6901	-1317	
		Δ_k (%)	0	4.218	3.073	9.304	23.595	9.529	1.834	
4	**Bursa**	**Actual**	10244	14879	19966	24092	24724	40894	42437	
		Forecasted	10244	14290	19318	25149	31395	37539	43098	6.906
		$\varepsilon^{(1)}(k)$	0	589	648	-1057	-6671	3355	-661	
		Δ_k (%)	0	3.960	3.247	4.389	26.983	8.203	1.557	
5	**Mersin**	**Actual**	11216	13692	15141	18464	18447	32393	31204	
		Forecasted	11216	14334	17879	21708	25624	29408	32870	13.400
		$\varepsilon^{(1)}(k)$	0	-642	-2738	-3244	-7177	2985	-1666	
		Δ_k (%)	0	4.686	18.080	17.571	38.905	9.216	5.339	
6	**Antalya**	**Actual**	24821	30602	31419	35451	34555	59478	62227	
		Forecasted	24821	29627	35228	41702	49116	57511	66903	12.272
		$\varepsilon^{(1)}(k)$	0	975	-3809	-6251	-14561	1967	-4676	
		Δ_k (%)	0	3.188	12.123	17.634	42.137	3.307	7.514	
7	**Eskişehir**	**Actual**	9928	11077	14006	17325	19422	21292	19921	
		Forecasted	9928	12544	14997	17068	18669	19823	20613	5.151
		$\varepsilon^{(1)}(k)$	0	-1467	-991	257	753	1469	-692	
		Δ_k (%)	0	13.245	7.076	1.481	3.878	6.902	3.474	
8	**Kayseri**	**Actual**	10615	13015	15873	19040	18581	27109	28375	
		Forecasted	10615	13073	15856	18907	22136	25428	28658	3.940
		$\varepsilon^{(1)}(k)$	0	-58	17	133	-3555	1681	-283	
		Δ_k (%)	0	0.446	0.106	0.697	19.133	6.202	0.996	
9	**Konya**	**Actual**	10102	13963	14434	16838	17491	27724	29385	
		Forecasted	10102	12491	15294	18513	22121	26055	30220	8.825
		$\varepsilon^{(1)}(k)$	0	1472	-860	-1675	-4630	1669	-835	
		Δ_k (%)	0	10.540	5.959	9.948	26.469	6.020	2.841	
10	**Adana**	**Actual**	9981	13057	14084	17412	15911	20928	20897	
		Forecasted	9981	12194	14392	16433	18213	19681	20838	5.018
		$\varepsilon^{(1)}(k)$	0	863	-308	979	-2302	1247	59	
		Δ_k (%)	0	6.610	2.189	5.621	14.466	5.959	0.282	
11	**Turkey**	**Actual**	427105	555184	607098	708275	701621	1157190	1165381	
		Forecasted	427105	531308	650261	781440	920703	1062706	1201670	9.178
		$\varepsilon^{(1)}(k)$	0	23876	-43163	-73165	-219082	94484	-36289	
		Δ_k (%)	0	4.301	7.110	10.330	31.225	8.165	3.114	

Table 6. Actual and forecasted house sales in GVM raw data (2008-2014)

	Provinces	House Sales Amount								MAPE (%)
		Years	2008	2009	2010	2011	2012	2013	2014	
1	Ankara	Actual	87087	104285	106006	117908	106019	137773	131825	
		Forecasted	87087	51640	75562	102662	126273	137607	131518	15.941
		$\varepsilon^{(0)}(k)$	0	52645	30444	15246	-20254	166	307	
		Δ_k (%)	0	50.482	28.719	12.930	19.104	0.120	0.233	
2	İstanbul	Actual	103503	140573	153897	169015	167110	234789	225454	
		Forecasted	103503	63030	95364	136372	180069	214284	225583	18.436
		$\varepsilon^{(0)}(k)$	0	77543	58533	32643	-12959	20505	-129	
		Δ_k (%)	0	55.162	38.034	19.314	7.755	8.733	0.057	
3	İzmir	Actual	26627	34828	39702	44876	46429	72421	71779	
		Forecasted	26627	15677	23797	34657	47546	60147	68740	20.201
		$\varepsilon^{(0)}(k)$	0	19151	15905	10219	-1117	12274	3039	
		Δ_k (%)	0	54.987	40.061	22.771	2.406	16.949	4.234	
4	Bursa	Actual	10244	14879	19966	24092	24724	40894	42437	
		Forecasted	10244	6567	10415	15969	23260	31467	38565	25.073
		$\varepsilon^{(0)}(k)$	0	8312	9551	8123	1464	9427	3872	
		Δ_k (%)	0	55.865	47.837	33.716	5.920	23.053	9.123	
5	Mersin	Actual	11216	13692	15141	18464	18447	32393	31204	
		Forecasted	11216	6472	9798	14298	19786	25459	29858	20.509
		$\varepsilon^{(0)}(k)$	0	7220	5343	4166	-1339	6934	1346	
		Δ_k (%)	0	52.732	35.290	22.563	7.259	21.406	4.313	
6	Antalya	Actual	24821	30602	31419	35451	34555	59478	62227	
		Forecasted	24821	12946	18979	26981	36724	47135	56140	22.571
		$\varepsilon^{(0)}(k)$	0	17656	12440	8470	-2169	12343	6087	
		Δ_k (%)	0	57.696	39.593	23.893	6.276	20.753	9.783	
7	Eskişehir	Actual	9928	11077	14006	17325	19422	21292	19921	
		Forecasted	9928	6827	10621	15239	19508	21630	20472	11.339
		$\varepsilon^{(0)}(k)$	0	4250	3385	2086	-86	-338	-551	
		Δ_k (%)	0	38.364	24.170	12.042	0.445	1.586	2.766	
8	Kayseri	Actual	10615	13015	15873	19040	18581	27109	28375	
		Forecasted	10615	6343	9651	14046	19171	23994	26974	19.471
		$\varepsilon^{(0)}(k)$	0	6672	6222	4994	-590	3115	1401	
		Δ_k (%)	0	51.268	39.196	26.228	3.176	11.491	4.938	
9	Konya	Actual	10102	13963	14434	16838	17491	27724	29385	
		Forecasted	10102	5649	8486	12335	17100	22213	26539	22.756
		$\varepsilon^{(0)}(k)$	0	8314	5948	4503	391	5511	2846	
		Δ_k (%)	0	59.540	41.209	26.745	2.235	19.876	9.687	
10	Adana	Actual	9981	13057	14084	17412	15911	20928	20897	
		Forecasted	9981	6223	9440	13445	17524	20379	20779	17.346
		$\varepsilon^{(0)}(k)$	0	6834	4644	3967	-1613	549	118	
		Δ_k (%)	0	52.339	32.973	22.783	10.140	2.622	0.562	
11	Turkey	Actual	427105	555184	607098	708275	701621	1157190	1165381	
		Forecasted	427105	243134	365983	530936	730380	934593	1091103	21.524
		$\varepsilon^{(0)}(k)$	0	312050	241115	177339	-28759	222597	74278	
		Δ_k (%)	0	56.207	39.716	25.038	4.099	19.236	6.374	

Table 7. Actual and forecasted house sales in NGVM (2008-2014)

	Provinces	House Sales Amount								MAPE (%)
		Years	2008	2009	2010	2011	2012	2013	2014	
1	Ankara	Actual	87087	104285	106006	117908	106019	137773	131825	
		Forecasted	87087	96987	106149	114353	121482	127518	132519	4.672
		$\varepsilon^{(1)}(k)$	0	7298	-143	3555	-15463	10255	-694	
		Δ_k (%)	0	6.999	0.135	3.015	14.585	7.443	0.526	
2	İstanbul	Actual	103503	140573	153897	169015	167110	234789	225454	
		Forecasted	103503	124963	147323	169529	190553	209580	226106	5.819
		$\varepsilon^{(1)}(k)$	0	15610	6574	-514	-23443	25209	-652	
		Δ_k (%)	0	11.104	4.271	0.304	14.029	10.737	0.289	
3	İzmir	Actual	26627	34828	39702	44876	46429	72421	71779	
		Forecasted	26227	32573	39358	46898	55036	63549	72165	6.168
		$\varepsilon^{(1)}(k)$	0	2255	344	-2022	-8607	8872	-386	
		Δ_k (%)	0	6.474	0.867	4.505	18.539	12.251	0.538	
4	Bursa	Actual	10244	14879	19966	24092	24724	40894	42437	
		Forecasted	10244	13852	18344	23684	29695	36056	42367	6.974
		$\varepsilon^{(1)}(k)$	0	1027	1622	408	-4971	4838	70	
		Δ_k (%)	0	6.902	8.123	1.692	20.105	11.830	0.165	
5	Mersin	Actual	11216	13692	15141	18464	18447	32393	31204	
		Forecasted	11216	13740	16676	20023	23753	27805	32088	9.241
		$\varepsilon^{(1)}(k)$	0	-48	-1535	-1559	-5306	4588	-884	
		Δ_k (%)	0	0.350	10.136	8.442	28.762	14.163	2.833	
6	Antalya	Actual	24821	30602	31419	35451	34555	59478	62227	
		Forecasted	24821	28688	33284	38792	45459	53630	63791	9.359
		$\varepsilon^{(1)}(k)$	0	1914	-1865	-3341	-10904	5848	-1564	
		Δ_k (%)	0	6.255	5.935	9.423	31.556	9.833	2.514	
7	Eskişehir	Actual	9928	11077	14006	17325	19422	21292	19921	
		Forecasted	9928	12561	15032	17119	18730	19891	20685	5.127
		$\varepsilon^{(1)}(k)$	0	-1484	-1026	206	692	1401	-764	
		Δ_k (%)	0	13.398	7.324	1.191	3.563	6.582	3.834	
8	Kayseri	Actual	10615	13015	15873	19040	18581	27109	28375	
		Forecasted	10615	12892	15495	18405	21579	24947	28421	4.419
		$\varepsilon^{(1)}(k)$	0	123	378	635	-2998	2162	-46	
		Δ_k (%)	0	0.944	2.381	3.335	16.132	7.975	0.163	
9	Konya	Actual	10102	13963	14434	16838	17491	27724	29385	
		Forecasted	10102	12217	14719	17655	21068	24991	29443	7.119
		$\varepsilon^{(1)}(k)$	0	1746	-285	-817	-3577	2733	-58	
		Δ_k (%)	0	12.507	1.972	4.852	20.449	9.859	0.197	
10	Adana	Actual	9981	13057	14084	17412	15911	20928	20897	
		Forecasted	9981	12093	14226	16258	18090	19661	20949	5.003
		$\varepsilon^{(1)}(k)$	0	964	-142	1154	-2179	1267	-52	
		Δ_k (%)	0	7.386	1.006	6.626	13.697	6.056	0.251	
11	Turkey	Actual	427105	555184	607098	708275	701621	1157190	1165381	
		Forecasted	427105	515308	617699	734908	866951	1013050	1171517	7.034
		$\varepsilon^{(1)}(k)$	0	39876	-10601	-26633	-165330	144140	-6136	
		Δ_k (%)	0	7.182	1.746	3.760	23.564	12.456	0.527	

When tables were examined it was observed that MAPE values between forecasted values and actual values regarding ten provinces where house sales are most intensively performed were observed to be calculated for GM (1,1) as 7.039%, for GVM original data as 7.329%, for GVM raw data as 19.364% and for NGVM as 6.390%. NGVM, GM (1,1) and GVM original data where mean absolute percentage error values are lowest are most reliable models for the study. On the other hand NGVM where MAPE value was determined to be lowest demonstrates a forecast reliability of 100% - 6.390% = 93.610%.

When house sales data in ten provinces of Turkey where house sales activity is most intensive between 2008-2014 were examined NGVM, GM (1,1) and GVM original data are most reliable models for the study. From this point of view NGVM where MAPE value was determined to be lowest demonstrates a forecast reliability of 100% - 7.034% = 92.966%. In terms of calculated mean absolute percentage error GVM original data gives much better results compared to GVM raw data and the fact that there is no significant difference between forecasted and actual values expresses the success of NGVM, GM (1,1) and GVM original data so as to perform forecasting on chaotic data with a very low error ratio.

In figure 3, it is possible to see realized house sales values in all provinces of Turkey and the forecast values for 2008-2018 obtained from GM (1,1), GVM original data, GVM raw data and NGVM. In this direction, the forecasts obtained from the NGVM, GM (1,1) and GV original data which have the lowest MAPE values shows that the house sales in Turkey will demonstrate an increasing trend between 2015 and 2018.

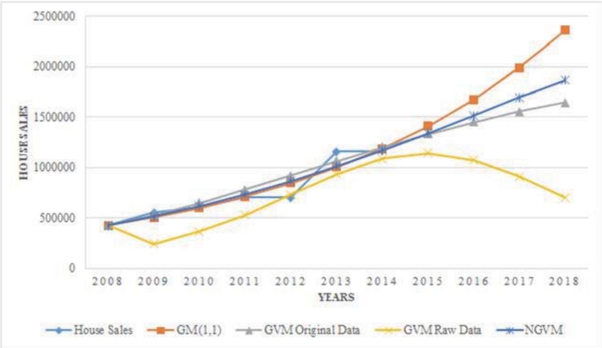

Figure 3. Actual values for all provinces in Turkey and forecasted values obtained from GM (1,1), GVM original data, GVM raw data and NGVM

5. Conclusions

In this study, GM (1,1), GVM and NGVM were used in order to analyze the house sales quantity in Turkey between 2008 and 2014 and to make forecast for the future in light of this data. These forecasts were compared with the values realized between the same years so it was demonstrated that GM (1,1), GVM and NGVM perform healthy forecasts in terms of obtained results and MAPE ratios. After the global crisis, starting from 2010, housing sector in Turkey was active. Together with the rapid growth in housing sector, which is the locomotive of the economical developments, Turkey's young and dynamic demographic structure is considered to support the demand towards housing market in incoming years. On the other hand urban conversion process which will further show its effect on the sector in incoming years and borrowing costs and stability in labor market which are most important factors affecting the demand of households are considered to have important contribution to development of sector.

Considering that the housing market in Turkey is directly affected mainly from demographic structure, prosperity and growth of the country, interest rates and regulations related with housing sector following and analysis of the indications related with the sector become more important. Forecasting the future in order to take proactive precautions against the possible problems is becoming obligatory for the sector. For these reasons GM (1,1), GVM and NGVM were used to demonstrate their reliability and the housing demand in Turkey between 2015 and 2018 was forecasted. As effective forecast models it was proved that GM (1,1), GVM and NGVM can be used for the forecast of other indications related with the sector.

When literature is examined it is observed that there are no studies in Turkey related with housing demand performed by grey forecast, that GM (1,1) is mostly used in studies related with demand forecast but that forecasts obtained from GVM original data, GVM raw data and NGVM were not comparatively incorporated to the studies together with GM (1,1).

In this study which was performed by GM (1,1), GVM original data, GVM raw data and NGVM, forecasts were made by starting from single data set. In the literature many intuitional and stochastic models are used together with GM. In future stages of the study, above mentioned models will be used and instead of using single data set the factors affecting the residence demand will be determined and forecasts will be developed by using these models together with GM (1,n) and / or fuzzy grey forecast models.

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