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Nhu-Ty Nguyen & Thanh-Tuyen Tran

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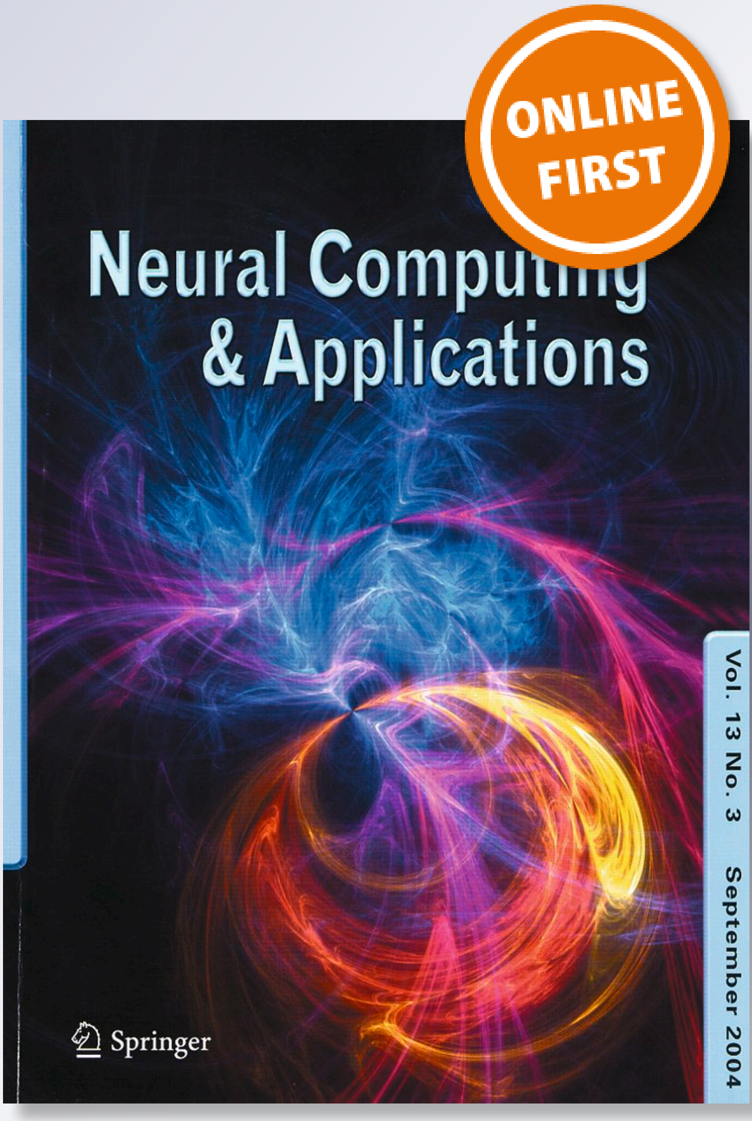

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ORIGINAL ARTICLE

Optimizing mathematical parameters of Grey system theory: an empirical forecasting case of Vietnamese tourism

Nhu-Ty Nguyen[1] · Thanh-Tuyen Tran[2]

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Abstract Accurately forecasting the demand for international and domestic tourism is a key goal for tourism industry leaders. The purpose of this study is to present more appropriate models for forecasting the demand for tourism in Vietnam. The authors apply GM(1,1), Verhulst, DGM(1,1) and DGM(2,1) to test which concise prediction models can improve the ability to predict the number of tourists visiting this country. In order to guarantee the accuracy of forecasting process, data cover in the period from 2005 through 2013 and are obtained from the official website of VNATR "Vietnam National Administration of Tourism" report. The MAPE, MSE, RMSE and MAD are four important criteria which are used to compare the various forecasting models results. Key findings indicate that the optimal value of GM(1,1), Verhulst, DGM(1,1) can enhance the forecasting results perfectly with minimum predicted errors. In the case of the tourism revenue, using the Verhulst model is evidently better than the others. For the number of international and domestic tourist prediction, the application of Verhulst and DGM(1,1) models is well done. For visitors coming from specific countries (i.e., China, Korea, Taiwan, Japan and America), DGM(2,1) is very poor for predicting in this situation, whereas remaining three models GM(1,1), Verhulst, DGM(1,1) and DGM(2,1) perform excellently. The results also pointed out that the tourism demands in Vietnam are growing rapidly; thus, the governments must be well prepared for tourism industry and enhance relative fundamental construction for tourism markets.

Keywords Vietnamese tourism · GM(1,1) · Verhulst · DGM(1,1) · DGM(2,1) · Forecasting

Nhu-Ty Nguyen and Thanh-Tuyen Tran have contributed equally to this work.

✉ Nhu-Ty Nguyen
nhutynguyen@hcmiu.edu.vn

Thanh-Tuyen Tran
copcoi2@gmail.com

1 School of Business, International University – Vietnam National University HCMC; Quarter 6, Linh Trung ward, Thu Duc District, Ho Chi Minh City, Vietnam

2 Scientific Research Office, Lac Hong University, No. 10 Huynh Van Nghe, Bien Hoa, Dong Nai, Vietnam

1 Introduction

Tourism contributes significantly to both the national economic growth and the economic welfare of local population [1, 2]. Since the 2000s, the Vietnamese tourism industry, which focuses on the core products of cultural tourism, marine tourism and resource-based tourism, has become an important segment of the economy although it has also suffered a lot from many difficulties during the economy recession. Tourism industry's difficulties of a nation may come from the economy crisis which caused people to hesitate to travel or from the winning marketing strategy of other countries; thus, Vietnamese tourism needs to understand exactly what their advantages and disadvantages and to carefully a distinct image of attraction.

Despite facing many obstacles in the progress of developing, Vietnamese tourism also gains prominent achievements. In the period 2013–2020, it is successful implementing tasks and plans assigned by the Ministry of Culture, Sports and Tourism (MCST), developing both international and domestic tourism with the priority on inbound and better control outbound tourism. According to the recent report—Vietnam National Administration of Tourism Report (Q4-2013), the total number of

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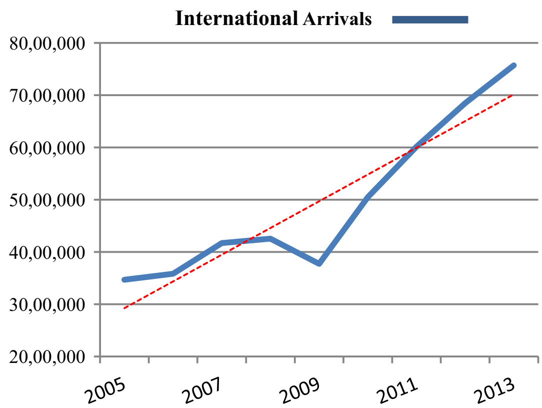

Fig. 1 Foreign visitor arrivals to Vietnam by year

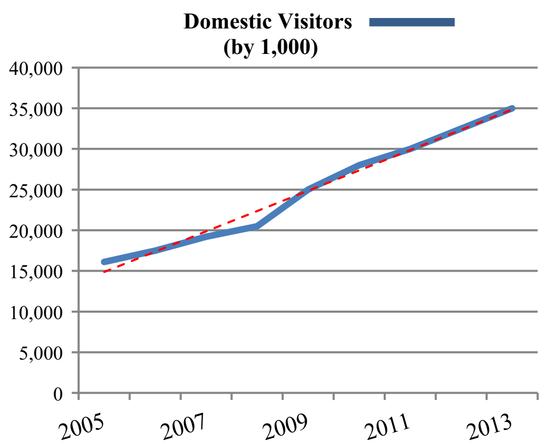

Fig. 2 Domestic visitor arrivals to Vietnam by year

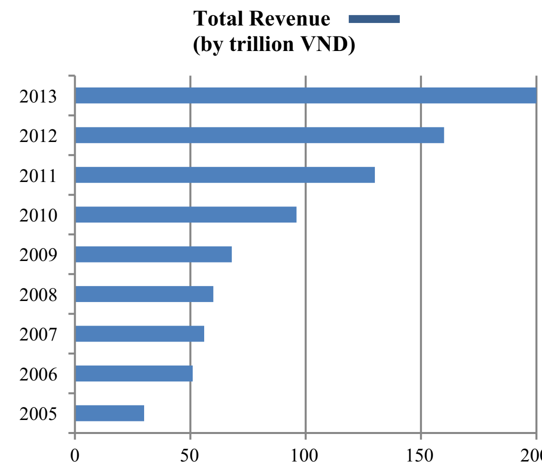

Fig. 3 Total revenue from tourists' period 2005–2013

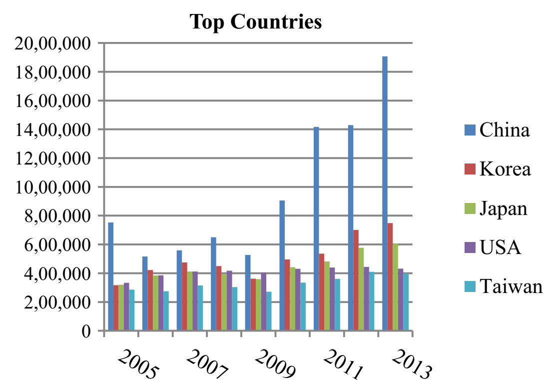

Fig. 4 Top countries of visitors to Vietnam from 2005 to 2013

international visitors in the first six months of 2013 reached to the peak of 3540,403, up 2.6% compared with the previous year 2012; for instance, the Russian market went up 60.4%, Thailand increased by 24.3%, Indonesia rose to 21.5%, China stepped up 21.0%, New Zealand improved by 16.7%, Malaysia grew up 12.2%, etc. However, in some markets international visitors also declined significantly; for example, German slumped by 41.3%, Hong Kong down 33.5%, and Finland fell more than 28.1% (Tourism Report-Q4-2013) in the first six months of 2013. In addition, there is an uptrend in the amount of both international and domestic tourists visiting by each year from 2005 to 2013 (as described in Figs. 1, 2). Also covering the period from 2005 to 2013, total revenue gained from Vietnamese tourism in first half of the year 2013 was estimated at 105 trillion VND, up 23.5% (as shown in Fig. 3). As can be seen from this result, it can conclude that the total revenue continues to rise steadily and Vietnam has gained stable steps in the activity of improving and developing tourism industry during the period as well. Besides, Fig. 4 also describes the top five countries sending most tourists to Vietnam. According to the figure, Chinese travelers account mostly from the total number of tourist passengers visiting Vietnam every year, and Korea, Japan, America and Taiwan follow this country.

For the purpose of competing with other nations and attracting visitors, it is apparent that Vietnamese tourism needs an accuracy vision for tourism demand. Accurate tourism forecasting is an important element in tourism planning and management. The need for improved tourism research and accurate tourism forecasting has been recognized by tourism professionals for some time. According to a comprehensive review by Li et al. [3], 420 studies on this topic were published during the period 1960–2002. The majority of these studies focus on the application of different techniques, both qualitative and quantitative, to model and forecast the demand for tourism in various destinations. These studies also attempted to establish forecasting principles that could be used to guide the practitioners in selecting forecasting techniques. Thus, this study presents the model of GM(1,1), Verhulst, DGM(1,1) and DGM(2,1) to test which models can handle the forecast accuracy of this situation.

The main contribution of the research topic is to investigate whether there are any new trends emerging recently in

Vietnam tourism and to suggest new directions for future research based on the new trends identified. Tourism in Vietnam in particular and Asian in general is going through a process of dynamic change, so the authors consider that forecasting of demand is significantly important for tourism industry in long-term decision making related to investment. Countries thus wish to better understand their international visitors and tourism revenues, to help rapidly formulate appropriate tourism policies.

2 Literature review

2.1 Tourism demand and forecasting

Tourism demand is usually regarded as a measure of visitors' use of a good or service [4]. Sara and Elias [5], in a study about Demand for Tourism in Portugal, refer tourism demand as the amount of a set of tourist products that the consumers are willing to acquire during a specific period of time and under certain conditions which are controlled by the explanatory factors used in the demand equation. Morley [6] also stated that "tourism demand is a special form of demand in that a tourism product is a bundle of complementary goods and services." In the study of modeling seasonality in tourism forecasting, Kulendran and Wong [7] have mentioned that the tourist arrivals variable is still the most popular measure of tourism demand over the past few years. Specifically, this variable was measured by total tourist arrivals from an origin to a destination, which could be decomposed further into holiday tourist arrivals, business tourist arrivals, tourist arrivals for visiting friends and relatives and tourist arrivals by air. Some studies used tourist expenditure in the destination as the demand variable (such as Li et al. [8]) and others employed tourist expenditure on particular tourism product categories, such as meal expenditure, sightseeing expenditure, sightseeing expenditure and shopping [9]. Other tourism demand variables used in the literature include tourism revenues, tourism employment and tourism import and export [10].

Accurate forecasts of tourism demand and its features can certainly improve planning and decision making. Thus, tourism forecasting has become an important component in tourism research and different approaches have been used to generate forecasts of tourism demand [11]. Along with the development of the international tourism in Vietnam, it is urgent to apply modeling and forecasting tourism demand. According to Fretchling [4], the nature of tourism demand presents a number of special challenges to the forecasters, such as the lack of historical data, the volatility of tourism demand and the complexity of tourism behavior. Nevertheless, forecasting plays a major role in tourism researching and the forecasting methods applied in this study may present a helpful tool to make more accurate future Vietnam tourism demand forecasts.

In a recent paper, Li and Song [12] found that tourism forecasting researchers have to collect data by governments or other agencies. Because of the nature of these data, tourism demand is usually measured by the numbers of tourists arriving at particular destinations from particular departure points, though a few researchers have used tourist expenditure as a measure of demand. In this study, the researchers collected data from the Vietnamese Ministry of Tourism.

There are various methods that researchers have tested into tourism demands and forecasting, for example: ARIMA models, complex econometric models, artificial intelligence methods (such as neural networks) and even technical analysis. Alternatively, a combination of methods is also worth considering by authors. Moreover, the relative accuracy of approaches depends on factors like how far ahead one is forecasting and whether it is for monthly, quarterly or annual demand.

2.2 Previous tourism demand modeling and forecasting studies

Tourism forecasting will help the country understand their international visitors and tourism revenues and formulate appropriate policies. Along with the development of forecasting techniques, a large number of quantitative methods have been applied to the forecasting of tourism demand.

Traditional time series methods such as autoregressive integrated moving average (ARIMA) model, seasonal autoregressive integrated moving average (SARIMA) model or multivariate autoregressive integrated moving average (MARIMA) model have been also applied usefully and popularly in the previous studies. For example, Lim and McAleer [13] used ARIMA model to forecast tourist arrivals to Australia from Hong Kong, Malaysia and Singapore. Goh and Law [14] presented the use of SARIMA and MARIMA time series models with interventions in forecasting tourism demand using ten arrival series for Hong Kong.

Although most of the researches focused on traditional quantitative forecasting techniques, such as ARIMA, exponential smoothing in the study of Ahmed et al. [15], the issue of how different machine learning models can be applied in the tourism prediction problem and to assess the performance of seven well-known machine learning methods was investigated.

In the study of Huang and Lin [16], they applied GM(1,1) with adaptive levels of α (hereafter GM(1,1)-α model) to provide a concise prediction model that will improve the ability to forecast the demand for health tourism in Asian countries, whereas Grey model—GM(1,1) was used to predict the manpower of undergraduate educational systems in Vietnam [17].

Choosing the appropriate model will help improving the quality of forecasting. The appropriate tools for forecasting are very important for policy making. In this study, both clarified value calculation and use of a genetic algorithm to find the optimal parameters are adopted simultaneously to construct improved models GM(1,1), Verhulst, DGM(1,1) and DGM(2,1). The purposes of applying these models in this study are to test which models can handle the forecast accuracy of the issue tourism demand in Vietnam.

2.3 Methodological developments

Grey system theory was initiated in 1982 by Deng. The concept of the Grey system in its theory and successful application is now well known in China. Grey system theory has been widely applied in areas like social science, economic, agriculture, providing solutions to a large number of practical problems and challenges met in daily lives and day to day works.

2.3.1 GM(1,1) model

The GM(1,1), which is pronounced as ''Grey Model First-Order One Variable'', can only be used in positive data sequences [18]. This model is a time series forecasting model. The differential equations of the GM(1,1) model have time-varying coefficients.

Let $X^{(0)} = (x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n))$ be a sequence of raw data. Denote its accumulation generated sequence by $X^{(1)} = (x^{(1)}(1), x^{(1)}(2), \ldots, x^{(1)}(n))$. Then

$$x^{(0)}(k) + ax^{(1)}(k) = b \tag{1}$$

is referred to as the original form of the GM(1,1) model, where the symbol GM(1,1) stands for *first-order Grey model in one variable* [19].

$$x^{(0)}(k) + az^{(1)}(k) = b \tag{2}$$

as the basic form of this model if $Z^{(1)} = (z^{(1)}(2), z^{(1)}(3),\ldots,z^{(1)}(n))$;

That is $z^{(1)}(k) = \frac{1}{2}\left(x^{(1)}(k) + x^{(1)}(k-1)\right)$; *with* $k = 2, 3, \ldots, n.$

Theorem 1 *Let* $X^{(0)}$, $X^{(1)}$, *and* $Z^{(1)}$ *be the same as above except that* $X^{(0)}$ *is nonnegative*. If $\hat{a} = (\boldsymbol{a}, \boldsymbol{b})^{\mathrm{T}}$ *is a sequence of parameters, and*

$$Y = \begin{bmatrix} X^{(0)} & (2) \\ X^{(0)} & (3) \\ & \vdots \\ X^{(0)} & (n) \end{bmatrix}, \quad B = \begin{bmatrix} -Z^{(1)} & (2) & 1 \\ -Z^{(1)} & (3) & 1 \\ & \vdots & \vdots \\ -Z^{(1)} & (n) & 1 \end{bmatrix} \tag{3}$$

then Eq. (2) *satisfies* $\hat{a} = (B^{\mathrm{T}}B)^{-1}B^{\mathrm{T}}Y$, *so from Theorem* 1 *notations, if*

$$[a, b]^{\mathrm{T}} = \left(B^{\mathrm{T}}B\right)^{-1}B^{\mathrm{T}}Y, \quad \text{then } \frac{\mathbf{d}\boldsymbol{x}^{(1)}}{\mathbf{d}\boldsymbol{t}} + \boldsymbol{ax}^{(1)} = \boldsymbol{b} \text{ (whitenization equation in Eq. (2))}$$

Theorem 2 *Let* $B, Y, \hat{a}$ *be the same as in Theorem* 1. *If* $\hat{a} = [a, b]^{\mathrm{T}} = (B^{\mathrm{T}}B)^{-1}B^{\mathrm{T}}Y$, *then*

1. *The solution of* $\frac{\mathbf{dx}^{(1)}}{\mathbf{dt}} + \boldsymbol{ax}^{(1)} = \boldsymbol{b}$ *given by*
$$X^{(1)}(t) = \left(X^{(1)}(1) - \frac{b}{a}\right)e^{-at} + \frac{b}{a} \tag{4}$$
2. *The time response sequence of* $\frac{\mathbf{dx}^{(1)}}{\mathbf{dt}} + \boldsymbol{ax}^{(1)} = \boldsymbol{b}$ is *given as following*
$$\hat{X}^{(1)}(k+1) = \left(X^{(0)}(1) - \frac{b}{a}\right)e^{-ak} + \frac{b}{a}, \quad k = 1, 2, \ldots, n \tag{5}$$
3. *The restored values of* $x^{(0)}(k)$*'s are given: * marked as equ.*
$$\begin{aligned} \hat{x}^{(0)}(k+1) &= \alpha^{(1)}\hat{x}^{(1)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k) \\ &= (1 - e^{a})\left(x^{(0)}(1) - \frac{b}{a}\right)e^{-ak}, \\ k &= 1, 2, \ldots, n \end{aligned} \tag{6}$$

2.3.2 Verhulst model

The Verhulst model was first introduced by a German biologist Pierre Franois Verhulst. The main purpose of Verhulst model is to limit the whole development for a real system, and it is effective in describing some increasing processes, such as an S-curve which has a saturation region.

$$x^{(0)}(k) + az^{(1)}(k) = b\left(z^{(1)}(k)\right)^{\alpha} \tag{7}$$

is established as the GM(1,1) power model, and

$$\frac{\mathrm{d}x^{(1)}}{\mathrm{d}t} + ax^{(1)} = b\left(x^{(1)}\right)^{\alpha} \tag{8}$$

is known as the whitenization equation of GM(1,1) power model when $X^{(0)}$ is assumed to be a sequence of raw data; $X^{(1)}$ a sequence of accumulation of generation of $X^{(0)}$; $Z^{(1)}$ adjacent neighbor mean of $X^{(1)}$.

Theorem 3 *Then*

$$x^{(1)}(t) = \left\{e^{-(1-a)at}\left[(1-a)\int be^{(1-a)at}\mathrm{d}t + c\right]\right\}^{\frac{1}{1-a}} \tag{9}$$

is the solution of Eq. (8).

Theorem 4 *With $X^{(0)}$; $X^{(1)}$ and $Z^{(1)}$ (as above), let*

$$B = \begin{bmatrix} -z^{(1)}(2) & \left(z^{(1)}(2)\right)^{\alpha} \\ -z^{(1)}(3) & \left(z^{(1)}(3)\right)^{\alpha} \\ \vdots & \vdots \\ -z^{(1)}(n) & \left(z^{(1)}(n)\right)^{\alpha} \end{bmatrix}, \quad Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix},$$

then the least-squares estimate of the parametric sequence $\hat{a} = [a, b]^{\mathrm{T}}$ of Eq. (7) is $\hat{a} = \left(B^{\mathrm{T}}B\right)^{-1}B^{\mathrm{T}}Y$. When the power of Eq. (7) $\boldsymbol{\alpha} = 2$, the resultant model is

$$x^{(0)}(k) + az^{(1)}(k) = b\left(z^{(1)}(k)\right)^{2} \tag{10}$$

This is the Grey Verhulst mode, and

$$\frac{\mathrm{d}x^{(1)}}{\mathrm{d}t} + ax^{(1)} = b\left(x^{(1)}\right)^{2}. \tag{11}$$

This is known as the whitenization equation of Grey Verhulst.

Theorem 5 *The solution of Eq. (10) is*

$$\begin{aligned} x^{(1)}(t) &= \frac{1}{e^{at}\left[\frac{1}{x^{(1)}(0)} - \frac{b}{a}\left(1 - e^{-at}\right)\right]} \\ &= \frac{ax^{(1)}(0)}{e^{at}\left[a - bx^{(1)}(0)\left(1 - e^{-at}\right)\right]} \\ &= \frac{ax^{(1)}(0)}{bx^{(1)}(0) + \left(a - bx^{(1)}(0)\right)e^{at}}. \end{aligned} \tag{12}$$

The time response sequence of the Grey Verhulst model is:

$$\hat{x}(k+1) = \frac{ax^{(1)}(0)}{bx^{(1)}(0) + \left(a - bx^{(1)}(0)\right)e^{ak}} \tag{13}$$

2.3.3 Discrete Grey models (DGM)

$x^{(1)}(k+1) = \beta_1 x^{(1)}\beta_2$ is written as a basic of discrete Grey model (DGM) or a discretization of the GM(1,1) model. The overall procedure to obtain all details about discrete Grey models can be referred to a full book about Grey systems theory written by Lin and Liu [19].

3 Data collection and description

This study focuses on forecasting the demands for international and domestic tourism and the total revenue gaining from tourism in Vietnam, as well as analyzes the demands generated by top countries sending most passengers visiting this country, i.e., China, Korea, Japan, USA and Taiwan.

In order to verify the feasibility of the proposed approach, we analyze data covering a period from 2005 through 2013 that are obtained from tourism reports published monthly on the official website of Vietnam National Administration of Tourism [20].

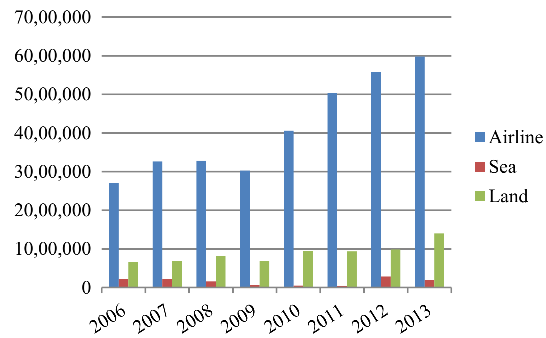

Fig. 5 Means of transportation

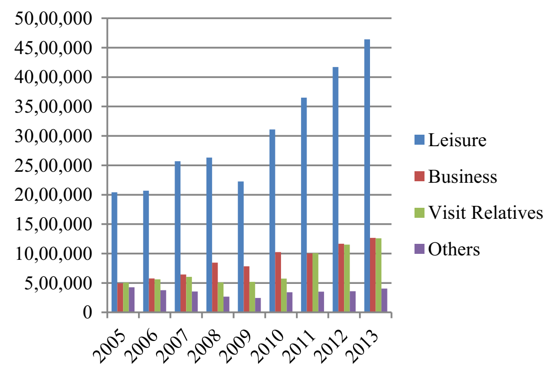

Fig. 6 Tourists' purposes of visiting

The data were obtained from the website include *total revenue index, international arrivals, domestic visitors* and *top arrivals by countries* (as described in Figs. 1, 2, 3, 4).

About the *international Arrivals*, we also obtain two datasets of variables. They are means of transportation and purposes of visiting. In the context of Vietnam, the group of means of transportation (described in Fig. 5) relates to the number of passengers directly because it decides how convenient of means of transportation by tourists' choices. The remaining group passenger's purposes of visiting (described in Fig. 6) reflect both the economic and social conditions and correlate with the tourism context in Vietnam over years.

Table 1 lists the descriptive statistics on the numbers of tourists visiting to Vietnam. The mean of tourism revenue index, and the number of domestic and international visitors are 94.56 (trillion VND), 2.49E4 (visitors), and 4.97E6 (visitors), respectively. China, Korea, Japan, USA and Taiwan got the mean values are 9.63E5, 5.01F5, 4.41E5, 4.11E5 and 3.28E5, respectively. This indicates that China is regarded as the biggest market in Vietnam.

Table 1 Descriptive statistics

	Mean	Minimum	Maximum	Std. deviation	Variance
Total revenue	94.56	30	200	57.129	3.264E3
Domestic visitors	2.49E4	16,100	35,000	6886.944	4.743E7
International visitors	4.97E6	3,467,757	7,572,352	1,506,582.094	2.270E12
China	9.63E5	516,286	1,907,794	501,689.502	2.517E11
Korea	5.01E5	317,213	748,727	143,740.911	2.066E10
Japan	4.41E5	320,605	604,050	96,286.936	9.271E9
USA	4.11E5	333,566	443,826	34,441.958	1.186E9
Taiwan	3.28E5	271,643	409,385	51,651.836	2.668E9

Total revenue by trillion VND; domestic visitors by 1000

Table 2 Parameters of building *GM(1,1)* in forecasting process of researched factors

	a	b	$(1-e^{a})\left(x^{(0)}(1)-\frac{b}{a}\right)$ (Eq. 6)
Total revenue	−0.23	27.86	31.03
Domestic visitors	−0.10	15,320.64	16,133.37
International visitors	−0.12	2,701,407.31	−3.88
China visitors.	−0.22	182,437.72	312,559.93
Korea visitors	−0.09	317,985.41	332,050.10
Japan visitors	−0.08	307,760.87	319,702.45
USA visitors	−0.02	388,631.82	390,863.54
Taiwan tourists	−0.06	245,240.09	254,392.82

Table 3 Parameters of building *Verhulst* in forecasting process of researched factors

	a	b	$\hat{x}(k+1)=\frac{ax^{(1)}(0)}{bx^{(1)}(0)+(a-bx^{(1)}(0))e^{ak}}$ (Eq. 13) *in which*		
			$\boldsymbol{ax}^{(1)}(0)$	$\boldsymbol{a-bx}^{(1)}(0)$	$\boldsymbol{bx}^{(1)}(0)$
Total revenue	−0.24	−0.0001	−7.31	−0.24	−0.003
Domestic visitors	−0.16	0.000	−2,549.82	−0.12	−0.038
International visitors	−0.04	0.000	−139,183.03	−0.08	0.044
China visitors	−0.0046	0.000	−3,425.09	−0.1142	0.11
Korea visitors	−0.07	0.000	−0.16	−0.13	0.024
Japan visitors	−0.04	0.000	−23,239.48	−0.095	0.0217
USA visitors	−0.71	0.000	−11,340.25	−0.068	0.0324
Taiwan tourists	−0.00007	0.000	−23,826.32	−0.166	−0.55

4 Data analysis and results

The quality of the information and data collected affect the accuracy of the forecasting process. In the description section, we mentioned that the data were collected from 2005 to 2013 from the official website of Vietnam National Administration of Tourism and have never been revised. The demand for tourism in Vietnam increased quite substantially during the period of time.

In this section, the parameters of models applied are described clearly in the following tables. In particular, Table 2 shows the *a, b* values, after that we can go to the formula of Eq. (6) shown in the previous section, which is $(1-e^{a})\left(x^{(0)}(1)-\frac{b}{a}\right)$.

Next, Verhulst model's parameters are shown in Table 3 with *a, b* values and other digit elements from Eq. 13, which is $\hat{x}(k+1)=\frac{ax^{(1)}(0)}{bx^{(1)}(0)+(a-bx^{(1)}(0))e^{ak}}$.

Finally, the calculations with the parameters of *DGM(1,1) and DGM(2,1)* are illustrated below: *total revenue* calculation is with the following parameters: $\beta_1 = 1.2567$; $\beta_2 = 31.6186$, so the equation $x^{(0)}(1)(\beta_1-1)+\beta_2 = 39.3192$.

With the same process, we have calculator for *domestic visitors*: $\beta_1 = 1.1054$; $\beta_2 = 16{,}140$, so the equation $x^{(0)}(1)(\beta_1 - 1) + \beta_2 = 17{,}837.4781$.

Calculation of *international visitors*: $\beta_1 = 1.1229$; $\beta_2 = 2{,}881{,}411.8858$, so the equation $x^{(0)}(1)(\beta_1 - 1) + \beta_2 = 3{,}307{,}486.0644$.

Calculation of *China visitors* is with the following parameters: $\beta_1 = 0.98797$; $\beta_2 = 6.972392$, so the equation $x^{(0)}(1)(\beta_1 - 1) + \beta_2 = 6.887939$.

We have calculator for *Korea visitors*: $\beta_1 = 1.0976$; $\beta_2 = 337227.5685$, so the equation $x^{(0)}(1)(\beta_1 - 1) + \beta_2 = 368{,}178.4550$.

Calculation of *Japan visitors*: $\beta_1 = 1.230543$; $\beta_2 = -4.597065$, so the equation $x^{(0)}(1)(\beta_1 - 1) + \beta_2 = -4.873716$.

USA visitors calculation is with the following parameters: $\beta_1 = 1.0163$; $\beta_2 = 391{,}900.7093$, so the equation $x^{(0)}(1)(\beta_1 - 1) + \beta_2 = 397{,}337.4944$.

Finally, with the same process, we have for *Taiwan visitors*: $\beta_1 = 1.0592$; $\beta_2 = 253{,}223.9533$, so the equation $x^{(0)}(1)(\beta_1 - 1) + \beta_2 = 270{,}175.9782$.

With the above-developed parameters, we also calculated to have the precious forecasting results which are illustrated in tables and figures concisely. Tables 4, 5 and 6 show the true values and forecasting results by GM(1,1), Verhulst, DGM(1,1) and DGM(2,1) models for Vietnam tourism demands for the next four years (2014–2017); followings are describing figures (from Figs. 7, 8, 9, 10, 11, 12, 13, 14).

Table 4 and Fig. 8 show the *total revenue* (trillion VND) is increasing steadily. It is nearly 7 times of development in the period of 2005 and 2013, in detail, 30–200 (trillion VND). Moreover, the forecasting results also show this rapid growth. It will be double and triple for the next 5 years (2013–2017)—depending on our built models.

In the mean time, Table 4 and Fig. 7 also show a steady growth of domestic tourists. In the first sight, it has gone to double in recent 9 years and tended to be triple in the period of 2005–2017, according to forecasting models. It is easy to see the same trend of international to domestic visitors when we consider Table 4 and Fig. 9.

Further analyzing, in Table 5 and Fig. 10, the noticed point is the error of *Verhulst* model in forecasting the value of Chinese tourists. However, we have to figure out that Chinese tourists recently have a tendency to choose Vietnam as their favorite destination. These numbers are jumping to millions of visitors. Then, we consider errors of *Verhulst* and *DGM(2,1)* models shown in Table 5 and Figs. 10 and 11.

During the time of building models for this study, these models with explained parameters in the previous section have got the out of range in forecasting. In detail, *Verhulst*

Table 4 True values and forecasting result for tourism revenue, domestic visitors and international visitors

Stages	Models	Actual	GM(1,1)	VER	DGM(1,1)	DGM(2,1)	Actual	GM(1,1)	VER	DGM(1,1)	DGM(2,1)	Actual	GM(1,1)	VER	DGM(1,1)	DGM(2,1)
		Total revenue (by trillion VND)*					Domestic visitors (by 1000)					International visitors				
Model building	2005	30	30	30	30	30	16,100	16,100	16,100	16,100	16,100	3,467,757	3,467,757	3,467,757	3,467,757	3,467,757
	2006	51	38.97	38.15	39.32	33.05	17,500	17,812	18,111	17,837	16,990	3,583,486	3,292,898	3,779,565	3,307,486	3,530,209
	2007	56	48.95	48.48	49.41	40.10	19,200	19,690	20,272	19,717	18,849	4,171,564	3,699,327	4,136,906	3,713,868	3,676,775
	2008	60	61.49	61.53	62.10	48.83	20,500	21,766	22,571	21,795	20,827	4,253,740	4,155,921	4,550,180	4,170,181	3,862,227
	2009	68	77.24	77.97	78.03	59.66	25,000	24,060	24,991	24,093	22,933	3,772,359	4,668,870	5,033,214	4,682,561	4,096,880
	2010	96	97.01	98.64	98.07	73.08	28,000	26,597	27,507	26,632	25,175	5,049,855	5,245,130	5,604,795	5,257,895	4,393,790
	2011	130	121.85	124.49	123.24	89.71	30,000	29,401	30,093	29,439	27,563	6,014,032	5,892,515	6,291,119	5,903,918	4,769,472
	2012	160	153.06	156.68	154.87	110.32	32,500	32,501	32,719	32,542	30,104	6,847,678	6,619,805	7,129,841	6,629,317	5,244,825
	2013	200	192.25	196.48	194.62	135.86	35,000	35,928	35,352	35,972	32,810	7,572,352	7,436,862	8,177,113	7,443,844	5,846,295
Forecasting	2014	–	241.48	304.70	244.58	206.75	–	39,716	40,509	39,763	38,757	–	8,354,764	11,304,702	8,358,449	7,570,295
	2015	–	303.31	375.99	307.36	255.38	–	43,903	42,973	43,955	42,022	–	9,385,960	13,786,732	9,385,430	8,788,732
	2016	–	380.98	460.42	386.26	315.64	–	48,532	45,326	48,587	45,498	–	10,544,432	17,471,898	10,538,593	10,330,431
	2017	–	478.53	558.75	485.41	390.33	–	53,649	47,548	53,709	49,199	–	11,845,889	23,508,446	11,833,442	12,281,157

* 1 USD = 21,323 VND (*Source* Vietcombank May 2014)

Table 5 Forecasting results for China, Korea and Japan visitors

Stages	Models	Actual China	GM(1,1)	VER	DGM(1,1)	DGM(2,1)	Actual Korea	GM(1,1)	VER	DGM(1,1)	DGM(2,1)	Actual Japan	GM(1,1)	VER	DGM(1,1)	DGM(2,1)
Model building	2005	752,576	752,576	752,576	752,576	752,576	317,213	317,213	317,213	317,213	317,213	320,605	320,605	320,605	320,605	320,605
	2006	516,286	389,604	849,385	397,603	783,343	421,741	365,020	349,183	368,178	311,625	383,896	344,678	343,471	345,934	322,113
	2007	558,719	485,640	974,125	495,029	863,409	475,535	401,264	385,271	404,102	297,812	411,557	371,606	368,866	372,710	325,664
	2008	650,055	605,349	1,140,918	616,329	980,811	449,237	441,107	426,206	443,530	278,986	392,999	400,638	397,214	401,558	330,181
	2009	527,610	754,565	1,375,338	767,351	1,152,961	362,115	484,907	472,903	486,806	253,324	359,231	431,937	429,040	432,639	335,924
	2010	905,360	940,562	1,728,971	955,378	1,405,389	495,902	533,055	526,516	534,305	218,346	442,089	465,682	465,003	466,126	343,228
	2011	1,416,804	1,172,407	2,323,751	1,189,480	1,775,531	536,408	585,984	588,523	586,438	170,670	481,519	502,063	505,938	502,205	352,516
	2012	1,428,693	1,461,401	3,533,931	1,480,944	2,318,281	700,917	644,169	660,852	643,657	105,684	576,386	541,286	552,920	541,077	364,327
	2013	1,907,794	1,821,630	7,338,238	1,843,826	3,114,129	748,727	708,131	746,066	706,460	107,106	604,050	583,574	607,361	582,957	379,347
Forecasting	2014	–	2,270,655	*Error*	2,295,628	5,992,270	–	778,444	970,440	775,390	*Error*	–	629,165	746,855	628,078	422,736
	2015	–	2,830,362	*Error*	2,858,136	8,501,401	–	855,738	1,121,418	851,046	*Error*	–	678,318	838,112	676,693	453,624
	2016	–	3,528,035	*Error*	3,558,479	12,180,608	–	940,708	1,310,967	934,083	*Error*	–	731,311	950,179	729,070	492,903
	2017	–	4,397,681	*Error*	4,430,430	17,575,531	–	1,034,115	1,555,279	1,025,224	*Error*	–	788,444	1,090,989	785,501	542,852

model in *China visitors* forecasting has sorted numbers to be over (as shown in Table 5). It has been building with parameters to be with seriously jumped numbers to 7 times of the actual value. Moreover, our strict range of MAPE (shown following) is set up to be fewer than 10% of error; so that the forecasting errors occurring for future (next 4 years) is wildly uncontrolled, and the researchers have regarded *Verhulst* model in this factor as "error" with its performance of not reflecting the reality.

DGM(2,1) in the section of *Korea visitors* is in downturn, which means its results to go down to the actual value. As shown in Table 5 and Fig. 11, it is 7 times lower than the actual value. Its parameters show the decrease to nearly zero of this factor if we continue to calculate with this model for the future of next 4 years forecasting.

From Tables 5, 6 and Figs. 12, 13 and 14, we show the growth trend of those tourism customers from Japan, USA and Taiwan with the common situations of double to triple in the researched time period.

5 Differences in results of proposed forecasting models

Before applying tests to see any significant differences among models, we check their correlation coefficients first. Tryon [21] described that the interpretation of the correlation coefficient is explained in more detail as follows. The correlation coefficient is always between -1 and $+1$. The closer the correlation is to ± 1, the closer to a perfect linear relationship. Its general meaning is shown in Table 7.

In fact, the more closely correlated the measures are, the higher the statistical power will be with fewer participants [22]. This is an important factor to consider, where sample sizes are generally small [23].

We mention here three factors (total revenue, domestic visitors and international visitors) in our study as examples to demonstrate the correlation coefficient of the forecasting models (Tables 8, 9, 10).

The results of Pearson correlation show that our forecasting models are correlated significantly that means the statistical tests will be powerful [24]. Then, we set up the null hypothesis and then we employ the *Friedman* test to see any significant differences among the forecasting models. After that, a post hoc test—*Wilcoxon*—is used to see how these differences are.

$\mathbf{H_0}$ There are no differences in results of forecasting models used in this study.

Here is the result of *Friedman* test using forecasting results in the *total revenue* section.

Table 6 True values and forecasting result for USA and Taiwan visitors

Stages	Models	Actual USA	GM(1,1)	VER	DGM(1,1)	DGM(2,1)	Actual Taiwan	GM(1,1)	VER	DGM(1,1)	DGM(2,1)
Model building	2005	333,566	333,566	333,566	333,566	333,566	286,324	286,324	286,324	286,324	286,324
	2006	385,654	397,254	378,304	397,338	358,215	274,663	269,575	297,550	270,176	286,073
	2007	412,301	403,750	404,887	403,814	393,439	314,026	285,663	309,683	286,172	285,451
	2008	417,198	410,351	419,311	410,395	414,220	303,527	302,711	322,838	303,115	284,606
	2009	403,930	417,061	426,754	417,085	426,481	271,643	320,776	337,149	321,061	283,454
	2010	430,993	423,880	430,494	423,883	433,714	334,007	339,919	352,777	340,070	281,886
	2011	439,872	430,810	432,349	430,791	437,982	361,051	360,205	369,912	360,204	279,751
	2012	443,826	437,854	433,263	437,813	440,500	409,385	381,702	388,782	381,530	276,844
	2013	432,228	445,013	433,712	444,949	441,985	398,990	404,482	409,665	404,119	272,885
Forecasting	2014	–	452,289	434,040	452,201	443,378	–	428,620	458,913	428,045	260,155
	2015	–	459,685	434,093	459,571	443,684	–	454,200	488,228	453,388	250,161
	2016	–	467,201	434,119	467,062	443,863	–	481,306	521,519	480,231	236,552
	2017	–	474,839	434,131	474,675	443,970	–	510,030	559,654	508,663	218,022

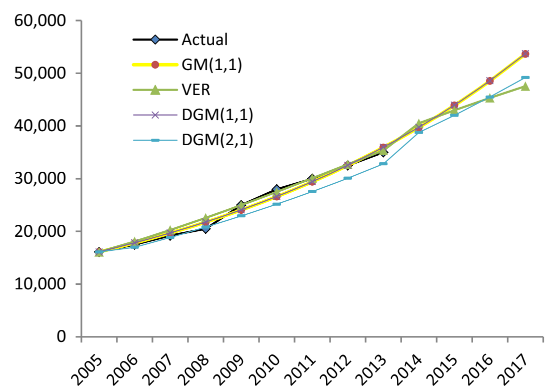

Fig. 7 Forecasting result for domestic visitors

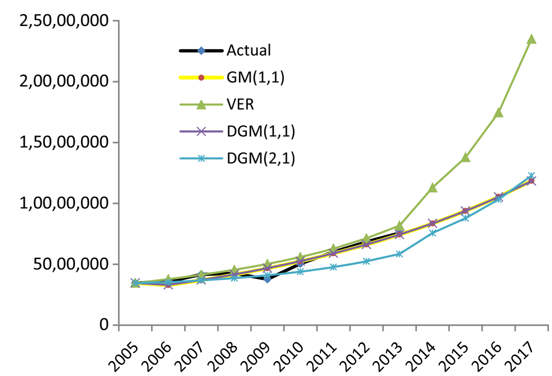

Fig. 9 Forecasting result for international visitors

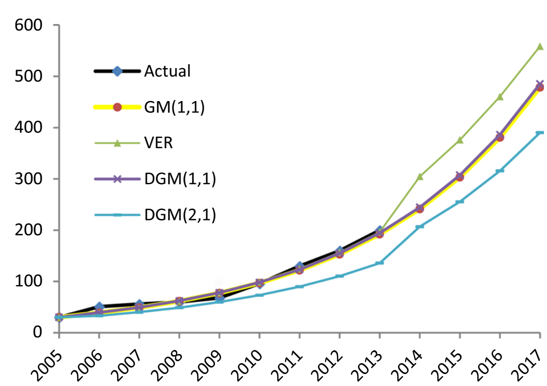

Fig. 8 Forecasting result for tourism revenue (by trillion VND)

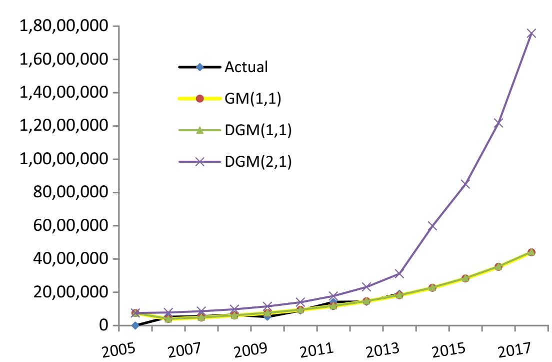

Fig. 10 Forecasting result for China visitors

From Table 11, the means of GM(1,1), Verhulst and DGM(1,1) for forecasting *total revenue* are much the same while DGM(2,1)'s is highest one.

The *Friedman* test result is shown in Table 12 ($\chi^2 = 29.2$, $df = 3$, $p = .000$), $p < 0.05$. That means the null hypothesis is rejected, i.e., there are significant differences among the results of forecasting.

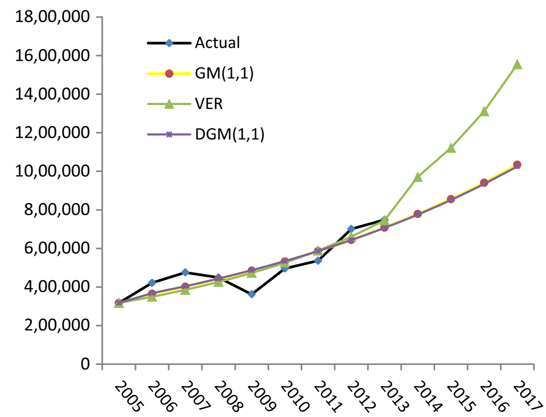

Fig. 11 Forecasting result for Korea visitors

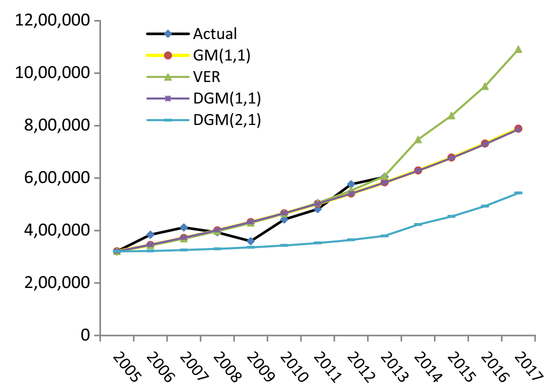

Fig. 12 Forecasting result for Japan visitors

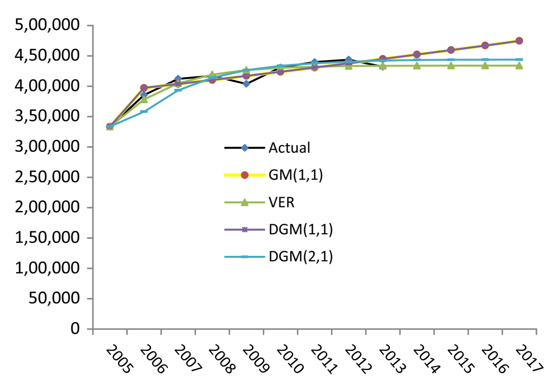

Fig. 13 Forecasting result for USA visitors

To further analysis, the post hoc test—*Wilcoxon*—is employed to find what and how these differences (see Table 13). In this section, we just summarize the only differences between DGM(2,1) and the other models because we see the result ($Z = 2.521$, $p = 0.012$; $p < 0.05$). Thus, there is significant difference between DGM(2,1) and the others in the forecasting results. This result is applied to the *total revenue* forecasting.

With the same process, we also see there are significant differences of DGM(2,1) and other models among

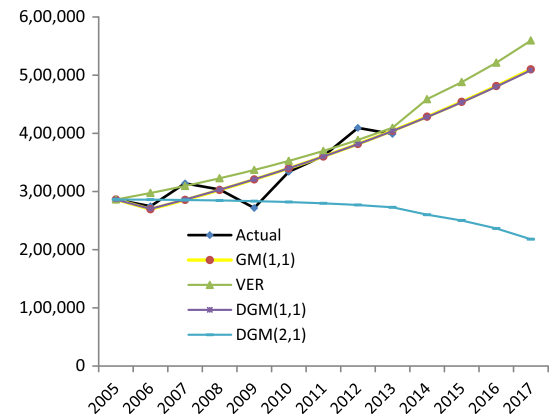

Fig. 14 Forecasting result for Taiwan visitors

Table 7 Pearson correlation coefficient

Correlation coefficient	Degree of correlation
>0.8	Very high
0.6–0.8	High
0.4–0.6	Medium
0.2–0.4	Low
<0.2	Very low

Table 8 Pearson correlation results for the four models of the *total revenue* factor ($N = 13$)

	GM(1,1)	Verhulst	DGM(1,1)	DGM(2,1)
GM(1,1)	1	.997**	1.000**	.997**
VER		1	.997**	1.000**
DGM(1,1)			1	.997**
DGM(2,1)				1

** $p < .01$, correlation is significant (two-tailed)

Table 9 Pearson correlation results for the four models of the *domestic visitors* factor ($N = 13$)

	GM(1,1)	Verhulst	DGM(1,1)	DGM(2,1)
GM(1,1)	1	.992**	1.000**	.998**
VER		1	.992**	.994**
DGM(1,1)			1	.998**
DGM(2,1)				1

** $p < .01$, correlation is significant (two-tailed)

the results of forecasting other factors in this study, i.e., *domestic visitors, international visitors and visitors from China, Korea, Japan, USA and Taiwan.*

In short, there exist some significant differences among forecasting models applied in this study and some small differences also. These differences are from results of DGM(2,1) compared with those from other models. Thus,

Table 10 Pearson correlation results for the four models of the *international visitors* factor ($N = 13$)

	GM(1,1)	Verhulst	DGM(1,1)	DGM(2,1)
GM(1,1)	1	.962**	1.000**	.977**
VER		1	.962**	.995**
DGM(1,1)			1	.976**
DGM(2,1)				1

** $p < .01$, correlation is significant (two-tailed)

the improved model DGM(1,1) performed very well in this case; at least, it has a close correlation with GM(1,1) and the others, except DGM(2,1).

6 Accurate inspection analysis of forecasting ability

So far, numerous methods exist for judging forecasting accuracy, and no single recognized inspection method exists for forecasting ability. Mean absolute percentage error (MAPE) is often used to measure forecasting accuracy. In the book of Stevenson [25], it stated out clearly MAPE is the average absolute percent error which measures of accuracy in fitted time series value in statistics, specifically trending.

$$\mathrm{MAPE} = \frac{1}{n}\sum \frac{|Actual - Forecast|}{Actual} \times 100;$$

$n:$ forecasting number of step

The parameters of MAPE state out the forecasting ability as follows:

- MAPE < 10% "Excellent"
- 10% < MAPE < 20% "Good"
- 20% < MAPE < 50% "Reasonable"
- MAPE > 50% "Poor"

Secondly, the **MSE** means squared forecast error can be decomposed as:

$$\mathrm{MSE} = \frac{1}{h+1}\sum_{t=s}^{s+h} (\hat{x}_{t-1}(1) - x_t)^2$$

(The smaller MSE, the better accuracy is)

The next step will be the development of MSE to its root one (**RMSE**). The root-squared forecast error (RMSE) depends on the scale of the dependent variable. It should be used as relative measure to compare forecasts for the same series across different models. The smaller the number, the better the forecasting ability of this model is—according to the RMSE criterion. "The use of the RMSE measure, or one of the other measures, to evaluate ex post forecasts is straightforward, and there is little more to be said about this" stated by Fair [26].

$$\mathrm{RMSE} = \sqrt{\frac{1}{h+1}\sum_{t=s}^{s+h} (\hat{x}_{t-1}(1) - x_t)^2}$$

Finally, to evaluate the ability of our available models used in this research, we apply mean absolute deviation (MAD). MAD is an average of the difference between the forecast and the actual values. Following is the formula:

$$\mathrm{MAD} = \sum_{i=1}^{n} |\mathrm{e}_i|$$

The smaller/lower value of MAD, the more accurate the forecast. One benefit of MAD is to compare the accuracy of several different forecasting techniques.

In this section, we apply the following models to test the accuracy level of forecasting the tourism demands in Vietnam based on the data collected from 2005 to 2013:

Table 14 shows in detail the ability to forecast of the available models. GM(1,1), Verhulst and DGM(1,1) show

Table 12 Test statistics

N	13
Chi-square	29.200
df	3
Asymp. sig.	.000

Friedman test

Table 13 Test statistics[b]

	DGM(2,1) versus other models
Z	−2.521[a]
Asymp. sig. (2-tailed)	.012

Wilcoxon signed-ranks test

[a] Based on negative ranks

Table 11 Descriptive statistics

	N*	Mean	Std. deviation	Mean Rank	Maximum
GM(1,1)	13	1.7116E2	142.24260	2.19	478.53
VER	13	1.9479E2	175.13936	3.42	558.75
DGM(1,1)	13	1.7333E2	144.35297	3.27	485.41
DGM(2,1)	13	1.3759E2	118.10924	1.12	390.33

* $n = 13$ (2005–2017)

Table 14 Evaluating models with tourism revenue forecasting errors *Source* calculated by authors

Models	GM(1,1)	Verhulst	DGM(1,1)	DGM(2,1)
MAPE	8.44%	8.39%	8.11%	33.26%
MSE	50.854	42.684	43.345	1055.554
RMSE	7.131	6.533	6.584	32.489
MAD	5.962	5.207	5.527	25.599
Evaluation	Good	*Excellent*	Good	Poor

Table 15 Evaluating models with domestic visitors forecasting errors. *Source* calculated by authors

Models	GM(1,1)	Verhulst	DGM(1,1)	DGM(2,1)
MAPE	2.65%	2.41%	2.68%	5.57%
MSE	6.67E+5	6.93E+5	6.68E+5	3.24E+6
RMSE	817.098	832.690	817.520	1801.433
MAD	659.808	547.011	666.737	1455.547
Evaluation	Good	*Excellent*	Good	Reasonable

Table 16 Evaluating models with international visitors forecasting errors. *Source* calculated by authors

Models	GM(1,1)	Verhulst	DGM(1,1)	DGM(2,1)
MAPE	6.02%	7.03%	5.88%	14.90%
MSE	1.38E+11	2.83E+11	1.38E+11	8.93E+11
RMSE	3.71E+05	5.32E+05	3.71E+05	9.44811.244
MAD	270,812.133	389,664.912	265,830.940	721,515.178
Evaluation	Good	Good	*Excellent*	Poor

a reliable method when their parameters of MAPE are lower than 10%. Moreover, the Verhulst model with MSE, RMSE and MAD parameters is less than others (see Table 14). DGM(2,1) is not chosen in this area since it performance for forecasting Vietnamese is under-expected. In fact, its MAPE is too high for forecasting at 33.26%. The other criteria are double or even triple to the evaluated model—Verhulst.

Table 15 summarizes the errors by using MAPE, MSE, RMSE and MAD to evaluate the ability of forecasting *domestic visitors* of the given models. It is obvious that GM(1,1) DGM(1,1) and Verhulst are good enough to forecast the number of domestic visitors when their MAPEs are only lower than 3% for the whole process. Again, the MAPE and MAD of Verhulst are much lower than GM(1,1) and DGM(1,1). However, their *MSE* and *RMSE* parameters are just likely equal among these three models, whereas DGM(2,1)'s are all higher to the advanced performance of Verhulst in this particular circumstance. Thus, DGM(2,1) in this case only shows as *reasonable* of forecasting. In short, applying GM(1,1), Verhulst and DGM(1,1) is more appreciate for best results and accuracy in this situation.

With the same explanation, Table 16 shows in detail the ability to forecast of the available models. GM(1,1), Verhulst and DGM(1,1) prove their abilities when their parameters of MAPE are low (<10%), while DGM(2,1) is not chosen in this area since its performance for forecasting is poor. By deeply analyzing, we can easily figure out that developed model from GM(1,1) to DGM(1,1) is advanced in the *International Visitors to Vietnam* forecasting. We rate it as *excellent*. The disappointed view goes to the built model DGM(2,1). Even though it also shows an acceptable result (e.g., 14.90% of MAPE; MSE, RMSE and MAD are closed to other models), this research is set up to be strict in the field of optimal accuracy. Thus, just a *poor* rating is evaluated for its performance in this area.

Table 17 shows GM(1,1) and DGM(1,1) are good enough for this situation of forecasting when their parameters of MAPE, MSE, RMSE and MAD are accepted. Compared to each other, the developed DGM(1,1) shows a little bit better than the original GM(1,1) with MAPE at 12.31 versus 12.95%; MSE (1.53E+10 and 1.6E+10); RMSE (123,718.042 vs. 126,648.602); MAD (94,377.848 vs. 96,654.611). Verhulst and DGM(2,1) are not chosen in this area since its performance for forecasting are poor. As we can see from Table 17, the MAPEs of these two models are very high—32.25 and 45.20%; also other criteria are high when a comparison with the good rates—GM(1,1) and DGM(1,1) is made in the task of forecasting *China Visitors*.

Experiencing the same situation is mentioned in Tables 18, 19 and 20, i.e., DGM(1,1) is a little bit better than GM(1,1)—the chosen ones; Verhulst shows the *reasonable* or *poor* rating together with DGM(2,1).

Making a comparison of four models to each other, it is clear to see the *"good" and "reasonable"* of evaluation to

Table 17 Evaluating models with China visitors forecasting errors. *Source* calculated by authors

Models	GM(1,1)	Verhulst	DGM(1,1)	DGM(2,1)
MAPE	12.95%	45.20%	12.31%	32.25%
MSE	1.6E+10	4.07E+12	1.53E+10	3.66E+11
RMSE	126,648.602	2,018,408.093	123,718.042	604,606.697
MAD	96,654.611	1,261,481.702	94,377.848	498,059.242
Evaluation	Good	Poor	Good	Poor

Table 18 Evaluating models with Korea visitors forecasting errors. *Source* calculated by authors

Models	GM(1,1)	Verhulst	DGM(1,1)	DGM(2,1)
MAPE	10.13%	10.46%	9.97%	597.84%
MSE	3,620,425,235.235	3,498,016,556.592	3,621,683,212.640	131,655,896,606.37
RMSE	60,169.970	59,144.032	60,180.422	362,844.177
MAD	49,553.955	46,899.420	49,261.437	281,891.738
Evaluation	Good	Reasonable	Good	Poor

Table 19 Evaluating models with Japan visitors forecasting errors. *Source* calculated by authors

Models	GM(1,1)	Verhulst	DGM(1,1)	DGM(2,1)
MAPE	6.67%	6.14%	6.66%	28.26%
MSE	1,234,284,145.572	1,114,518,595.065	1,234,404,714.325	15,284,320,370.017
RMSE	35,132.380	33,384.406	35,134.096	123,629.771
MAD	28,802.893	25,694.424	28,878.086	99,824.794
Evaluation	Good	Good	Good	Poor

Table 20 Evaluating models with USA visitors forecasting errors. *Source* calculated by authors

Models	GM(1,1)	Verhulst	DGM(1,1)	DGM(2,1)
MAPE	1.99%	1.58%	1.99%	2.50%
MSE	84,313,994.764	89,443,319.449	84,316,146.595	193,700,143.252
RMSE	9182.265	9457.448	9182.382	13,917.620
MAD	8340.163	6641.010	8339.205	9947.110
Evaluation	Excellent	Excellent	Excellent	Good

Table 21 Evaluating models with Taiwan visitors forecasting errors. *Source* calculated by authors

Models	GM(1,1)	Verhulst	DGM(1,1)	DGM(2,1)
MAPE	4.22%	5.57%	4.17%	18.49%
MSE	453,029,304.982	686,217,016.840	453,109,097.948	4,915,573,301.571
RMSE	21,284.485	26,195.744	21,286.359	70,111.150
MAD	13,703.745	18,995.140	13,562.767	51,420.420
Evaluation	Good	Good	Good	Poor

be chosen in forecasting tourism demand for Korea visitors. GM(1,1) and DGM(1,1) are rated "good" when Verhulst to be "reasonable." Once again, DGM(2,1) has "poor" forecasting.

Table 19 shows GM(1,1), Verhulst and DGM(1,1) are rated "good" when DGM(2,1) to be "poor". DGM(2,1) has always "poor" in this situation of forecasting (compared with others').

Through Table 20, we observe the outstanding in building forecasting model process. This time, four models GM(1,1) DGM(1,1), Verhulst and DGM(2,1) are very good for forecasting tourism demand for American visitors when their parameters of MAPE are really low (<2%). Other parameters including MSE, RMSE and MAD are very small and just a little different to each other. However, with the stated purposes of this study, only Verhulst is qualified due to its excellent performance in this case—forecasting the *USA Visitors to Vietnam.*

Finally, Table 21 shows GM(1,1), Verhulst and DGM(1,1) are good for forecasting when DGM(2,1) to be "poor".

For a brief evaluation, it is easy to see that GM(1,1), Verhulst and DGM(1,1) are good enough to forecast the number of visitors since their MAPE, MSE, RMSE and MAD are reliable for the whole process, while DGM(2,1) is not appreciated in the situation of forecasting tourism demands in Vietnam based on the above analyses, reasons and ratings.

7 Conclusions and implications

Tourism makes a significant contribution to the economy, and tourism market is also most rapidly growing in the world [27]. With the current trend toward the globalization of tourism industry, visitors prefer to seek destinations for lower costs and better service quality, which has led to the emergence of international tourism services and related tour arrangements. As for Asian countries, due to the increase demand of international visitors or rapid economic development (e.g., Vietnam, Thailand, and Singapore), the demand for overseas tour is also on the increase.

Thus, the purpose of this study is developing an easy and accurate method to optimize the predicting of demands for tourism. This study used the models of GM(1,1), Verhulst, DGM(1,1) and DGM(2,1) to test which models can enhance better forecasting results and minimum the predicated errors. The forecasting results show that GM(1,1), Verhulst and DGM(1,1) are good enough to forecast the total revenue of Vietnam tourism industry and the number of visitors since their MAPE, MSE, RMSE and MAD are reliable for the whole process, while DGM(2,1) is not appreciated in the situation of forecasting tourism demand in Vietnam.

The results of this study have several practical implications. First, this study provides effective methods for forecasting the international and domestic tourists visiting Vietnam and predicting the visitors of top countries that have sent the biggest number of them to Vietnam (e.g., China, Korea, Taiwan, Japan, and America) as well.

Second, in the case of the tourism revenue, which may continuously increase in the future, using the Verhulst model is evidently better than the others. Similarly, for international and domestic tourists the application of Verhulst and DGM(1,1) models is well done. Besides, the forecasting process has demonstrated that the number of visitors who come from China, Korea, Taiwan, Japan, and America continues to rise in the next four years. For those countries' visitors, DGM(2,1) is very poor for predicting the future tourist numbers, while the remaining three models GM(1,1), Verhulst, DGM(1,1) and DGM(2,1) are very appreciated in the same situation.

Finally, the result pointed that the tourism demands in Vietnam are growing rapidly; therefore, the governments must be well prepared for tourism industry and enhance relative fundamental construction for tourism markets.

8 Future research

In this study, we apply many methods to give out the best solution to forecast the numbers of tourists which are based on the statistics provided by the Vietnamese General Statistic to make prediction values for the next few years. The results which help enterprises to hit the target in the near future are shown with low tolerance proven by mean absolute percent error (MAPE). From this study, a useful method can be provided in the case of the Vietnam tourism and the results may shed insight into decision making concerning the direction of a firm, to improve economic efficiency and to determine the financial performance of the business now, and it is the basis for determining results of operations for production the following period.

Moreover, in the future, we suggest more research focus on the factors which may change the concepts of going traveling. Based on this study, researchers would figure out more ideas to change or increase the number of tourists coming to Vietnam.

Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interests regarding the publication of this paper.

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