Grey Group Model Forecasting of Quarterly Accounting Earnings

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Abstract: - Forecasting quarterly accounting earnings is an important task in prospective analysis and seasonality is an important phenomenon in those data's behavior. In this paper, we investigate the efficiency of applying grey group model to forecast the earning per share. Unlike traditional statistical model such as Foster Model, grey group model inheres not only easy to calculate but also few observations needed than statistics methods when model building. Furthermore, the model liberates the users from the sample data assumptions from statistics analysis such as identically independent distribution. A data sample with fifty firms trading on Taiwan Stock Exchange is employed here and the forecasting performances are compared with those obtained by Foster Model. The results demonstrate that the grey group model is a competitive and competent one in prospective analysis.

Key-Words: - Quarterly Accounting Earnings, Forecasting, Grey Group Model.

1 Introduction

Forecasting sales, earnings, and earnings per share are important tasks in prospective analysis. Quarterly accounting earning forecasts are of significant interest to investors, managers, financial analysts, and capital markets researchers [3]. The earnings per share (EPS) of a company may be influenced by many factors such as different industries, life cycle of their products, net sales, operating profit and non-operating revenues. Thus quarterly accounting earnings forecasting need the deeply understanding and estimating about the factors of forming earnings. However, for those who are unfamiliar with the behavior of earning data to understand how it tends to evolve through time, some statistical methods, for example, Box and Jenkins ARIMA models [2], Foster models [10] and Griffin models [11], are usually employed for the empirical study of forecasting quarterly earning per share. Furthermore, the classical technique for predicting a continuous target variable is the statistical ordinary least squares (OLS) regression model. The statistical regression model is assumption-full such as the target variable is normally distributed. When the latter is not met, the predictions are questionable. Furthermore, such models are treat the quarterly earning per share series as linear, which could not captured the characteristic of the nonlinearity discussed by several researches [15]

With rapid development in the study of forecasting, several comparative methodologies have been evolved in the past decades. One special technique, grey model (denoted as GM) [7, 8], has been applied successfully in forecasting the behavior of a system or a series. For examples, Chang et al. [4] propose a variable P value rolling grey forecasting model for Taiwan semiconductor industry production; Lai [13, 14] applied GM group model to forecast non-stationary seasonal and nonlinear time series; Li et al. [16] combine grey model and Markov chain to predict the number of Chinese international airlines; Several hybrid models based on Grey model are widely discussed and applied successfully in various fields such as factors analysis[24], decision making [17], risk estimation [18], Cross-Straots Trade[6] and other fields [5, 12, 20, 23].

The grey theory describes random variables with time factors and uses ‘color’ to represent the degree of uncertainty in a dynamic system. The number in the system is considered as “partly known”, “partly unknown”, “partly certain” and “partly uncertain in grey model, which are more reasonable for the situation of real world. If a system whose information is completely clear is called as a white system. Otherwise, if a system whose information is partly unknown or partly certain is called as a grey system [21]. The grey forecasting model is one of the applications of the grey theory. There are several advantages employing grey forecasting model to time series, such as easy to calculate and few observations needed than statistics methods when model building [7].

Notice that seasonal is an important phenomenon in those quarterly earning data’s behavior. It is present for more than just the retail companies that benefit from holiday sales. Seasonality also results from weather-related phenomena (e.g., for electric and gas utilities, construction firms, and motorcycle manufacturers), new product introduction patterns (e.g., for the automobile industry), and other factors. Analysis of the time series behavior of earnings suggests that at least some seasonality is present in nearly every major industry. For example, the quarterly accounting earnings of Taiwan Cement Corporation from the first quarter of 1998 until the fourth quarter of 2002 are shown in Fig. 1. One may observe that the quarter earning exhibit strong seasonality and the peak appears in the fourth quarter each year.

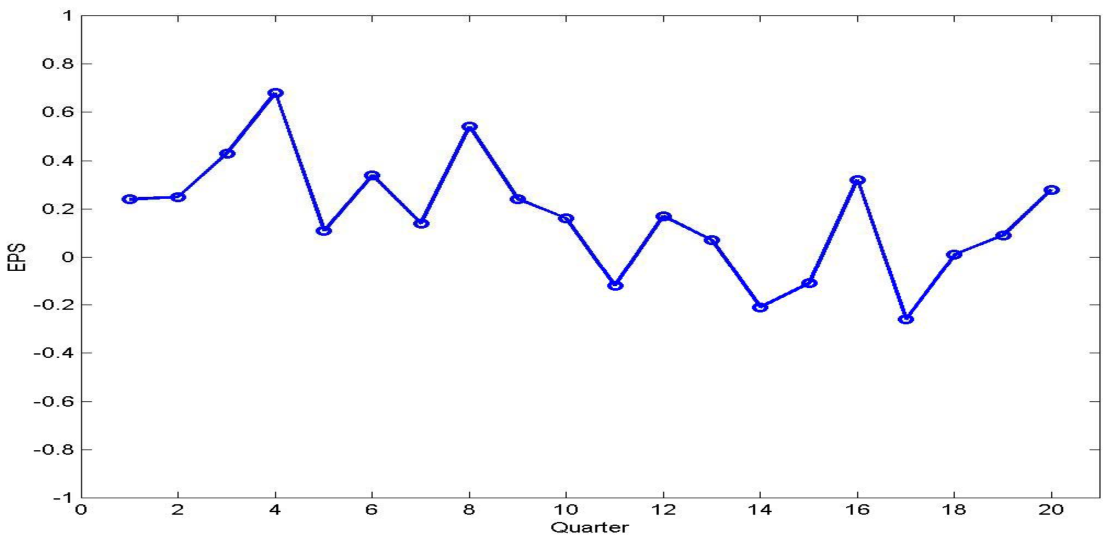

Fig. 1 The seasonal nature of the quarterly accounting earnings of Taiwan Cement Corporation from the first quarter of 1998 until the fourth quarter of 2002

Although Fan [9] proposed a hybrid method that combines the GM(1,1) model and the ratio-average de-seasonality method to forecast seasonal time series, no application of the grey forecasting model was reported on forecasting quarterly earning data. Thus, the purpose of this research is to investigate the efficiency and ability of applying GM(1,1) group model to forecast the earning per share. Furthermore, the empirical evidence to date indicates that the Foster or Griffin models dominate the forecasting abilities of other general Box-Jenkins models [1]. Therefore, the study compares the relative forecasting ability of the parsimonious Foster model with the forecasting ability of hybrid grey model in quarterly accounting earnings for a sample of firms trading on Taiwan Stock Exchange (TWSE).

The organization of this paper is as follow. In section 2, we make a brief describe of data, the linear models and grey group model. Section 3 compares the forecast accuracy of grey model to that of the Foster model. In section 4, some concluding remarks are made.

2 Quarterly earnings forecast models

The model used in this study consists of three stages: data preparation, Grey Group model and foster model established, and validation. Data preparation includes task such as data cleaning, completeness and rearranging. Then the second stage of models construction can be conducted by utilized those observations. The validation step confirms with validations data set.

2.1 Data

Quarterly earnings per share data were collected from the value line data base for firms actively trading on the Taiwan Stock Exchange (TWSE). There are two criteria to choose these firms. First, the firms must be listed in the TWSE Taiwan Index Series Compiled by FTSE group, such as TSEC Taiwan 50 Index, TSEC Taiwan Mid-Cap 100 Index, TSEC Taiwan Technology Index and TSEC Taiwan Dividend Index. FTSE is a world-leader in the creation and management of over 120,000 equity, bond and alternative asset class indices, thus the firms listed in these compiled indexes are of clear rules that are publicly available and which govern index management in all foreseeable eventualities. The second criterion dictated that each firms have a sufficiently lengthy time series of quarterly earnings per share data for estimation and valuation purposes. Furthermore, the data had to include the entire period from the first quarter of 1996 until the fourth quarter of 2007. According to the criteria described above, 50 firms listed in TWSE were selected with a total of 48 observations for each firm. In this research, all data are collected from the database of CMoney Investment Decision Support System.

Table 1 shows the descriptive statistics of the quarterly earnings per share data of 50 firms in this study. The 50 firms listed in TWSE are shown in appendix.

Table 1 Descriptive statistics of quarterly earnings per share data

Summary statistics			
Mean	0.249	Kurtosis	41.740
Median	0.210	Skewness	-2.370
Mode	0.170	Minimum	-8.700
Standard deviation	0.542	Maximum	3.770

2.2 The Foster model

In this subsection, we first describe the Foster model, which is usually employed for the empirical study of forecasting quarterly earning per share.

Let to denote earnings per share (or EPS) for quarter t, then the Foster models for EPS forecasting take the following form:

$$(Q_t - Q_{t-4}) = \alpha + \beta(Q_{t-1} - Q_{t-5}) + \varepsilon_t \quad (1)$$

, where and are parameters to be estimated and is random noise on the quarter.

Note that equation (1) is a simple regression model with the dependent variable $(Q_t - Q_{t-4})$ and the independent variable $(Q_{t-1} - Q_{t-5})$. Thus, to estimate those parameters, prior earnings data must first be expressed in term of year-to-year changes. Then using the processed data, the coefficients can be estimated by a least square approach or standard maximum likelihood approach.

Research has produced models that forecast earning per share based only on prior quarters' observations. Although such linear regression models are not used by many analysts, who have access to much more information than such simple models contain. However, the models are useful for helping those unfamiliar with the behavior of earnings data to understand how it tends to evolve through time [19].

In this study, the sample data described in subsection 2.1 will be used to compare the forecasts obtained from grey group model.

2.3 Grey group model

Given the non-negative series

$y^{(0)} = \{x^{(0)}(i), i = 1,2,...N\}$

A GM(1,1) is the solution of the psudo difference equation formed as

$$\frac{dy^{(1)}}{dt} + az^{(1)} = b \qquad (2)$$

,where

$$z^{(1)}(i) = \frac{1}{2}(y^{(1)}(i) + y^{(1)}(i-1))$$

for $2 \le i \le N$.

And $y^{(1)}(i)$ is accumulated generating sequence by using the one accumulated generating operation (1-AGO). Accumulated generating operation is one of the important ideal in Grey Theory because it can outline the series behaviours. Practically, the 1-AGO may reduce the noise embedded in the input data from statistics and can be expressed as:

$$x^{(1)}(i) = \sum_{i=1}^{N} x^{(0)}(i) \qquad (3)$$

, for $2 \le i \le N$.

For example, if

$y^{(0)} = \{x^{(0)}(i), i = 1,2,...5\} = \{3,5,4,6,5\}$

Then

$y^{(1)} = \{x^{(1)}(i), i = 1,2,...5\} = \{3,8,12,18,23\}$

by 1-AGO transfering.Fig.2 indicates the $y^{(0)}$ and $y^{(1)}$ respectively. One may find out $y^{(1)}$ is more regular or smooth then $y^{(0)}$. In fact, functions derived from 1-AGO transformation of original series are always well fitted to exponential functions, from which it is relatively easy to obtain a differential equation of the grey system as in equation (2).

The parameters a and b in (2.1) can be obtained by least square method as

$$\begin{bmatrix} a \\ b \end{bmatrix} = (B^T B)^{-1} B^T y \qquad (4)$$

, where $B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \\ -z^{(1)}(N) & 1 \end{bmatrix}$

and

$y = \begin{bmatrix} y^{(0)}(2) \\ y^{(0)}(3) \\ \vdots \\ y^{(0)}(N) \end{bmatrix}$.

Then $\hat{x}^{(0)}(i)$ is obtained by

$$\hat{x}^{(1)}(i) = (x^{(0)}(1) - \frac{b}{a})e^{-a(i-1)} + \frac{b}{a},$$

$i = 2,3,..., N$

(5)

and the estimate of $x^{(0)}(i)$, denoted by $\hat{x}^{(0)}(i)$, is

$$\hat{x}^{(0)}(i) = \hat{x}^{(1)}(i) - \hat{x}^{(1)}(i-1),.$$

$i = 2,3,..., N$.

(6)

, where

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

Equation (6) is inverse accumulated generating operation (inverse-AGO), which could obtain the estimated sequence of $\hat{y}^{(0)}$.

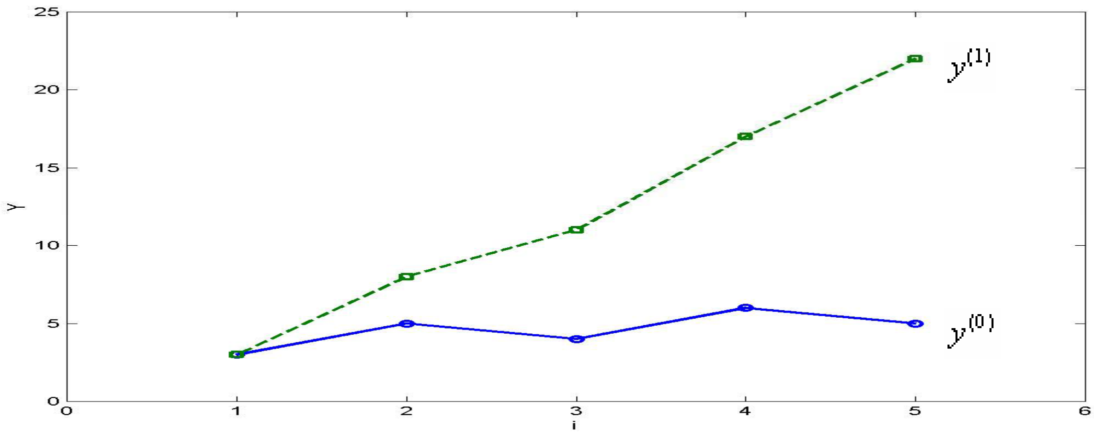

Fig. 2 Original sequence ($y^{(0)}$) and the sequence derived from 1-AGO transformation ($y^{(1)}$)

Assume $y^{(0)}$ is seasonal with seasonal period p. To analyze the series, it is helpful to arrange the series in a two-dimensional table according to the period and season as shown on Table 2. If $N = n \times p$, then a GM(1,1) group model for modelling $y^{(0)}$ includes the following steps:

1. Arrange $y^{(0)}$ into a two-dimensional table according its seasonal period p as shown in Table 1.
2. Define the sub-sequence ss_i as follow:
$$ss_i = \{ x^{(0)}(k), k = (m-1)\cdot p + i, \quad m = 1,2,...,n-1\},\ 1 \le i \le p. \tag{7}$$
3. Re-index subsequence ss_i as
$$ss_i = \{x^{(0)}(k), x^{(0)}(p+k), x^{(0)}(2p+k),... ,x^{(0)}((n-1)p+k)\} = \{x^{(0)}_{ss_k}(1), x^{(0)}_{ss_k}(2), x^{(0)}_{ss_k}(3),..., x^{(0)}_{ss_k}(n)\}$$
, where $1 \le i \le p$ (8)
4. Utilizing n observations in each subsequence ss_i to construct GM(1,1). Then p GM(1,1)s are constructed and named as GM(1,1) group model.

The forecasts of $x^{(0)}(t)$, $N < t \le N + p$ thus can be obtained by the following formula:

$$\hat{x}^{(0)}(t) = \begin{cases} \hat{x}^{(1)}_{ss_1}(t) - \hat{x}^{(1)}_{ss_1}(t-1), & \text{if } REM(\frac{t}{p}) = 1 \\ \hat{x}^{(1)}_{ss_2}(t) - \hat{x}^{(1)}_{ss_2}(t-1), & \text{if } REM(\frac{t}{p}) = 2 \\ \cdots & \cdots \\ \hat{x}^{(1)}_{ss_p}(t) - \hat{x}^{(1)}_{ss_p}(t-1), & \text{if } REM(\frac{t}{p}) = 0 \end{cases}$$

, where

$$\hat{x}^{(1)}_{ss_i}(t) = (x^{(1)}_{ss_i}(1) - \frac{b_{ss_i}}{a_{ss_i}})e^{-a_{ss_i}(k-1)} + \frac{b_{ss_i}}{a_{ss_i}} \tag{9}$$

. a_{ss_i}, b_{ss_i} is the parameters vector derived from the GM(1,1) model with subsequence ss_i . And the symbol $REM(t/P)$ denotes the remainder of t/P.

Note that $m = 4$ is the smallest number for grey model construction and $p = 4$ is the period of the Quarterly Accounting Earnings series.

Table 2 Arrange the seasonal time series into a two-dimension table with period 4

	1	2	3	4
	$x^{(0)}(1)$	$x^{(0)}(2)$	$x^{(0)}(3)$	$x^{(0)}(4)$
	$x^{(0)}(p+1)$	$x^{(0)}(p+2)$	$x^{(0)}(p+3)$	$x^{(0)}(p+4)$
	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$x^{(0)}((n-1)\cdot p+1)$	$x^{(0)}((n-1)\cdot p+2)$	$x^{(0)}((n-1)\cdot p+3)$	$x^{(0)}((n-1)\cdot p+4)$

The series must satisfy the condition of non-negative while applying grey forecasting model [7, 8]. However, in this research, the quarterly accounting earnings data may be negative because of the loss of operating profit or sales. Thus we may transfer these negative series into positive by mapping generation operation [22]. There are several mapping generation operations. The first one is that one may shift the original series by adding a constant number, which could guarantee the original series are positive. It can be expressed as

$$y^{(0)} = \{x^{(0)}(i) + C, i = 1,2,...N\} \tag{10}$$

, where C is the constant so that $y^{(0)}$ is positive for all elements in $y^{(0)}$.

The second one is to map the original series into am exponential function, which also could make sure the transferred series are positive. It can be expressed as

$$y^{(0)} = \{d^{e\cdot x^{(0)}(i)}, i = 1,2,...N\} \tag{11}$$

, where $d, e \ge 0$.

After accomplishing the grey model construction and forecasting, one may de-transfer these series by subtracting the constant we added or by operating the inverse mapping.

For the convenient, in this our research we apply equation (10) to transfer the series with negative values in it.

3 Comparing quarterly earnings forecasts

In order to compare the forecasting abilities and forecasting performance, each of the linear time series Foster model and the grey group model are established by using the in-sample data from the first quarter of 1996 until the fourth quarter of 2006. The in-sample data are used to estimate the parameters of Foster model and grey group model. After the parameters are obtained, the series from the first quarter of 2007 until the fourth quarter of 2007 are reserved as a post-sample, which is used to evaluate and compare the one step ahead (one year) forecasting abilities of both models at each company. And the following statistics are used to compare the forecasting performance:

1. Mean square error

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(x^{(0)}(i) - \hat{x}^{(0)}(i))^2 \qquad (12)$$

2. Mean absolute error

$$MAE = \frac{1}{n}\sum_{i=1}^{n}\left|x^{(0)}(i) - \hat{x}^{(0)}(i)\right| \qquad (13)$$

To show the availability of grey group model, the in-sample series from the first quarter of 1996 to the fourth quarter of 2006 and those predicted with grey group model and traditional Foster model are compared in the left hand side of Table 3. Note that the in-sample series are used to parameters estimated and the in-sample MSE and MAE indicate the performance of model fitting. The MSE and MAE of one-year-ahead forecasts are also showed on the right hand side of Table 3.

Table 3 shows the average in-sample square error and absolute error of Foster model are 0.3455 and 0.3313 respectively. On the other hand, the results predicted by grey group model have the in-sample mean square error 0.1629 and mean absolute error 0.2108, which are significantly smaller than those obtained by Foster model. The results clearly show that the linear Foster model does not fit the series well.

For the post-sample forecasts, the mean square error and the mean absolute error of Foster model are smaller than those of grey group model. However, the post-sample errors differences between grey group model and Foster model are not significant and could be roughly accepted by the users who are unfamiliar in quarterly earnings forecasts. Note that the observations we used to establish grey group model and Foster model are 44 (11 years) respectively for each firms.

As we know, there are several advantages employing grey model to time series forecasting, such as easy to calculate and few observations needed than statistics methods when model building. Four observations are the smallest requirement for GM(1,1) model construction [7]. Too many observations way increase the model building cost. Thus the chosen of a proper amount of observations while constructing the grey model is an important issue.

To investigate the proper amount of observations and the forecasts performance while grey model building, we discard the longest four observations (one year observations) step by step to establish the grey group models. The mean square error and mean absolute error of the forecasting performances are calculated according to the different data length. Figure 3 and Figure 4 show the in-sample and post-sample mean square error and mean absolute error with different data lengths respectively. In Figure 3, one may find out that the mean square error and mean absolute error look like reversed V. We may conjecture that that the improper amount of data lengths in grey group quarterly earnings forecasting models construction lie in between 6 to 8 years. On the other hand, Figure 4 indicates that the post-sample mean square error and mean absolute error are lowest with 9 years data lengths. In this research, we may conclude that the proper amount of data lengths in grey group quarterly earnings forecasting model are nine years. Table 3, Figure 3 and Figure 4 demonstrate that the grey group model is a compatible one in prospective analysis.

Table3 Forecasting Comparisons of Grey Group Model and Foster Model

	In-sample		Post-sample	
	Grey group Model	Foster Model	Grey group Model	Foster Model
MSE	0.1629	0.3455	0.2296	0.1956
MAE	0.2108	0.3313	0.3324	0.3007

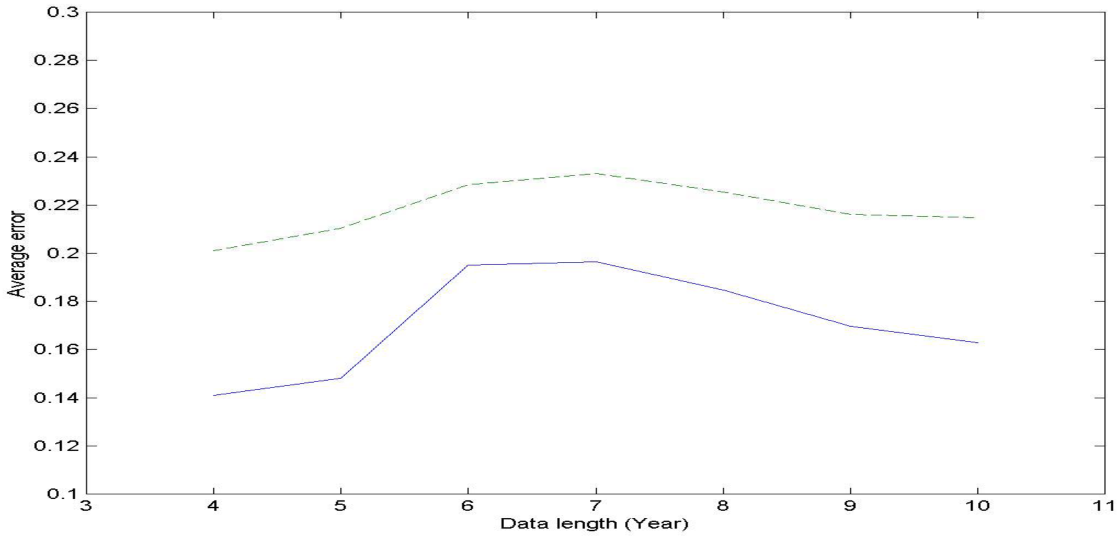

Fig. 3 Grey group model in-sample MSE (solid line), MAE (dash line) vs. Different data length

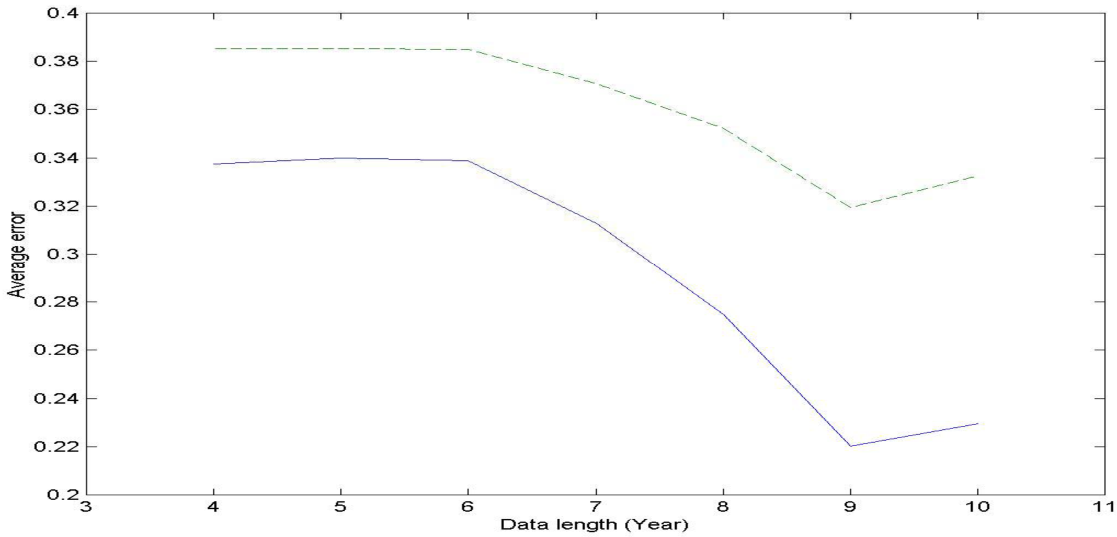

Fig. 4 Grey group model post-sample MSE (solid line), MAE (dash line) vs. Different data length

4 Conclusion

Forecasting represents the first step of prospective analysis, and serves to summarize the forward-looking view that emanates from business strategy analysis, accounting analysis, and financial analysis. In this study, we investigate the efficiency of

GM(1,1) group model on forecasting the earnings-per-share. Empirical study indicates improper amount of observations is not helpful to reduce the forecasting errors but increasing the cost of model construction. Furthermore, the in-sample and post-sample forecast performances also show the grey group model with the proper amount of observations is a competitive and competent method for the non-stationary seasonal time series analysis, forecast and control. Not only do the advantages of the grey group model inhere the ability of forecasting but also the characteristics of easy calculating and few observations necessary. The grey group model has also liberated the users from the procedures of the model-based selection and the sample data assumptions in statistics analysis. Analyzing the seasonal time series, we can conclude that the grey group model suggests a competitive method for the system analysis, forecast and control.

Despite of the efficiency of the grey group model, there remain some problems to be solved. For example: (i) What are the appropriate mean factors in grey group model? (ii) How many observations are appropriate for model building in different application cases?

However, in order to get an appropriate seasonality for quarterly accounting earnings time series, we hope the grey group model will be a worthwhile approach and will stimulate more future empirical work in time series analysis.

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Appendix

The Code, Company Name and Industry of the selected 50 firms listed in TWSE

No.	Code	Company Name	Industry
1	1101	Taiwan Cement Corp.	Cement
2	1104	Universal Cement Corp.	Cement
3	1108	Lucky Cement Corp.	Cement
4	1109	Hsing Ta Cement Co.,Ltd	Cement
5	1110	Southeast Cement Co., Ltd.	Cement
6	1201	Wei Chuan Foods Corp.	Food
7	1210	Greatwall Ent	Food
8	1215	Charoen Pokphand Enterprise (Taiwan) Co., Ltd.	Food
9	1303	Nan Ya Plastics Co.	Plastics
10	1314	China Petrochemical Development Corp.	Plastics
11	1326	Formosa Chemicals & Fibre Corp.	Plastics
12	1402	Far Eastern Textile Ltd.	Textiles
13	1440	Tainan Spinnung Co., Ltd.	Textiles
14	1503	Shihlin Electric & Engineering Corp.	Electric Machinery
15	1512	Jui Li Enterprise Co., Ltd.	Electric Machinery
16	1603	China Wire & Cable Co., Ltd.	Electrical and Cable
17	1608	Hua Eng Wire & Cable Co., Ltd.	Electrical and Cable
18	1609	Ta Ya Electric Wire & Cable	Electrical and Cable
19	1612	Hong Tai Electric Industrual Co., Ltd.	Electrical and Cable
20	1613	Tai-I Electric Wire & Cable Co., Ltd.	Electrical and Cable
21	1704	Lee Chang Yung Chemical Industry Corp.	Chemical
22	1710	Oriental Union Chemical Corp.	Chemical
23	1907	Yuen Foong Yu Ppaper Mfgco., Ltd.	Paper, Pulp
24	2006	Tung Ho Steel Enterprise Corp.	Iron and Steel
25	2015	Feng Hsin Iron & Steel Co., Ltd	Iron and Steel
26	2023	Yieh Phui Enterprise Co., Ltd.	Iron and Steel
27	2104	China Syntheyic Rubber Corp.	Rubber
28	2105	Cheng Shin Rubber Ind., Co., Ltd.	Rubber
29	2303	United Micro Electronics Corp.	Semiconductor
30	2311	Advanced Semiconductor Engineering,Inc.	Semiconductor
31	2325	Solocon Ware Precision Indutries Co. Ltd.	Semiconductor
32	2337	Macronix International Co., Ltd	Semiconductor
33	2338	Taiwan Mask Corp.	Semiconductor
34	2340	Opto Tech Corp.	Optoelectronic
35	2374	Ability Enterprise Co., Ltd.	Optoelectronic

No.	Code	Company Name	Industry
36	2504	Goldsun Development & Construction Co., Ltd.	Building Material and Construction
37	2607	Evergreen International Storage & Transport	Shipping and Transportation
38	2612	Chinese Maritime Transport Ltd.	Shipping and Transportation
39	2704	The Ambassador Hotel, Ltd.	Tourism
40	2823	China Life Insurance Company, Ltd.	Financial and Insurance
41	2884	E.Sun Financial Holding Company, Ltd.	Financial and Insurance
42	2885	Yuanta Financial Holdings	Financial and Insurance
43	2887	Taishin Financial Holding Co., Ltd.	Financial and Insurance
44	2889	Waterland Financial Holdings	Financial and Insurance
45	2903	Far Eastern Department Stores Ltd.	Trading and Consumers' Goods Industry
46	9907	Ton Yi Industrial Corp.	Other
47	9917	Taiwan Secom Co., Ltd.	Other
48	9933	Ctci Corporation	Other
49	9945	Ruentex Development Co., Ltd.	Other
50	9907	Ton Yi Industrial Corp.	Other