Time Series Moving Average, Smoothing Analysis, Forecasting Analysis and Evaluation for Natural Gas Consumption

Prabodh Kumar Pradhan
Assistant Professor, Regional College of Management, Bhubaneswar

Sunil Kumar Dhal
Associate Professor, Sri Sri University, Cuttack

Nilayam Kumar Kamila
Principal Associate, Capital One, Wilmington, USA

Abstract

Natural Resources is a limited resource and its optimal usage is at most priority now a day as we are approaching towards the run-out situation for these natural resources. As we aware the forecasting is a major factor for the natural resource usage optimization and the oversupply or over usage is a major concern for its optimized usage. We analyses the forecasting models based on time series and compare the results with actual demand to trace the result difference between the actual and forecasted results. The evaluation method and the graphical interpretation shows a clear impression about the natural gas forecasting and would be considered as a true awareness of the existing forecasting models.

Keywords: Natural Gas, LPG Consumption, Time Series, Natural Gas Forecasting

Introduction

Natural Gas include Petroleum gas e.g.LPG (Liquified Petroleum Gas) which available in market in two types e.g. domestic LPG and commercial LPG. Domestic LPG has the higher usage than commercial LPG [1]. This LPG is extracted in various complex process [2] and transported to different states and cities of the nation for domestic and commercial usages. This usage runs with the demand and supply mechanism [5] and a forecasting model is executed for meeting each states' demand. Without demand forecasting models results, the natural gas supply will be either over supplied or under supplied. There are multiple number of time series models used for demandforecasting. In this paper, we focused on moving average method.

The organization of this article is a s follows. In Section 2, we discuss briefly about the moving average method. The data analysis and moving average calculation is shown in section 3. In Section 4, we show the results through graphical representation. Section 5 concludes our work.

Time Series Analysis

Time series analysis is a method for forecasting the future data from a time series data. The time series calculates the future data from the existing input data. For example, if there are sales data for a number of months or number of years, then the next successive month(s) or successive year(s) could be calculated through the time series methods. There are multiple number of time series methods, and here we enlisted few of them.

a. Moving Average
b. Smoothing Analysis

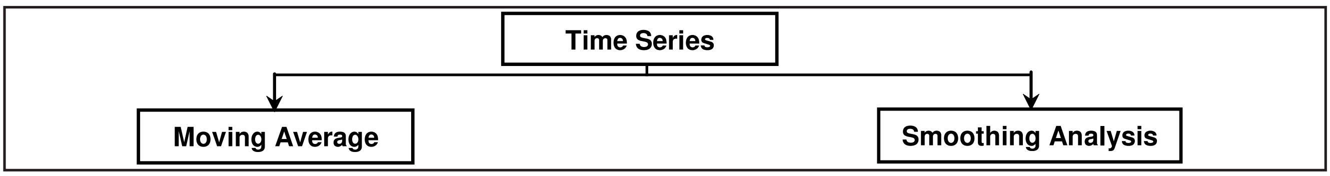

Figure 1: Time Series Analysis Methods

Here in this article we'll briefly discuss each method and in next section, we'll apply the methods on our natural gas consumption data so as to find a best fit model.

A. Moving Average

Moving average is the most popular and simple method for forecast data evaluation. The past data average is taken into consideration for evaluating the future data. For example, the last 3 months sales average is the sales forecast data for the 4th month. This 2 months is known as lagging period. There are two types of moving average method e.g. SMA (simple moving average) and EMA (Exponential Moving Average). As name suggests, Simple Average is the average of the past time data. In case of EMA, bigger weights given to the recent past time data than older past data.

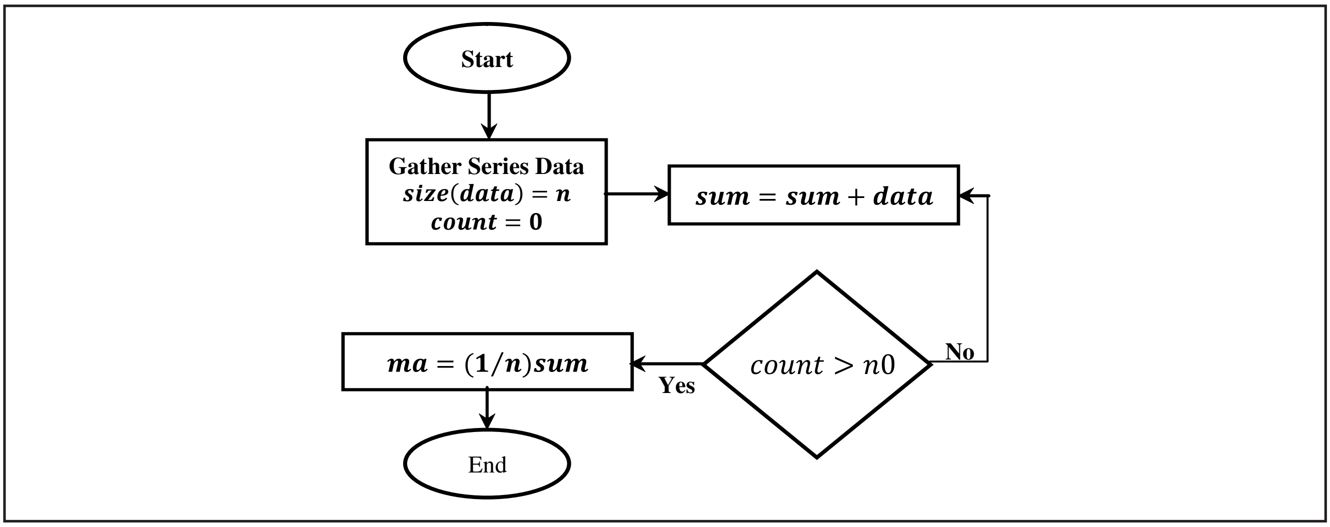

Figure 2: Moving Average Flow Model

Let the data set for 1st time interval till t-time interval we have as follows.

$$Y = \{y_1, y_2, y_3, \dots\dots\dots y_t\}$$

So, the t+1- time, the moving average is

$$y_{t+1} = \frac{1}{n}(y_t + y_{t-1} + \cdots + y_{t-n+1})$$

Similarly, for t+2 – time, the moving average can be calculated as

$$y_{t+2} = \frac{1}{n}(y_{t+1} + y_t + \cdots + y_{t-n+2})$$

Hence for t+m time interval, the moving average is

$$y_{t+m} = \frac{1}{n}(y_{t+m-1} + y_{t+m-2} + \cdots + y_{t-n+m})$$

Algorithm:movingAverage

Initialization: *Gather the data for which forecasting to be evaluated.*

$$Y = \{y_1, y_2, y_3, \dots\dots\dots y_t\}$$

n: number of days/weeks/months/years

m: till the number of period data to be forecasted

for $i = 1$ *to* m *do*

  $y_{t+i} = 0$

  for $j = 0$ *to* $n - 1$ *do*

    evaluate $y_{t+i} = y_{t+i} + y_{t-j}$

  done

  evaluate $ma = (1/n)sum$

done

B. Smoothing Analysis

The main difference between moving average and smoothed analysis method is the weight associated with the data. In case of moving average, the average of previous data is taken into consideration to evaluate the future forecast data. In case of the Smoothing analysis, the weight $(0 < \propto < 1)$ is given to the previous time data and the remaining weight $(1 - \propto)$ is given to the evaluated current future data(f_i). The average of the complete actual data set is treated as f_1. The basic flow model of evaluation of the Smoothed analysis method is shown in figure 3

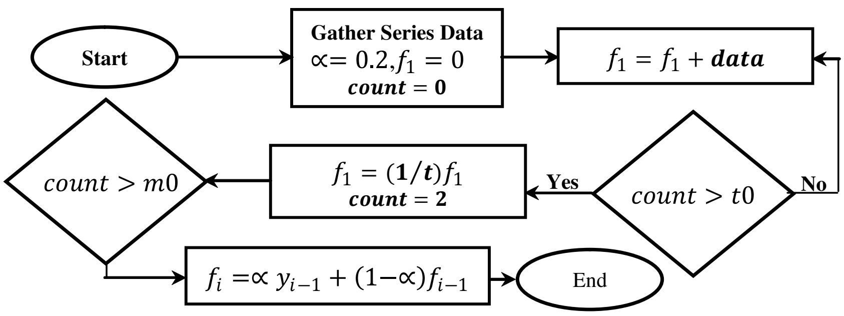

Figure 3: Smoothing Analysis Flow model

Here is the complete evaluation process for the Smoothed analysis method.

The forecast at period t+1 could be calculated as the below formula.

$$f_{t+1} = \propto y_t + (1-\propto) f_t$$

Similarly, the forecast at period t is calculated as per the below formula

$$f_t = \propto y_{t-1} + (1-\propto) f_{t-1}$$

So, if we continue, then after t-2 iteration, we'll get the following

$$f_{t-(t-2)} = f_2 = \propto y_1 + (1-\propto) f_1$$

Where f_1 is the average i.e. $f_1 = \frac{1}{t}(y_1 + y_2 + \cdots + y_t)$

Algorithm: smoothingAnalysis

Initialization:*Gather the data for which forecasting to be evaluated.*

$$Y = \{y_1, y_2, y_3, \dots \dots \dots y_t\}$$

$$\propto = 0.2,\ f_1 = 0$$

$for\, i = 1\ to\ t\, do$

$$f_1 = f_1 + y_i$$

done

$$f_1 = \frac{1}{t} f_1$$

$for\, i = 2\ to\ m\, do$

$$f_i = \propto y_{i-1} + (1-\propto) f_{i-1}$$

done

Forecasting DataError Evaluation

In each of the model, we evaluate the errors which are presented in the graph for the visual presentation.Let's illustrate an example of the year 2012 for the domestic usage of liquified petroleum gas for the state of Odisha, India.

A. Natural Gas Consumption Moving Average Forecasting & Error Analysis

The 3-months moving average method is applied for the year 2012. The average of January through March is taken and forecasted as the April 2012 data. The absolute error is calculated followed by absolute percentage of error.

Table 1: Actual Data and MA Forecast Evaluationfor 2012 LPG Consumption

Months	Year 2012	MA	Absolute Error	Abs % Error
Jan	16425			
Feb	16293			
Mar	16682			
Apr	14850	16466.66667	1616.666667	10.88664422
May	17098	15941.66667	1156.333333	6.762974227
Jun	16348	16210	138	0.844139956
Jul	17413	16098.66667	1314.333333	7.548000536
Aug	17848	16953	895	5.014567459
Sep	17123	17203	80	0.467207849
Oct	16610	17461.33333	851.3333333	5.12542645
Nov	16824	17193.66667	369.6666667	2.197257886
Dec	16648	16852.33333	204.3333333	1.22737466

In figure 6, the actual vs forecasted Moving Average(MA) value for the year 2012 is compared. The error percentage is found with the range from 0.46 – 10.88.

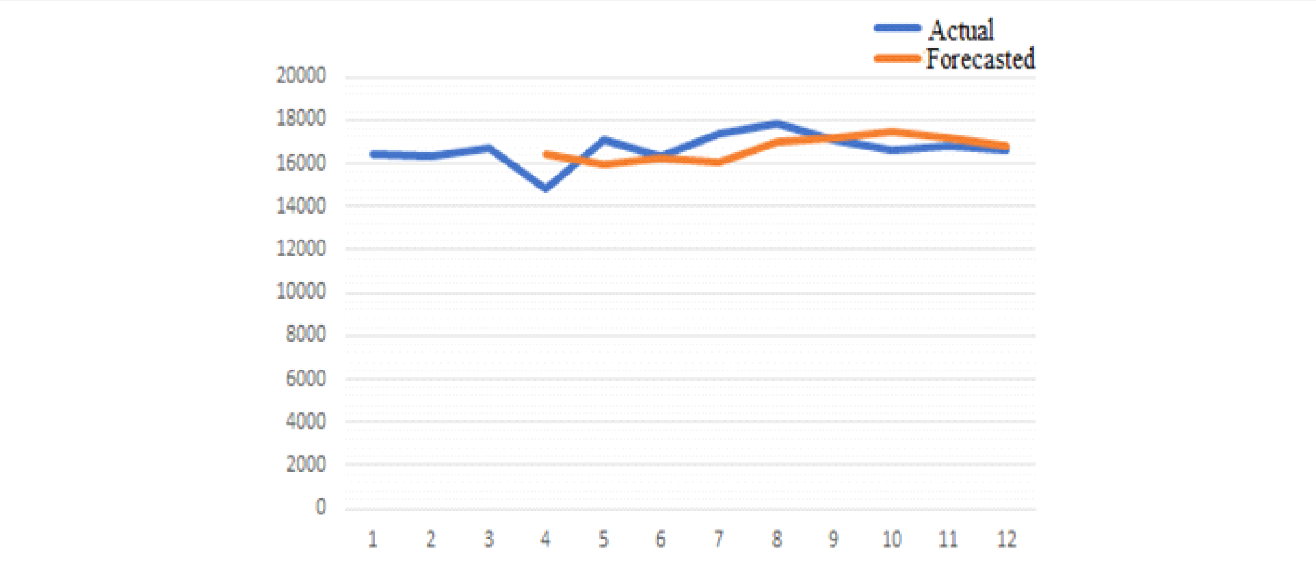

Figure 4: Comparison of Actual Vs MA Forecasted for 2012 LPG Consumption Data Set

In below table, we have taken the LPG Domestic gas consumption data for the year 2013 in the Indian state Odisha. The same moving average is calculated and listed from April – December 2013.

Table 2: Actual Data and MA Forecast Evaluationfor 2013LPG Consumption

Months	Year 2013	Moving Average	Absolute Error	Abs % Error
Jan	16449			
Feb	15409			
Mar	17732			
Apr	16092	16530	438	2.721849366
May	16428	16411	17	0.10348186
Jun	15259	16750.66667	1491.666667	9.775651528
Jul	18287	15926.33333	2360.666667	12.90898817
Aug	17715	16658	1057	5.966694891
Sep	17047	17087	40	0.234645392
Oct	18412	17683	729	3.959374321
Nov	19536	17724.66667	1811.333333	9.271771772
Dec	19030	18331.66667	698.3333333	3.669644421

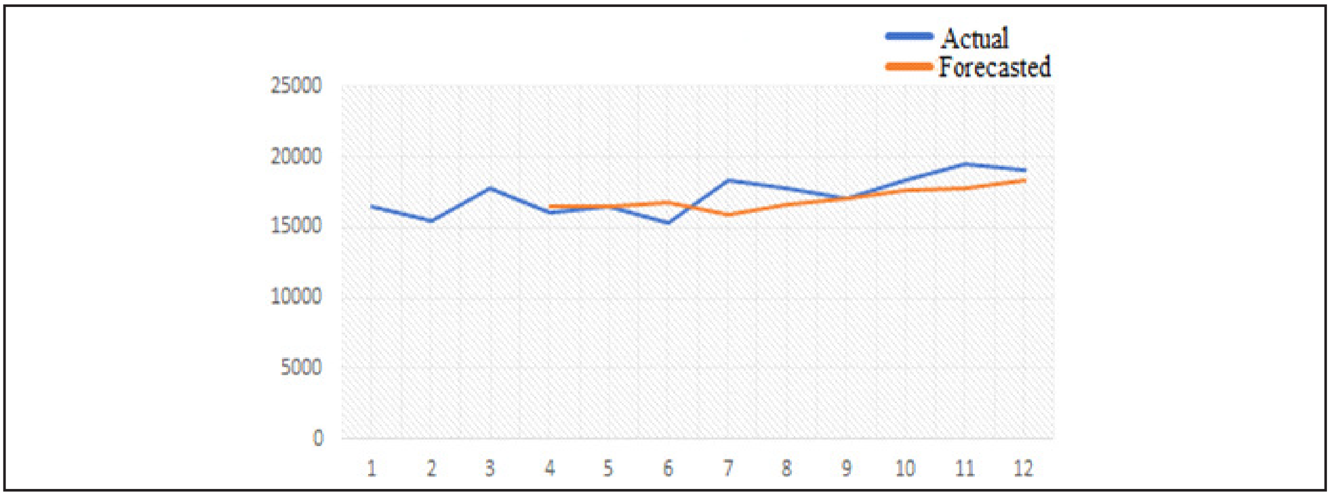

Figure 5: Comparison of Actual Vs MA Forecasted for 2013LPG Consumption Data Set

The actual vs moving average forecasted value for the natural gas consumption year 2013 is shown is figure 7. The absolute percentage error is ranged from 0.10 – 12.90.

The actual consumption data and the moving average forecasted data for the year 2014 is shown in table 3.

Table 3: Actual Data and MA Forecast Evaluation for 2014 LPG Consumption Data Set

Months	Year 2014	Moving Average	Absolute Error	Abs % Error
Jan	20174			
Feb	18531			
Mar	21205			
Apr	18250	19970	1720	9.424657534
May	18831	19328.66667	497.6666667	2.642805303
Jun	18039	19428.66667	1389.666667	7.703679066
Jul	20233	18373.33333	1859.666667	9.19125521
Aug	21142	19034.33333	2107.666667	9.969097846
Sep	22570	19804.66667	2765.333333	12.25225225
Oct	21581	21315	266	1.232565683
Nov	22941	21764.33333	1176.666667	5.129099284
Dec	25350	22364	2986	11.7790927

The actual and forecasted data for the 2014 LPG consumption data is shown in figure 8. The absolute error percentage is ranged from 1.23 – 11.77.

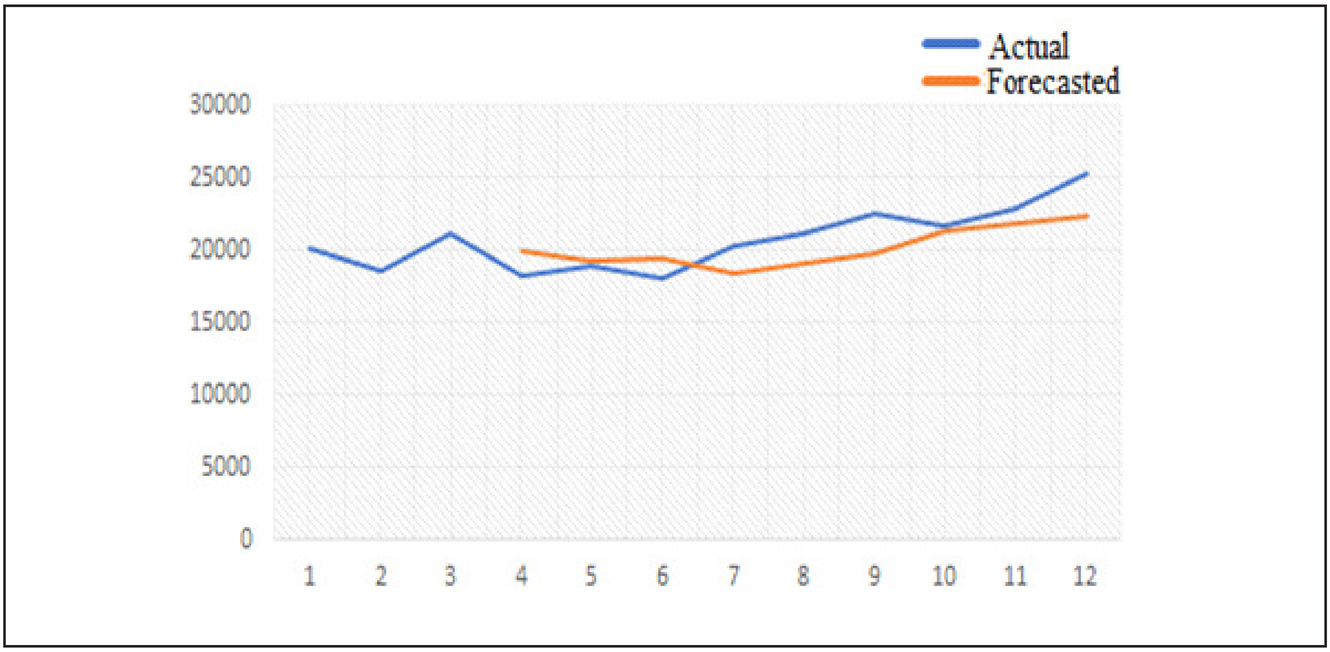

Figure 6: Comparison of Actual Vs MA Forecasted for 2014 LPG Consumption Data Set

B. Natural Gas Consumption Smoothing Method Forecasting& Error analysis

In this model method, we've taken the same LPG domestic consumption data for 3 years e.g. 2012 – 2014. We've calculated the forecasted starting from the February of each ear with $\propto = 0.2$. The value of $\propto$ is varied from 0.1 -0.9, but the absolute percentage error varies from 0.001 – 0.009. The smoothing analysis algorithm is applied as discussed in above section on the year 2012 LPG consumption data and the forecasted data is listed in table 4

Table 4: Actual Data and SA Forecast Evaluation for 2012 LPG Consumption Data Set

Months	Year 2012	Smoothing Analysis	Absolute Error	Abs % Error
Jan	16425			
Feb	16293	16629.13333	336.1333333	2.063053663
Mar	16682	16561.90667	120.0933333	0.719897694
Apr	14850	16585.92533	1735.925333	11.68973288
May	17098	16238.74027	859.2597333	5.025498499
Jun	16348	16410.59221	62.59221333	0.382873828
Jul	17413	16398.07377	1014.926229	5.828554697
Aug	17848	16601.05902	1246.940983	6.986446568
Sep	17123	16850.44721	272.5527868	1.591735016
Oct	16610	16904.95777	294.9577706	1.77578429
Nov	16824	16845.96622	21.96621647	0.130564767
Dec	16648	16841.57297	193.5729732	1.162740108
Average	16680.16667		Mean Absolute % Error	3.396080183

The graph displayed in figure 9 is shown the actual data vs forecasted data. The forecasted results for the month of Sept – Dec 2012 is very close to the actual data. The mean absolute percentage of error is 3.39% and the mean error percentage is varied from 0.13 – 11.68%.

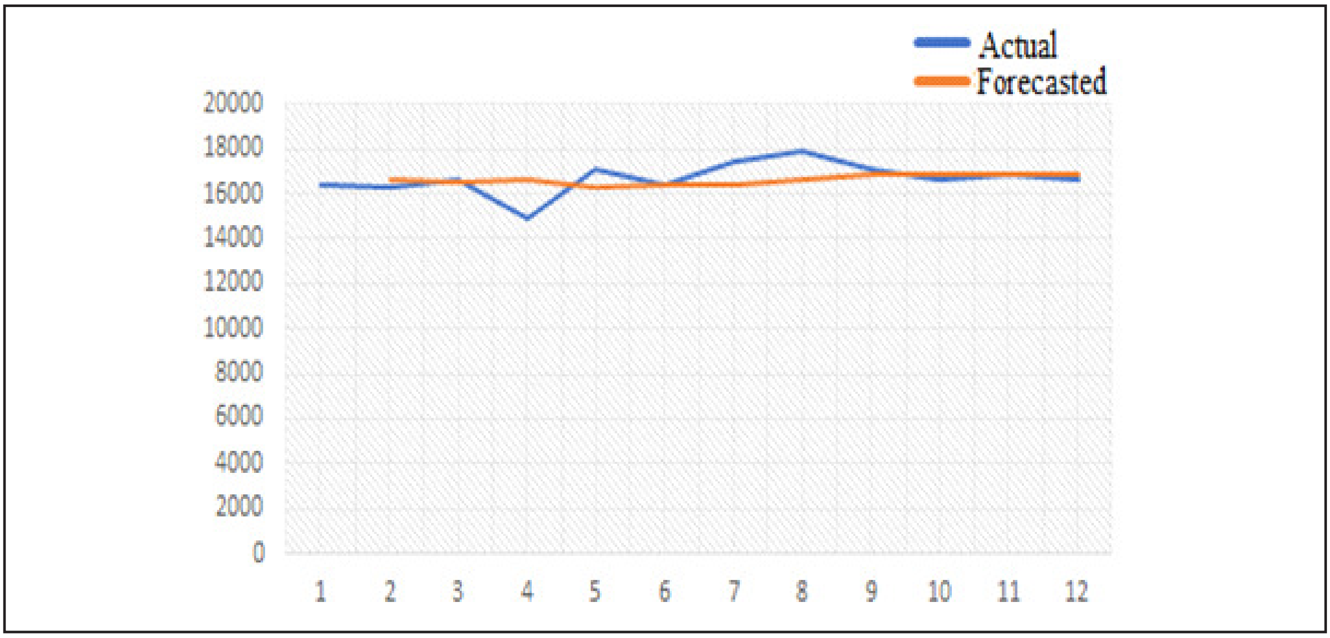

Figure 7: Comparison of Actual Vs SA Forecasted for 2012 LPG Consumption Data Set

Smoothing analysis method is also applied on the LPG consumption data on the year 2013 with $\propto = 0.2$. The forecasted values are deviated with the absolute error percentage from 0.38 – 11.55.

Table 5 : Actual Vs SA Forecasted for 2013 LPG Consumption Data Set

Months	Year 2013	Smoothing Analysis	Absolute Error	Abs % Error
Jan	16449			
Feb	15409	17116.2	1707.2	11.07923941
Mar	17732	16774.76	957.24	5.398375818
Apr	16092	16966.208	874.208	5.432562764
May	16428	16791.3664	363.3664	2.211872413
Jun	15259	16718.69312	1459.69312	9.566112589

Jul	18287	16426.7545	1860.245504	10.17250235
Aug	17715	16798.8036	916.1964032	5.171867927
Sep	17047	16982.04288	64.95712256	0.381047237
Oct	18412	16995.0343	1416.965698	7.69588148
Nov	19536	17278.42744	2257.572558	11.55596109
Dec	19030	17729.94195	1300.058047	6.831623998
Average	17283		Mean Absolute % Error	6.863367915

The actual LPG consumption data is plotted against the forecasted LPG consumption data for the year 2013 in figure 10. The mean absolute percentage error is calculated as 8.98%.

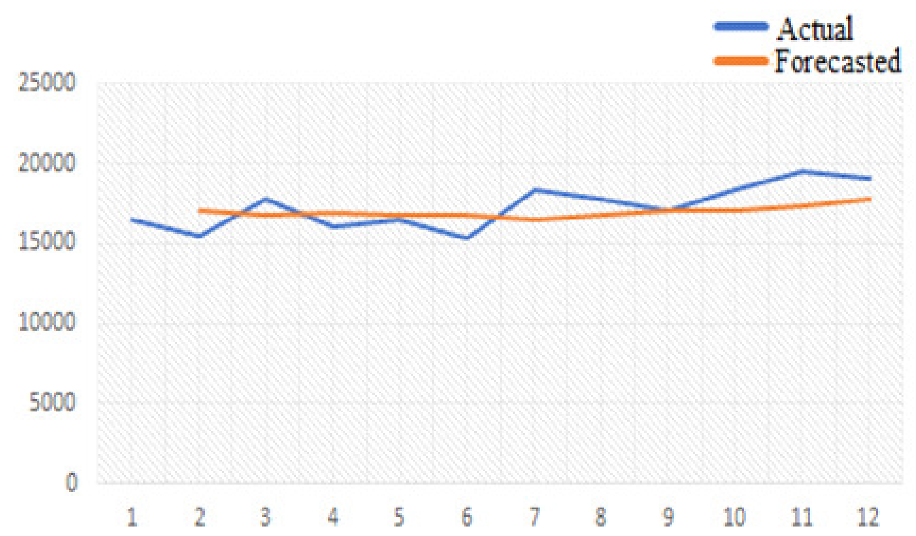

Figure 8: Comparison of Actual Vs SA Forecasted for 2013 LPG Consumption Data Set

The below table is the list of data for the year 2014. The absolute error and absolute percentage error is also enlisted in the table. The absolute percentage error is evaluated in the range from 4.71 to 16.72. The minimum error percentage is observed in March 2014 and the maximum error percentage is found in December 2014. The average mean absolute percentage error is 8.98. In smoothing analyses, most data deviation is found in the year 2014. As mentioned earlier the $\propto = 0.2$ and variation on $\propto$ did not make any significant error percentage improvement.

Table 6: Actual Data and SA Forecast Evaluation for 2014 LPG Consumption Data Set

Months	Year 2014	Smoothing Analysis	Absolute Error	Abs % Error
Jan	20174			
Feb	18531	20624.6	2093.6	11.29782527
Mar	21205	20205.88	999.12	4.711718934
Apr	18250	20405.704	2155.704	11.81207671
May	18831	19974.5632	1143.5632	6.07276937
Jun	18039	19745.85056	1706.85056	9.462002107
Jul	20233	19404.48045	828.519552	4.094892265
Aug	21142	19570.18436	1571.815642	7.434564571
Sep	22570	19884.54749	2685.452513	11.89832748
Oct	21581	20421.63799	1159.362011	5.372142211
Nov	22941	20653.51039	2287.489608	9.971185251
Dec	25350	21111.00831	4238.991687	16.7218607
Average	20737.25		Mean Absolute % Error	8.986305897

In figure 11, the comparison between actual vs forecasted data is shown. As it's clear most of the months have approximate 9-11% mean absolute percent error and in the month of December, it goes till 16.72% error. This increases the overall mean absolute percentage of error for the year 2014.

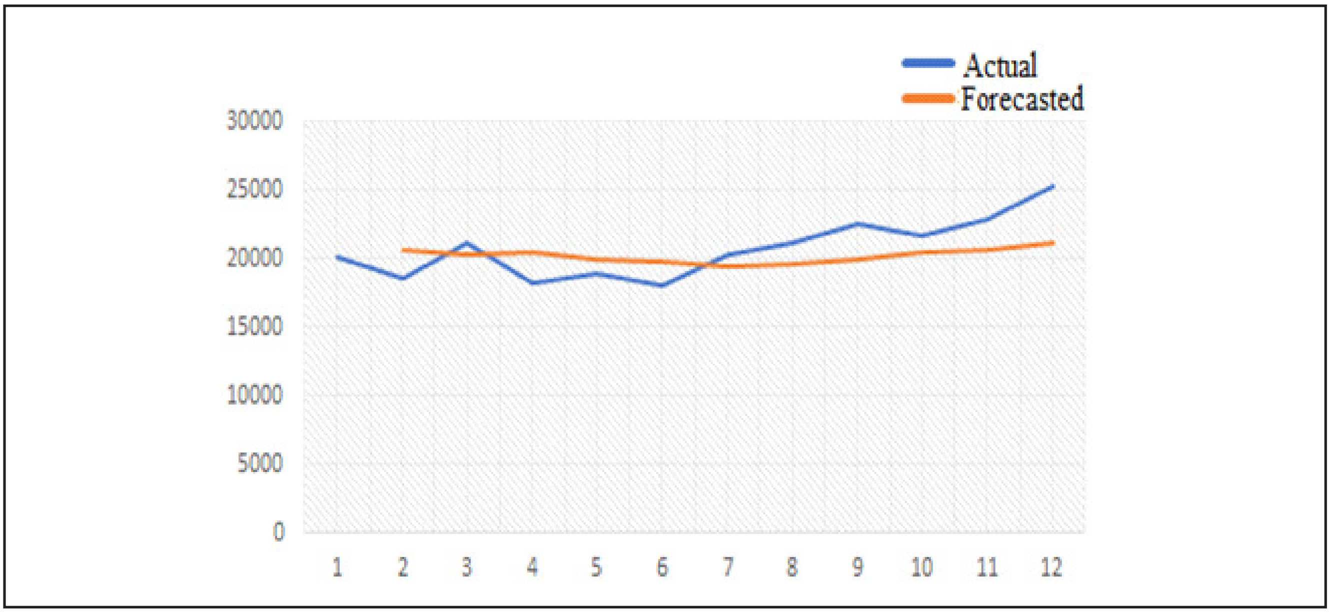

Figure 9: Comparison of Actual Vs SA Forecasted for 2014 LPG Consumption Data Set

C. Natural Gas Consumption Least Square Regression Forecasting & Error Analysis

Conclusion

In this article, we discussed about different popular time series regression models and applied the Domestic LPG consumption data for 3 years. The forecasted data is evaluated and compared with the actual data with absolute percentage error calculation. We found that the Moving average shows better results in year 2013 and 2014whereasSmoothing analysis has a better results in year 2012. All methods though show a fit to this natural gas consumption data set and the percentage of error varies between 0.01 – 12.90%. The forecasting through the time series model is showing a random behavior with moving average and smoothing analysis. The forecasted data though approximating to an error with <13%, but the consistency is not achieved with these models. The consumption data set requires still a better suit model to forecast the future consumption data with more accuracy and consistency. The best fit model with more accuracy and consistency is the future scope of the work.

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