Chapter 7

Development of a New Method for measuring Forecast Accuracy

7.1 INTRODUCTION

Periodical review of current level of forecast is vital for deciding the appropriateness for the given forecast accuracy goals and review process.

A forecasting process will rarely be successful if the progress is not measured and the results reported. The forecast if good or bad should be recorded and the progress they have made over time. After that time everyone is committed to the process and the real work can begin to fine tuning the already successful process.

There are some commonly used accuracy measures whose scale depends on the scale of the data. These are useful when comparing different methods on the same set of data, but should not be used when comparing across data sets that have different scales.
The forecast error is given by the following equation

$$\delta_i = A_i - F_i$$

Where,

$$\delta_i = error$$
$$F_i = forecast\ value$$
$$A_i = actual\ value$$

The forecast error is regardless of how the forecast was produced. This is on the same scale as the data, applying to anything from ships to screws. Accuracy measurements based on $\boldsymbol{\delta_i}$ are therefore scale-dependent. The most commonly used scale-dependent metrics are based on absolute errors or on squared errors: The use of absolute values or squared values prevents negative and positive errors from offsetting each other. Since all

of these metrics are on the same scale as the data, none of them are meaningful for assessing a method's accuracy across multiple series

Percentage errors have the advantage of being scale independent, so they are frequently used to compare forecast performance between different data series. The most commonly used metric is:

Mean Absolute Percentage Error is given by

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\frac{|\delta_i|}{D_i}$$

In spite of many methods for calculating the forecast accuracy, limitations prevail for the methods. After understanding the limitations, the existing methods were modified to overcome some of these limitations and an optimized model was developed that can be used in a real-time scenario. Intermittent-demand goods were targeted, i.e. goods which have sporadic demand, low volume, and which require specific forecast and safety stock or lead time techniques.

Two formulae were successfully developed and discussed in this chapter, namely – Modified MAPE 1 and Modified MAPE 2. This chapter is organized as follows. Section 7.2 discusses about Modified MAPE 1 and Section 7.3 discusses about Modified MAPE 2. Section 7.4 discusses about the results and analysis of the forecast accuracy of the new methods as well as the existing methods.

Proposed formulae:

Measurements based on percentage errors have the disadvantage of being infinite or undefined if there are zero values in a series, as is frequent for intermittent data. Moreover, percentage errors can have an extremely skewed distribution when actual values are close to zero. With intermittent-demand data, it is impossible to use the MAPE because of the occurrences of zero periods of demand.

7.2 MODIFIED MAPE 1

The modified MAPE 1 formulae is devised as follows

$$\text{Modified MAPE 1} = \frac{\sum_{i=0}^{n} \delta_i}{\sum_{i=0}^{n} D_i} \times 100$$

Where,

$$\delta_i = D_i - F_i$$

$$\delta_i = error$$
$$D_i = actual\ value$$

Modified MAPE 1 is calculated by the summation of the error to the summation of the actual value. Since the proposed formulae are a metric of percentage error, they have the advantage of being scale independent, so they can be used to compare forecast performance between different data series. Therefore, Modified MAPE 1 is a very good metric to find the forecast accuracy of goods with intermittent demand.

More importantly the Modified MAPE 1 also overcomes the main the disadvantage observed in MAPE i.e. of being infinite or undefined if there are zero values in the series as observed in our data.

7.3 MODIFIED MAPE 2

Modified MAPE 2 is calculated as follows

$$\text{Modified MAPE 2} = \frac{\sum_{i=0}^{n} \delta_i}{\sum_{i=0}^{n} F_i} \times 100$$

Where,

$$\delta_i = error$$
$$F_i = forecast\ value$$

In Modified MAPE 2, the forecasted value is used in the denominator instead of the actual sale value. It is calculated by the division of the summation of the error to the summation of the Forecast

Using forecast in the denominator enables to measure performance against forecast or plan. For revenue forecasting, using forecast as the denominator is considered to be more appropriate since the forecast is the revenue estimate determining and constraining the state budget. Any future budget adjustments by the Governor and Legislature due to changing economic conditions are equal to the percentage deviations from the forecasted amounts initially used in the budget. Therefore, the error as a percent of the forecasted level is the true measure of the necessary adjustment, instead of the more commonly used *actual* in the denominator.

7.4 RESULTS AND ANALYSIS OF NEW METHOD FOR FORECAST ACCURACY

The forecast accuracy has been measured by two different new formulae created .It has been developed by modifying the MAPE formulae to some extent. The results of the Consumer goods and Intermittent goods are discussed in this section.

Tables 7.1 shows the Sales data of the biscuits .The Forecast and error calculation for the products based on which accuracy is calculated is also shown in the table.

Table 7.1-Sales and Forecast data of FMCG products

Week	Actual sales	Forecasted value	Error	Absolute Error	Squared error	Abs Percentage error
1	27	27	0	0	0	0
2	31	30	-1	1	1	3.22
3	29	29	0	0	0	0
4	30	32	2	2	4	6.67
5	32	33	1	1	1	3.13
6	34	35	1	1	1	2.94
7	36	37	1	1	1	2.78
8	35	30	-5	5	25	14.29
9	37	40	3	3	9	8.11
10	39	42	3	3	9	7.69
11	40	39	-1	1	1	2.5

12	42	41	-1	1	1	2.38
13	39	42	3	3	9	7.69
14	41	43	2	2	4	4.82
15	40	38	-2	2	4	5
16	43	44	1	1	1	2.33
17	44	40	-4	4	16	9.09
18	42	41	-1	1	1	2.38
19	45	46	1	1	1	2.22
20	44	41	-3	3	9	6.82
21	46	47	1	1	1	2.17
22	48	52	4	4	16	8.34
23	47	45	-2	2	4	4.25
24	48	50	2	2	4	4.16
Total:	**939**	**944**		**45**	**123**	**113.04**
Mean:				**1.88**	**5.13**	**4.71**

The weekly sales and forecast values of products are shown in the Figures 7.1 and 7.2

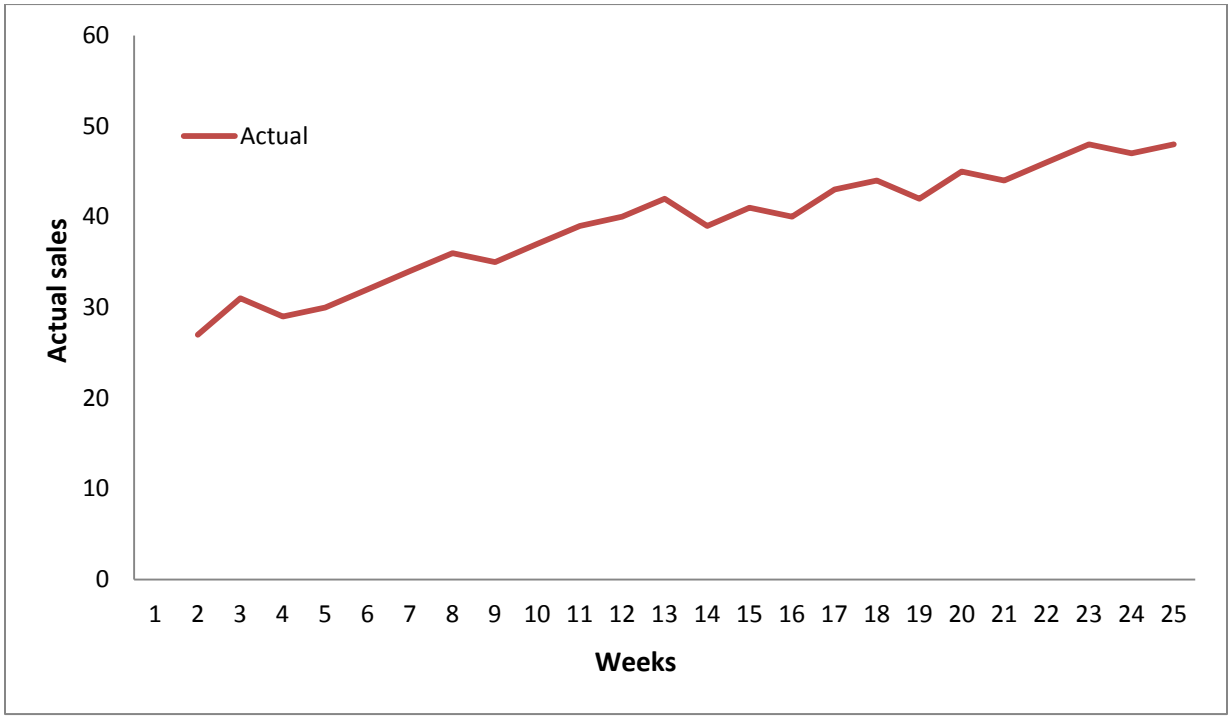

Fig 7.1 -Weekly Actual sales trend of FMCG products

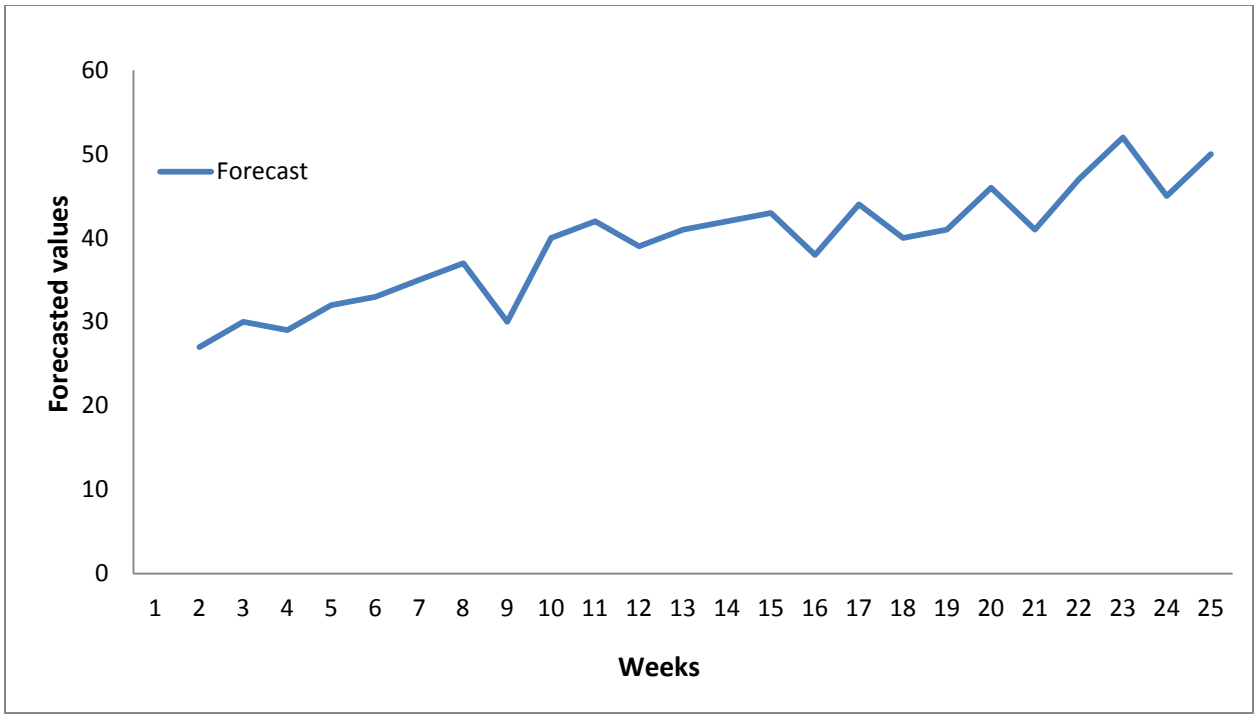

Fig 7.2-Weekly Forecasted values of FMCG products

Table 7.2 gives the forecast accuracy values calculated using the various methods. Modified MAPE 1 and Modified MAPE 2 gives better results when compared to the other methods.

Table 7.2-Forecast accuracy results of the FMCG products

Sl. No.	Forecast Accuracy Measure	Value
1	MAD	1.88
2	MSE	5.13
3	MAPE	4.71%
4	MdAPE	3.70%
5	Modified MAPE 1	4.79%
6	Modified MAPE 2	4.77%

Table 7.3 shows the sales data of biscuits in months and the forecasted values along with the calculations of error for the intermittent demand.

Table 7.3-Sales and forecast data of intermittent-demand with error calculations

Period (months)	Actual Sales	Forecast	Error	Absolute Error	Squared error	Abs percentage error
1	0	3	3	3	9	∞
2	15	10	-5	5	25	33.33
3	0	2	2	2	4	∞
4	0	3	3	3	9	∞
5	0	1	1	1	1	∞
6	11	9	-2	2	4	18.18
7	11	15	4	4	16	36.36
8	12	17	5	5	25	41.67
9	24	18	-6	6	36	25
10	10	7	-3	3	9	30
11	11	14	3	3	9	27.27
12	67	90	23	23	529	34.33
13	54	35	-19	19	361	35.19
14	0	0	0	0	0	∞
15	0	1	1	1	1	∞
16	5	4	-1	1	1	20
17	6	6	0	0	0	0
18	20	27	7	7	49	35
19	7	5	-2	2	4	28.58
20	17	13	-4	4	16	23.53
21	4	4	0	0	0	0
22	6	5	-1	1	1	16.67
23	12	15	3	3	9	25
24	6	7	1	1	1	16.67
25	4	3	-1	1	1	25
26	6	8	2	2	4	33.33
27	7	5	-2	2	4	28.57
28	11	7	-4	4	16	36.36
29	8	8	0	0	0	0
30	10	8	-2	2	4	20
Total	**344**	**350**		**110**	**1148**	∞
Mean				**3.24**	**33.76**	∞

The monthly actual sales and forecast values of intermittent demand are shown in the Figs 7.3 and 7.4

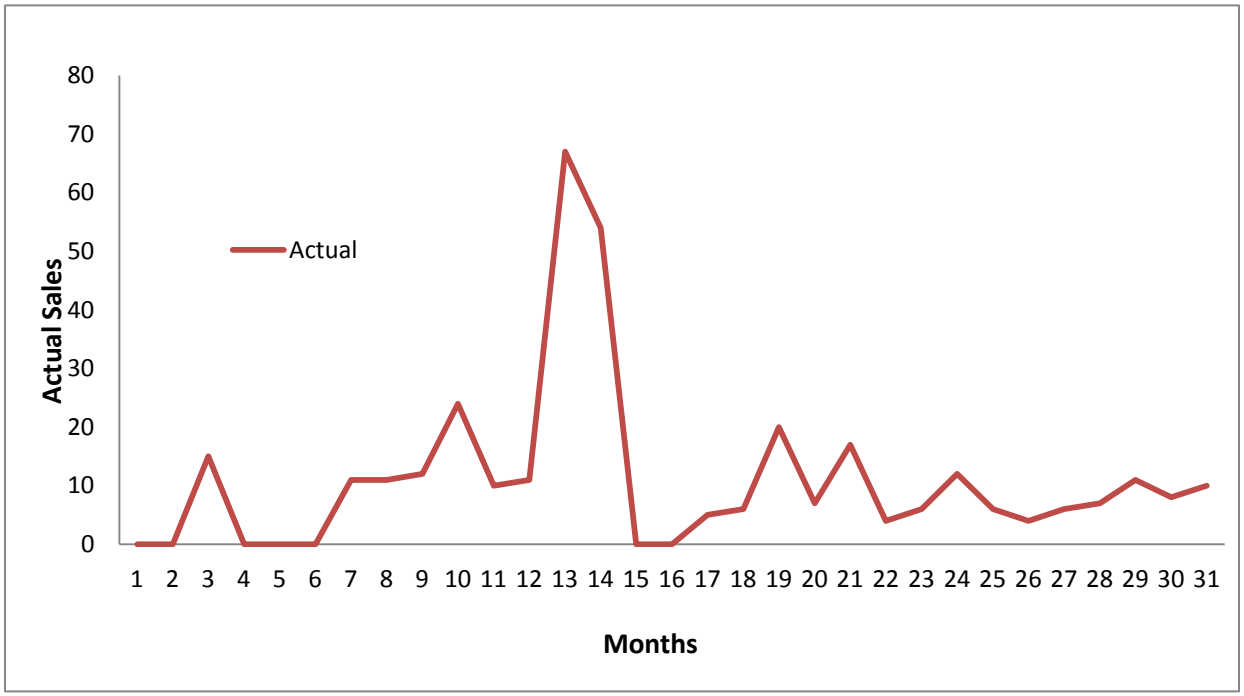

Fig 7.3- Monthly Actual sales of intermittent demand

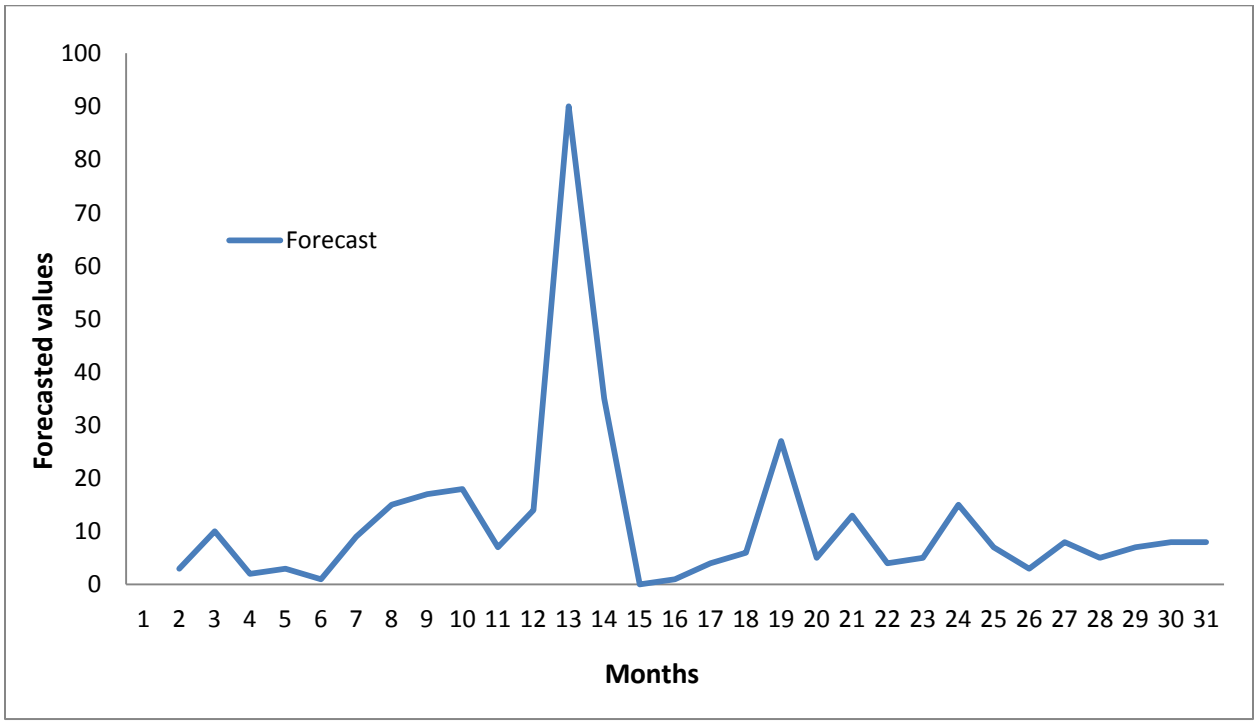

Fig 7.4- Monthly Forecasted values of intermittent demand

The forecast accuracy values of intermittent data through various methods are shown in Table 7.4 which clearly indicates that the new formulae are showing better values.

Table 7.4 Forecast accuracy results of intermittent-demand data

Sl. No.	Forecast Accuracy Measure	Value
1	MAD	3.24
2	MSE	33.76
3	MAPE	∞
4	MdAPE	∞
5	Modified MAPE 1	31.97%
6	Modified MAPE 2	31.43%

Table 7.5-Weekly Sales and forecast data of intermittent-demand and the error calculations

Period (Weeks)	Actual Sales	Forecast values	Error	Abs error	Squared error	Abs percentage error
1	0	0	0	0	0	∞
2	112.36	91.58	20.78	20.78	431.81	18.49
3	0	0	0	0	0	∞
4	0	0	0	0	0	∞
5	0	0	0	0	0	∞
6	0	0	0	0	0	∞
7	170.2	169.21	0.99	0.99	0.98	0.58
8	63.84	62.63	1.21	1.21	1.46	1.89
9	52.14	58.92	-6.78	6.78	45.97	13.01
10	146.55	154.3	-7.75	7.75	60.06	5.29
11	46.76	73.7	-26.94	26.94	725.76	57.61
12	44.11	74.05	-29.94	29.94	896.41	67.88
13	261.46	339.4	-77.94	77.94	6074.64	29.81
14	130.72	151.93	-21.21	21.21	449.86	16.23
15	0	0	0	0	0	∞
16	32.96	39.55	-6.59	6.59	43.43	19.99

17	37.6	82.74	-45.14	45.14	2037.62	120.05
18	0.32	0	0.32	0.32	0.102	100
19	0.02	0	0.02	0.02	0.0004	100
20	0.15	0.28	-0.13	0.13	0.017	86.67
21	0	0	0	0	0	∞
22	0	0	0	0	0	∞
23	0.05	0	0.05	0.05	0.003	100
24	0.06	0	0.06	0.06	0.004	100
Total	1099.3	1298.29		245.85	10768.1	∞
Mean	45.81	54.1		10.24	448.67	∞

The error calculation is also shown which is used for accuracy calculations. The monthly sales and forecast values are shown in the Figures 7.5 and 7.6.

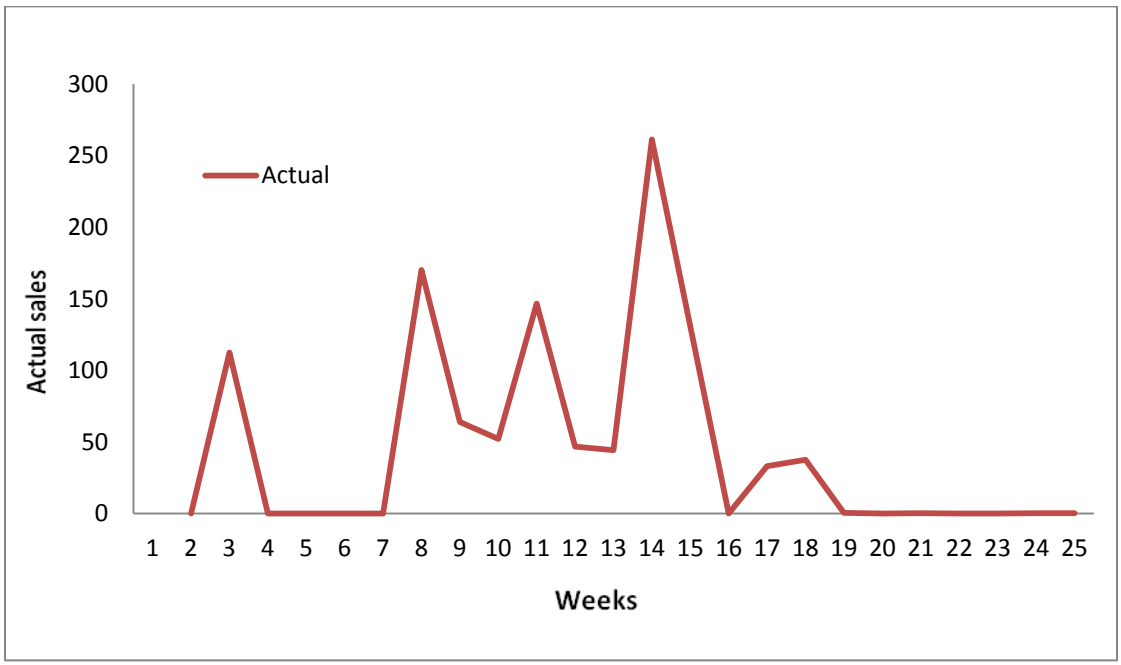

Fig 7.5-Weekly actual sales of intermittent data

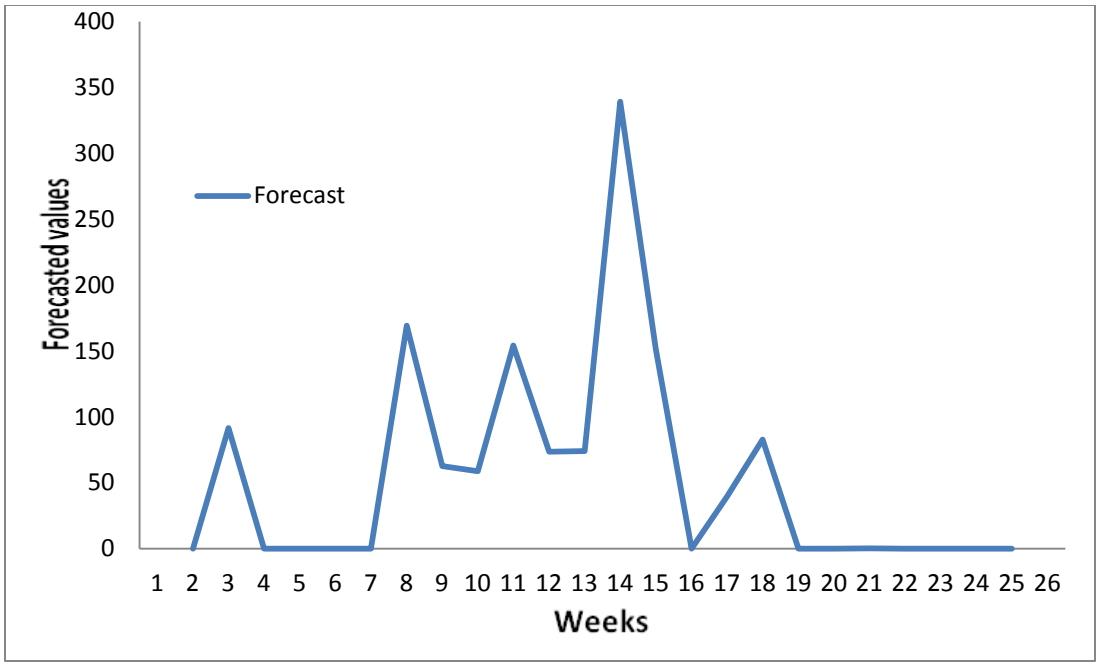

Fig 7.6-Weekly Forecasted values of intermittent data

The forecast accuracy results of the intermittent demands are shown in Table 7.6.

Table 7.6 Forecast accuracy results of intermittent-demand data

Sl. No.	Forecast Accuracy Measure	Value
1	MAD	10.24
2	MSE	448.67
3	MAPE	∞
4	MdAPE	∞
5	Modified MAPE 1	22.36%
6	Modified MAPE 2	18.94%

It has been observed that though MAPE and Median Absolute Percentage Error (MdAPE) hold good to find the forecast accuracy for fast moving goods, they fail for goods with intermittent demand and return an infinite or undefined value. This is due to the presence of zero values in the actual demand series, which is frequent for intermittent data. Thus, this method is unsuitable in this case.

MAD and MSE are scale-dependant errors. For assessing accuracy on a single series, MAD is preferred because it is the easiest to understand and compute. However, it cannot be compared across series because as mentioned earlier, it is scale dependant. In this context, one set of values give the weekly demand while the other set gives the monthly demand. Hence to compare accuracy among different scales using MAD is not suitable.

The proposed formulae are a metric of percentage error and they have the advantage of being independent of scale. They can be used to compare forecast performance between different data series. Therefore, **Modified MAPE 1** is a very good metric to estimate the forecast accuracy of goods with intermittent demand.

More importantly the Modified MAPE 1 also overcomes the main disadvantage observed in MAPE i.e. of being infinite or undefined, if there are zero values in the series as observed in our data.

Modified MAPE 2 uses the forecasted value in the denominator instead of the actual sale value.

Forecast in the denominator helps to measure the performance against forecast or plan. In revenue forecasting, using forecast as the denominator is considered to be more appropriate since the forecast is the revenue estimate determining and constraining the state budget. Any future budget adjustments by the Governor and Legislature due to changing economic conditions are equal to the percentage deviations from the forecasted amounts initially used in the budget. Therefore, the error as a percent of the forecasted level is the true measure of the necessary adjustment, instead of the more commonly used *actual* in the denominator.

The forecast is what drives manufacturing and is what is communicated to the shareholders.