Revisiting the Simple Time Series Methods for Forecasting on the Domestic Sales of the Indian Automobile Industry

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Abstract

In the forecasting literature, it has been observed that simple techniques can be employed unless there is a strong case for complexity in the historical data. This paper studies the annual trends and patterns in the domestic sales of the four main segments of the Indian automobile industry namely the passenger vehicles, commercial vehicles, three-wheelers and two wheelers in the last two decades from 2001-02 to 2020-21 in which the benefits of opening the economy after the reforms of 1991 seemed to be realised with an investment in equity, technology transfer and managerial skills that would reflect the reliable prediction for the year of 2021-22. The data was obtained from the secondary source mainly from the Society of Indian Automobile Manufacturers' (SIAM) database. The forecasting methods comprising of regression linear trend, Simple Moving Averages (SMA), Weighted Moving Averages (WMA), Brown's Exponential Smoothing (ES), and Holt's Double Exponential Smoothing (DES) have been used for the time series based on annual data and these techniques are evaluated on the basis of Mean Absolute Deviation (MAD), Mean Absolute Percentage Deviation (MAPD),Root Mean Square Error (RMSE) from Mean Square Error (MSE) .It was observed that out of all the methods Holt's DES was carrying the least MAPD for the passenger vehicles, for the commercial vehicles and three wheelers and for two-wheelers , MAD was minimum with DES in the passenger vehicles, for the commercial vehicles and for two-wheelers but not in three wheelers segment, and RMSE value was minimum for ES method in commercial vehicle, three wheelers and two wheelers' forecast estimates for the passenger vehicles, for the commercial vehicles and three wheelers and for two-wheelers.

Keywords: *Indian Automobile Industry, Domestic Sales, Forecasting.*

Introduction

''We really can't forecast all that well, and yet we pretend that we can, but we really can't.''

-Alan Greenspan

(American Economist)

In simple words, forecasting can be regarded as the statistical technique undertaken to predict the direction of the future values of a variable given its historical data. Armstrong (1985) divided the forecasting process into a number of stages comprising formulation of the forecasting problem, choice of method, application of method, comparison and combination of forecasts, assessment of uncertainty in forecasts, adjustment of forecasts, and evaluation of forecasts. The annual data on the automobile industry since the lat two decades provides us with the exact data required for this study to and it is used for the transportation of passengers and goods on the ground and comprises of four major segments in Original Equipment Manufacturers (OEMs), engaged in vehicle manufacturing or assembling of all components into an automobile.

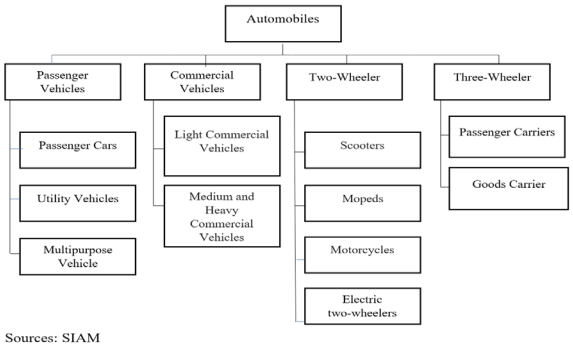


Figure 1 Structure of OEMs in the Indian Automobile Sector

Source: SIAM

As shown in Figure 1 with i) Passenger vehicles including Cars, Utility Vehicle and Multipurpose vehicles, ii) Commercial vehicles that include a) Light Commercial Vehicles and b) Medium and Heavy Commercial Vehicles, iii) Two-Wheeler comprising of Scooters, Mopeds and Motorcycles and Electric Two-Wheelers; and (iv) Three-Wheeler including Passenger Carriers & Goods Carrier .SIAM has released the data for the year 2020-21 on the domestic market share of each of the individual segments of the automobile sector. The passenger vehicle holds 13% of the total market share for the time period of 2020-21 and commercial vehicles and the three-wheelers are at the tie at an equal domestic market share of 3% each. As depicted in the Figure 1.2 pie diagram representation on the market share data by SIAM, it is the two-wheeler segment that has the dominant position holder of the domestic automobile industry with 81% of the market share in the year 2020-21.

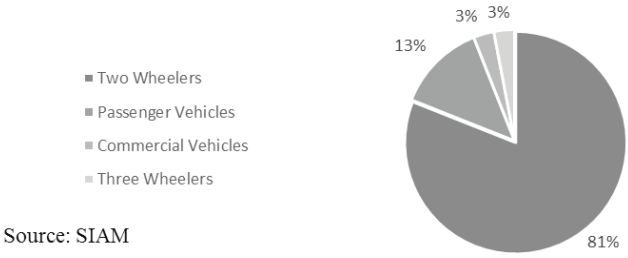


Figure 2 Domestic Market share of various segments for the year 2020-21 (in percentage).

Along these lines, the simple time series-based methods of forecasting to get the idea of the current situation in the domestic sales would contribute to understand the extent to which the various segments in the automobile industry could efficiently operate in the year 2021-22. The onset of the global pandemic from December 2019 in China led to worldwide lockdowns and disrupted the production process. With the national lockdown in India since March 2020, the Indian automobile had witnessed a discernible slowdown and some really worrying expectations reflected in the domestic sales of the main segments of the automobile industry with respect to the year 2021-2022. This calls for the following objectives: -

Objectives of the Study

- To analyse the trends and patterns of the domestic sales with regression-based trend analysis.
- To analyse the trends and patterns of the domestic sales with Simple Moving Averages (SMA), Weighted Moving Averages (WMA), Brown's Exponential Smoothing (ES) and Holt's Double Exponential Smoothing (DES).
- To compare the domestic sales for the year 2021-22 on the basis of Mean Absolute Deviation (MAD), Mean Absolute Percentage Deviation (MAPD), Mean Square Error (MSE) and Root Mean Square Error (RMSE).

Review of the Literature

Kharina et al. (2021) compared the forecasting techniques of trend moment and double moving averages with MAD, based tracking signal and moving range and found a difference between the actual data and forecasting results is not too significant. in the case of dengue haemorrhagic fever patients in Indonesia. Febrian et al. (2020) took double moving average and double exponential smoothing methods of forecasting and compared the values with the help of MAD, MAPE and MSE to assess the number of foreign tourists in Northern Sumatra. it was found that Holt's DES produced minimum MAPE values. According to Saha and Sinha (2020) Holt's exponential smoothing method shows good forecasting performance in the absence of seasonal or cyclical variations listed the number of agricultural studies that made use of Holt's linear trend method and concluded that this method shows good forecasting performance in the absence of seasonal or cyclical variation. Beevi et al. (2019) compared the simple forecasting methods in the case of stock market totality such as DES and ARIMA in the case of stock market volatility with the help of MSE, MAD and MAPE. Ivanovski et al. (2018) tried to predict tourist trends in Macedonia using a moving average model for extrapolation on monthly data moving average model provided accurate forecasting for the number of tourist guests in 2017. Kolkova (2018) also depended on SMA and the ES as the forecast techniques while giving more preference to the technique with lower MAPE. Karmarker (2017) made a comparison between eight different forecasting techniques on the basis of least value of MAD, MSE and MAPE in case of jute your demand. Ravinder (2013) compared simple methods of

forecasting simulated random data generated on MS Excel with ES and DES through the minimum value of MAD and MSE.

Research Methodology

This study is mainly time series based that analysed the trends and patterns of the domestic sales for various segments of the Indian automobile sector from 2001-02 to 2020-21 and predict the values for the 2021-22 based on simple moving averages, weighted moving averages and exponential smoothing and double exponential smoothing having the smallest MAE, MAPE, and mean MSE value and with regression-based trend. In this study, secondary data of domestic sales is compiled from various SIAM's Annual Reports from April-March,2001-02 to April-March, 2020-21 on the annual basis. For the purpose of calculations, MS -Excel (where the values of alpha and beta are estimated with solver) and Stata software have been used.

Annual Growth Rae (Percentage Change)

Annual Growth Rate = (Final Value/Initial Value)-1

Average Annual Growth Rate (AAGR)

$$Average\ Annual\ Growth\ Rate = \sum_{i=1}^{N} Average\ Growth\ Rate / N$$

where N is the number of years.

Compound Annual Growth Rate (CAGR)

Compound Annual Growth Rate=(Final Value/Initial Value)$^{(1/N)}$-1

where N is the number of years.

Since the 20-year period has the ability to reflect on the general tendency of the data for the domestic sales data for various segments is being characterized by a rising movement throughout the same time period. Therefore, its analysis called for the following time serries techniques: -

Linear Regression based Trend

The trend line is fitted into the data represented by the regression of the time variable as the independent variable and the forecast values as the dependent variable

$$F_i = a + btime_i$$

where a= intercept when time=0 and b is the slope of the trend line satisfying the conditions that $\sum_{i=1}^{n}(D_i - F_i) = 0\ and \sum_{i=1}^{n}(D_i - F_i)^2$ and is minimum.

Simple Moving Average

A simple moving average (3 yearly) of order N (here N=3) is simply the arithmetic average of the most recent N observations

$$F_t = (1/N)\sum_{i=t-N}^{t-1} D_i$$

Weighted Moving Average

In Simple Moving Average Forecast assigned equal weights to the previous three values but in **weighted moving average** different m weights i.e.W_1, …,W_m are assigned such that W_1+…. +W_m = 1 to

$$F_i = w_m D_{i-m} + \ldots. + w_1 D_{i-1}$$

Exponential Smoothing

The current forecast (F_t) is the weighted average of the last forecast value (F_{t-1})and the current actual value (D_{t-1}),

$$F_t = \alpha D_{t-1} + (1-\alpha)F_{t-1}$$

where $0<\alpha\leq 1$ is the smoothing constant, which determines the relative weight placed on the current observation of actual value and (1–a) is the weight placed on past observations of forecast value.

Holt's Double Exponential Smoothing

Holt's method is a type of double exponential smoothing especially for time series with linear trend having two smoothing constants, α and β where $\beta\leq \alpha$, and two smoothing equations; -

i) for the value of the intercept S_t at time t

$$S_t = \alpha D_t + (1-\alpha)(S_{t-1} - G_{t-1})$$

and for the value of the slope at time t

$$G_t = \beta(S_t - S_{t-1}) + (1-\beta)G_{t-1}$$

The τ–step-ahead forecast made in period t, which is denoted by $F_{t,t+\tau}$ is given by

$$F_{t,t+\tau} = S_t + \tau G_t$$

For the evaluation of the forecast value let $e_i = e_1, e_2$…… .,e_t be the error terms that is the difference between the actual values $D_i = D_1, D_2$ ... ..., D_t and the forecast values $F_i = F_1, F_2$ ... ..., Fn observed over t periods of the time series i.e. $e_t = F_t - D_t$ then,

MAD

The Mean Absolute Deviation is the average of the sum of the error terms as the difference between the actual values from the mean. Symbolically, it is expressed as

$$\text{MAD} = \left(\frac{1}{n}\right)\sum_{i=1}^{n}|e_i|$$

MAPD

The Mean Absolute Percentage Deviation (MAPD) measures the average absolute error as a percentage of the average value of the absolute error rate of the actual data period.

$$\text{MAPE} = \left(\frac{1}{n}\right)[\sum_{i=1}^{n}|e_i / D_i|]\times 100$$

MSE and RMSE

Mean Square Error can be defined as the averaged sum of squared difference between the actual values and the forecast values and the square root of MSE generates root mean square error.

$$\text{MSE} = \left(\frac{1}{n}\right)\sum_{i=1}^{n} e_i^2 ; \text{whereas RMSE} = \sqrt{\text{MSE}}$$

Data Analysis and Interpretation

In table 1, the percentage change (the annual growth rate) in the domestic sales tend to be negative in the year 2013-14 and 2018-2021 for the passenger vehicles that also show the largest compound annual growth rate (CAGR) of 7.20% and the annual average growth rate (Annual Average Growth Rate) of 7.80 % over the 20 years of time period with a major change being witnessed in 2010-11. With three-wheeler segment the least change (0.38%) in the

Table 1 Domestic sales for the Passenger Vehicle, Commercial Vehicles, Three-Wheeler and Two-Wheeler segments from 2001-2002 to 2020-2021. (in numbers).

Segments	Passenger Vehicles		Commercial Vehicles		Three Wheelers		Two Wheelers	
Year	Domestic Sales	Percentage Change	Domestic Sales	Percentage Change	Domestic Sales	Percentage Change	Domestic Sales	Percentage Change
2001-02	675116		146671		200276		4,203,725	
2002-03	707198	4.752072236	190682	30.0066134	231529	15.6049651	4,812,126	14.4729
2003-04	902096	27.55918427	260114	36.4124563	284078	22.6965089	5,364,249	11.47358
2004-05	1061572	17.67838456	318430	22.4194007	307862	8.37234844	6,209,765	15.76206
2005-06	1143076	7.677670474	351041	10.2411833	359920	16.9095244	7,052,391	13.56937
2006-07	1379979	20.72504365	467765	33.2508169	403910	12.2221605	7,872,334	11.62645
2007-08	1549882	12.31199895	490494	4.85906385	364781	-9.6875542	7,249,278	-7.9145
2008-09	1552703	0.182013857	384194	-21.672029	349727	-4.1268597	7,437,619	2.598066
2009-10	1951333	25.6732936	532721	38.6593752	440392	25.9245068	9,370,951	25.99396
2010-11	2501542	28.19657127	684905	28.5672988	526024	19.4444949	13,435,769	43.37679
2011-12	2629839	5.128716608	809499	18.191428	513281	-2.422513	13,409,150	-0.19812
2012-13	2665015	1.337572376	793211	-2.0121087	538290	4.87237985	13,797,185	2.893808
2013-14	2503509	-6.060228554	632851	-20.216563	480085	-10.812945	14,806,778	7.317384
2014-15	2601236	3.903600906	614948	-2.8289439	532626	10.9441036	15,975,561	7.893567
2015-16	2789208	7.226257056	685704	11.5060135	538208	1.04801493	16,455,851	3.006405
2016-17	3047582	9.263346441	714082	4.13852041	511879	-4.8919748	17,589,738	6.890479
2017-18	3288581	7.907875818	856916	20.0024647	635698	24.189115	20,200,117	14.84035
2018-19	3377389	2.70049605	1007311	17.5507284	701005	10.2732744	21,179,847	4.85012
2019-20	2773519	-17.8797882	717593	-28.761524	637065	-9.1211903	17,416,432	-17.7688
2020-21	2711457	-2.237662695	568559	-20.768597	216197	-66.063588	15,119,387	-13.189
AAGR		**7.802320934**		**8.97727989**		**3.44077746**		**7.374744**
CAGR		**7.20%**		**7.01%**		**0.38%**		**6.61%**

Source: Compiled and computed by Author on the basis of various Annual Reports of SIAM.

CAGR and AAGR (3.44%) can be observed over the 20 years in domestic sales which were. showing a degrowth in the years of 2007-2009 following the Automotive Mission Plan (2006),then in 2011-2014; where spiralling inflation ,interest rate and rapid rise in the petrol prices took its toll on the overall sentiments in the domestic market; then in 2016-17 marked by second Automotive Mission Plan (2016) and then from 2019-2021 marked by number of events such as demonetization ,new emission norms and lockdown due to COVID-19; although sales achieved maximum growth rate in 2009-2010 at 25.92%.The AAGR has been the largest in the case of the commercial vehicles 8.98% and the CAGR have also been impressive at 7.01% in the same period but the annual growth rate has remained negative in the years of 2008-2009,2012-2015 and 2019-2021while the maximum growth was seen in the year similar to three wheelers sector at 38.66%.Finally the dominant segment of the two wheelers has shown the CAGR of 6.61% and AAGR of 7.37 % with its percentage change being negative in the year 2007-2008 ,2011-2012 and in 2019-2021saw a largest percentage change in 2010-11 at 43.38%

In order to understand such basic numbers in the domestic sales, regression based linear trend line has been employed to estimate the forecast value computed on the basis of the regression line, slope coefficient and the intercept in table 2 followed by the graphical representation in figure 3 for the passenger vehicle segment, figure 4 for commercial vehicle segment, figure 5 for three wheelers, and figure 6 for two wheelers respectively. The importance of the regression-based trend line has also been emphasized by Armstrong (2001) who states that drawing a best-fitted line through a data series reduces inconsistency at the application of method stage of the forecasting process, however when data are independent and without causal factors, the line of best fit itself is a good source of forecasts. With this statement in mind, the linear trend line in the case of all the segments of the OEMs are increasing at a steady rate, despite of the random shocks that arose due to various economic events that managed to change the sentiment of the domestic consumers in the terms of spending. With table 2, in the case of passenger vehicle segment the estimated value comes out to be 35,74,130 (in numbers) through y = 141289x + 607061, with regression line y = 33201x + 212776 the estimated value in the case of commercial vehicles has turned out to be 9,09,997 (in numbers),with three wheelers the estimated forecast value is 617,857 (in numbers) from y = 17068x + 259429 and with two-wheelers is 21,080,895 (in numbers) in 2021-22 from y = 860995x + 2907463 where domestic sales (in numbers) acted as the dependent variable (y) and the time (in years) acted as the independent variable (x).

Table 2 Linear Regression based Trend analysis of domestic sales for the Passenger Vehicle, Commercial Vehicles, Three-Wheeler and Two-Wheeler segments from 2001-2002 to 2020-2021.

Year	Passenger Vehicles	Linear Trend	Commercial Vehicles	Linear Trend	Three Wheelers	Linear Trend	Two Wheelers	Linear Trend
2001-02	675116	748349.3	146671	245977	200276	276496.9	4203725	3768458
2002-03	707198	889637.9	190682	279177.8	231529	3.95E+09	4812126	4629453
2003-04	902096	1030927	260114	312378.6	284078	4.85E+09	5364249	5490448
2004-05	1061572	1172215	318430	345579.4	307862	5.25E+09	6209765	6351444
2005-06	1143076	1313504	351041	378780.2	359920	6.14E+09	7052391	7212439
2006-07	1379979	1454793	467765	411981	403910	6.89E+09	7872334	8073434
2007-08	1549882	1596081	490494	445181.8	364781	6.23E+09	7249278	8934429
2008-09	1552703	1737370	384194	478382.6	349727	5.97E+09	7437619	9795425
2009-10	1951333	1878659	532721	511583.4	440392	7.52E+09	9370951	10656420
2010-11	2501542	2019947	684905	544784.2	526024	8.98E+09	13435769	11517415
2011-12	2629839	2161236	809499	577984.9	513281	8.76E+09	13409150	12378410
2012-13	2665015	2302525	793211	611185.7	538290	9.19E+09	13797185	13239405
2013-14	2503509	2443813	632851	644386.5	480085	8.19E+09	14806778	14100401
2014-15	2601236	2585102	614948	677587.3	532626	9.09E+09	15975561	14961396
2015-16	2789208	2726391	685704	710788.1	538208	9.19E+09	16455851	15822391
2016-17	3047582	2867679	714082	743988.9	511879	8.74E+09	17589738	16683386
2017-18	3288581	3008968	856916	777189.7	635698	1.09E+10	20200117	17544382
2018-19	3377389	3150257	1007311	810390.5	701005	1.2E+10	21179847	18405377
2019-20	2773519	3291545	717593	843591.3	637065	1.09E+10	17416432	19266372
2020-21	2711457	3432834	568559	876792.1	216197	3.69E+09	15119387	20127367
2021-2022		3574130		909997		617857		21080895
	Intercept	6070601	**Intercept**	212776	**Intercept**	259429	**Intercept**	2907463
	Slope	141289	**Slope**	33201	**Slope**	17068	**Slope**	860995

Source: Computed by Author on the basis of various Annual Reports of SIAM.

It is to be kept in mind that the longer into the future values a forecast is applied, the more uncertain the results become. Hence, forecast is made only for the relevant year of 2021-22. (See table 2). It is also to be noticed that since only annual figure of the domestic sales are presented there are no seasonal variations exhibiting any definite pattern. Such variables are more of an irregular nature arising out of the various policies programmes implementation and change in consumption pattern in the domestic market. In this scenario four main models of forecasting namely SMA, WMA, ES and DES have been employed for domestic sales within each segment of the automobile industry respectively. Following the literature reviewed the accuracy of these techniques shall be compared using the minimum value of MAD, MAPD, MSE and RMSE.

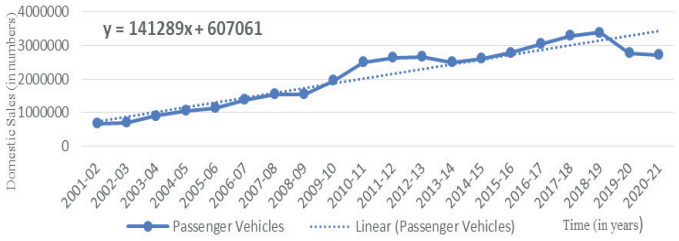


Figure 3 Linear Trend Line of Domestic Sales in Passenger Vehicles from 2001-02 to 2020-21.

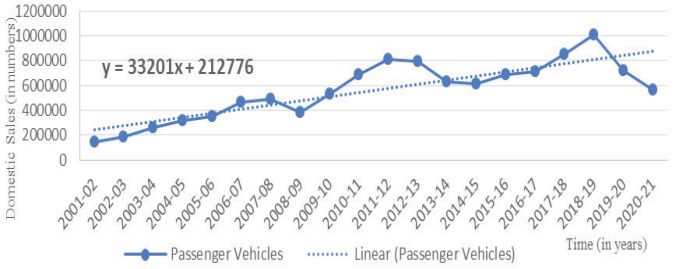


Figure 4 Linear Trend Line of Domestic Sales in Commercial Vehicles from 2001-02 to 2020-21.

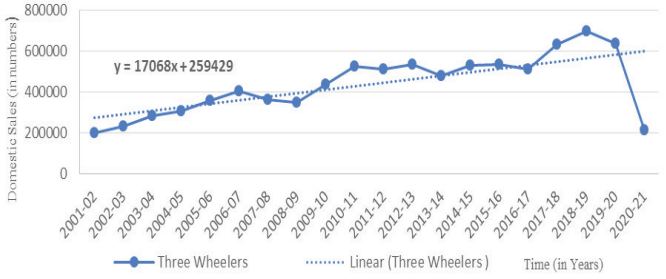
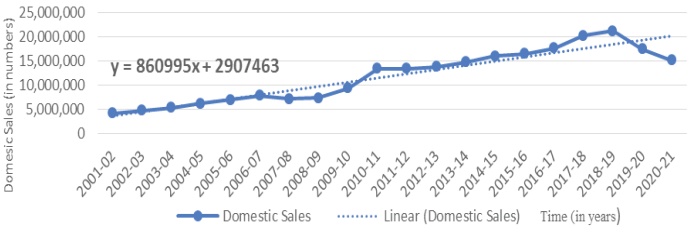


Figure 5 Linear Trend Line of Domestic Sales in Three Wheelers from 2001-02 to 2020-21.



Source: Computed by author based on Table 2

Figure 6 Linear Trend Line of Domestic Sales in Two- Wheelers from 2001-02 to 2020-21.

In the time series for the annual domestic sales from 2001-02 to 2020-21, the 3- yearly simple moving average (SMA) is taken to calculate the trend values while smoothening the data. However, it is the SMA method of forecasting that have generated the largest errors in the case of the passenger vehicle sector (see table 3) and the two wheelers sector (see table 6) of RMSE equalling 403357.46 and 2574720.57 respectively. The value of MAD and MAPD is also the maximum in case of all the four sectors. For passenger vehicles MAD=357469.84 and MAPD= 16.71 % (see table 3), for commercial vehicles MAD =143453.67 and MAPD= 23.60 % (see table 4), for three wheelers MAD= 82796.39 and MAPD= 23.85 (see table 5) and finally for the two wheelers, MAD=2191518.24 and MAPD=16.64 % (see table 6). The next method of weighted average methods is a step above the simple moving averages as the most recent data is weighted while taking the averages as WMA with equal weights generate forecast values same to that of SMA. However, it is must be understood that the recent data on domestic sales has been suffering from temporary instabilities since 2018 such as demonetization, lockdown and new emission norms and that might prove detrimental to forecasts. That is why the weights have been assigned with the help of the solver function in the MS-Excel. Accordingly, in the passenger vehicle segment, commercial vehicle segment, three wheelers and two wheelers greater weight of W1 is assigned to the earlier data when the data was relatively free from major random shocks. Before discussing the measures of accuracy, it would be interesting to look at the next method of exponential smoothing. The Exponential Smoothing (ES) makes the use of smoothing constant (α) to dampen the level effect in the time series. According to Armstrong (2001), Brown's ES is appropriate in the case of time-series data with limitation of only one new data point per time period (i.e., short-range forecasts of long-interval data) allowing only small parameter adjustments, which accumulate and eventually catch up with pattern regime changes thus making the smoothing estimates appear to drift. The value of α has been computed with the help of solver function in MS-Excel

and in the case of all the segments of the automobile industry it is coming out to be 1. Now, The MAPD with the ES method in the case of the Passenger Vehicle in table 3 is 9.72% which is similar to that of the WMA at 9.33%. The value of MAD in ES (194274.5789) is lesser than WMA (203778.6471), with smaller value of RMSE turns out be for the WMA method at 2352268. 259.The MAPD in the case of the commercial vehicles is coming out to be 18.05% for ES method and 17.24 % in the case of the WMA method. On the other hand, the value of MAD is greater when the forecasts estimates are computed on the basis of the ES in the table 4. The value of RMSE is smaller for the ES method with the value of 121110. 5251. In the case of three wheelers, the forecast value of ES is lesser than that of the WMA method. (See table 5) The two wheelers

Table 3 SMA (3-yearly), WMA, ES and DES methods of Forecasting of Domestic Sales for the Passenger Vehicle.

Year	Passenger Vehicles	SMA	WMA	ES	DES
2001-02	675116			675116	
2002-03	707198			675116	750312.6767
2003-04	902096			707198	780688.9088
2004-05	1061572	761470	902096	902096	980390.1992
2005-06	1143076	890288.6667	1061572	1061572	1143078.036
2006-07	1379979	1035581.333	1143076	1143076	1224581.955
2007-08	1549882	1194875.667	1379979	1379979	1467633.008
2008-09	1552703	1357645.667	1549882	1549882	1640790.066
2009-10	1951333	1494188	1552703	1552703	1640126.033
2010-11	2501542	1684639.333	1951333	1951333	2051068.472
2011-12	2629839	2001859.333	2501542	2501542	2619099.785
2012-13	2665015	2360904.667	2629839	2629839	2747821.666
2013-14	2503509	2598798.667	2665015	2665015	2779721.544
2014-15	2601236	2599454.333	2503509	2503509	2607287.607
2015-16	2789208	2589920	2601236	2601236	2704775.184
2016-17	3047582	2631317.667	2789208	2789208	2896087.642
2017-18	3288581	2812675.333	3047582	3047582	3160455.291
2018-19	3377389	3041790.333	3288581	3288581	3406523.393
2019-20	2773519	3237850.667	3377389	3377389	3494178.734
2020-21	2711457	3146496.333	2773519	2773519	2861796.907
2021-22		2954121.667	2711457	2711457	2793786.933
MAD		357469.8431	203778.6471	194274.5789	156479.7975
MAPD		0.1671	0.0933	0.0972	0.0750
MSE		162697242201.50	5533165960385.71	63559194272.58	54433523389.55
RMSE		403357.4621	2352268.259	252109.4887	233309.9299
			W_1=1	α=1	α=1
			W_2 =0		β=0.0396
			W_3 = 0		

Source: Computed by Author

Table 4 SMA (3-yearly), WMA, ES and DES methods of Forecasting of Domestic Sales for the Commercial Vehicle

Year	Period	Commercial Vehicles	SMA	WMA	ES	DES
2001-02	1	146671			146671	
2002-03	2	190682			146671	147351.5942
2003-04	3	260114			190682	220357.8021
2004-05	4	318430	199155.6667	260114	260114	316393.2738
2005-06	5	351041	256408.6667	318430	318430	376072.1805
2006-07	6	467765	309861.6667	351041	351041	391933.1808
2007-08	7	490494	379078.6667	467765	467765	559401.2097
2008-09	8	384194	436433.3333	490494	490494	536019.8899
2009-10	9	532721	447484.3333	384194	384194	328123.2591
2010-11	10	684905	469136.3333	532721	532721	613559.9861
2011-12	11	809499	533940	684905	684905	813485.6001
2012-13	12	793211	675708.3333	809499	809499	935411.9053
2013-14	13	632851	762538.3333	793211	793211	823967.9811
2014-15	14	614948	745187	632851	632851	535719.112
2015-16	15	685704	680336.6667	614948	614948	570833.3417
2016-17	16	714082	644501	685704	685704	718456.8105
2017-18	17	856916	671578	714082	714082	743907.3387
2018-19	18	1007311	752234	856916	856916	962362.8236
2019-20	19	717593	859436.3333	1007311	1007311	1142835.588
2020-21	20	568559	860606.6667	717593	717593	568559.9658
2021-22	21		764487.6667	568559	568559	419525.3195
MAD			143453.6667	105155.9412	100057.5789	94823.23254
MAPD			0.2360	0.1724	0.1805	0.1685
MSE			26487977918.29	409371987031.35	14667759294.42	18761356443.28
RMSE			162751.2762	639821.8401	121110.5251	136972.101
				W_1=1	α=1	α=1
				W_2 =0		β=0.67
				W_3 = 0		

Source: Computed by Author

Table 5 SMA (3-yearly), WMA, ES and DES methods of Forecasting of Domestic Sales for the Three Wheelers.

Year	Three Wheelers	SMA	WMA	ES	DES
2001-02	200276			200276	
2002-03	231529			200276	200558.9187
2003-04	284078			231529	253853.9944
2004-05	307862	238627.6667	278020.6426	284078	327914.3134
2005-06	359920	274489.6667	302344.5152	307862	337426.8843
2006-07	403910	317286.6667	354438.0055	359920	405493.5644
2007-08	364781	357230.6667	396967.48	403910	448356.6827
2008-09	349727	376203.6667	364429.6383	364781	349745.0516
2009-10	440392	372806	353643.4435	349727	334677.5526
2010-11	526024	384966.6667	434926.7026	440392	500581.8082
2011-12	513281	438714.3333	513280.9397	526024	604322.3895
2012-13	538290	493232.3333	508012.4536	513281	526783.4643
2013-14	480085	525865	537403.3917	538290	559981.2048
2014-15	532626	510552	482484.4658	480085	444912.4397
2015-16	538208	517000.3333	533035.404	532626	559880.4527
2016-17	511879	516973	534006.7663	538208	550038.3835
2017-18	635698	527571	513378.63	511879	496550.3571
2018-19	701005	561928.3333	628651.2496	635698	719403.4429
2019-20	637065	616194	687334.6368	701005	771616.958
2020-21	216197	657922.6667	636966.1908	637065	611913.2796
2021-22		518089	251239.7833	216197	-90595.59312
MAD		82796.39	70139.63	67813.53	70414.59
MAPD		0.2385	0.2072	0.2030	0.2011
MSE		16591676014.80	238134323464.17	12354452556.37	12653207251.03
RMSE		128808.6799	487990.0854	111150.585	112486.4759
			$W_1 = 0.927718224$	α=1	α=1.000
			$W_2 = 0$		β=0.71
			$W_3 = 0.072281776$		

Source: Computed by Author

Table 6 SMA (3-yearly), WMA, ES and DES methods of Forecasting of Domestic Sales for the Two Wheelers.

Year	Two Wheelers	SMA	WMA	ES	DES
2001-02	4203725			4203725	
2002-03	4812126			4203725	4207529.392
2003-04	5364249			4812126	5245981.634
2004-05	6209765	4793366.667	5364249	5364249	5882228.539
2005-06	7052391	5462046.667	6209765	6209765	6960722.131
2006-07	7872334	6208801.667	7052391	7052391	7868552.451
2007-08	7249278	7044830	7872334	7872334	8691185.277
2008-09	7437619	7391334.333	7249278	7249278	7042496.637
2009-10	9370951	7519743.667	7437619	7437619	7511889.268
2010-11	13435769	8019282.667	9370951	9370951	10767577.03
2011-12	13409150	10081446.33	13435769	13435769	16730287.37
2012-13	13797185	12071956.67	13409150	13409150	14341334.16
2013-14	14806778	13547368	13797185	13797185	14342314.35
2014-15	15975561	14004371	14806778	14806778	15682281.63
2015-16	16455851	14859841.33	15975561	15975561	17059675.06
2016-17	17589738	15746063.33	16455851	16455851	17110463.33
2017-18	20200117	16673716.67	17589738	17589738	18585259.73
2018-19	21179847	18081902	20200117	20200117	22344291.18
2019-20	17416432	19656567.33	21179847	21179847	22495748.81
2020-21	15119387	19598798.67	17416432	17416432	15119401.69
2021-22		17905222	15119387	15119387	12822346.24
MAD		2191518.235	1363259.294	1280838.526	1109205.022
MAPD		0.1664	0.1052	0.1062	0.0890
MSE		6629186007275.75	184707913844304.00	2880160545203.16	2910055328103.35
RMSE		2574720.569	13590728.97	1697103.575	1705888.428
			W_1=1	α=1	α=1
			W_2 =0		β=0.71
			W_3 = 0		

Source: Computed by Author

sector in table 6 shows the forecast value of WMA more accurate than that of the ES with RMSE =13590728.97. The values for the MAPD are coming out to be similar with WMA at MAPD=10.52% and ES with MAPD=10.62% whereas MAD is greater in the case of WMA at 1363259. 294.Although in theory, the ES method is considered to be superior than that of the WMA but here, in some cases the accuracy measures are falling in favour of WMA method purely because of the fact that in the case of ES the smoothing constant is following the most recent data as opposed to the WMA which has placed greater weights to the older data in the series. In this regard, Beevi et al. (2019) added that exponential smoothing is an averaging technique that uses unequal intervals such that the intervals applied to past observations decline in an exponential manner. The final method of calculating computing the forecast values is Holt's Double Exponential Smoothing (DES) which as per Saha and Sinha (2020), shows good forecasting performance in the absence of seasonal or cyclical variations. Beevi et al (2019) defines DES as exponential smoothing over an already smoothed time series. The DES method according to Ravinder (2013) depends on the initial estimates of the level component (α) and the trend component (β). The DES method generates the least values of the prediction accuracy measures with MAD at 156479.7975, MAPD at 7.50% and RMSE at 233309.9299 when compared with SMA, WMA and ES techniques of forecasting in the case of passenger vehicle segment in table 3. In table 3, the value of is α=1 and is β=0.04 approximately. The forecast values for the year 2021-22 is much closer to the actual value in 2020-21 at 2793786. 933.With α=1 and is β=0.67 in the case of the commercial vehicle segment, the value of MAPD =16.85 % and MAD=94823.23254 is the minimum when compared to the values of the same measures of accuracy in other forecasting technique. (See table 4) However, the value of RMSE=136972.101 is greater than that of generated with ES with RMSE=136972. 101.Even in this case, forecast from DES method will be treated as more accurate because RMSE is not independent of scale causing a disproportionate increase or decrease in its computed value. Febrian *et al. (*2020) has mentioned the importance of MAPE criteria in evaluating the accuracy of forecasting results, where MAPD value of less than 10% is regarded very good and the value of MAPD between 10% -20% is regarded good. In table 5, with three wheelers being the main focus the value of MAPE is minimum in the case of DES at 20.11 %, the value of MAD is 70414.59 which is greater than the minimum value of MAD at 67813.53 with the ES. The RMSE of ES method is also the least. The value of smoothing constants α=1 and β=0.71. In the case of two wheelers, the value of MAPD is least at 8.90 % and so is the value of MAD at

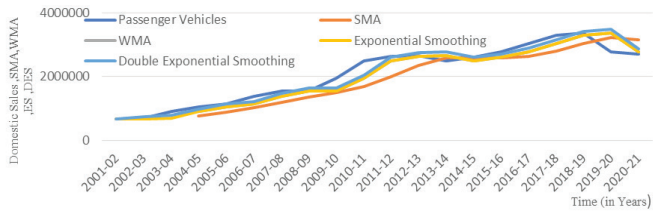


Figure 7 Graphic Effects of Forecasting in Passenger Vehicles from 2001-02 to 2020-21.

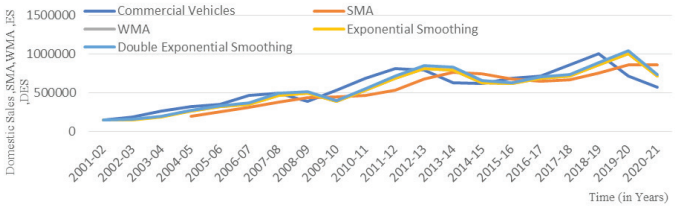
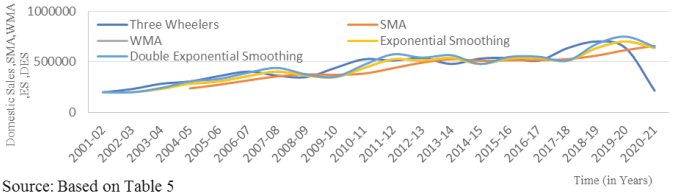


Figure 8 Graphic Effects of Forecasting in Commercial Vehicles from 2001-02 to 2020-21.



Source: Based on Table 5

Figure 9 Graphic Effects of Forecasting in Three Wheelers from 2001-02 to 2020-21.

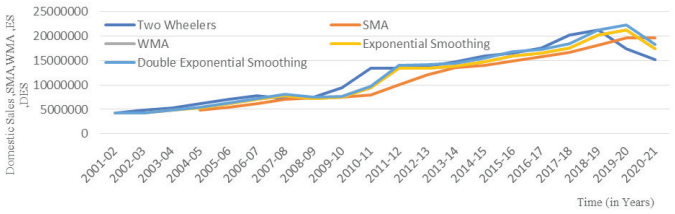


Figure 10 Graphic Effects of Forecasting in Two Wheelers from 2001-02 to 2020-21.

1109205. 022.The value of RMSE is 1705888.428 which is greater than the minimum value generated by ES method with α=1 and β=0.71.(See table 6)The graphic effects of forecasting the domestic sales with all the four methods of SMA, WMA, ES and DES are shown in figure 7 for the passenger vehicles, in figure 8 with respect to the commercial vehicles, and figure 9 and figure 10 deal with the three wheelers and two wheelers. It was observed that out of all the methods Holt's Double Exponential Smoothing was carrying the least MAPD for the passenger vehicles, for the commercial vehicles and three wheelers and for two-wheelers , MAD was minimum with DES for the passenger vehicles, for the

commercial vehicles and for two-wheelers but not in three wheelers segment, and RMSE value was minimum for ES method in commercial vehicle, three wheelers and two wheelers' forecast estimates for the passenger vehicles, for the commercial vehicles and three wheelers and for two-wheelers. Therefore, on the basis of MAPE value it can be said the Holt's DES method has been able to compute the most accurate forecast estimates for passenger vehicles segment at 2793786.933 that are actually closer to the actual values of the domestic sales in 2020-21 at 2711457. (see table 3) With the commercial vehicles segment in table 4, the forecast values with DES method in the year 2021-22 and at 419525.3195 which are also closer to the actual value to the domestic sales in 2020-21.In the case of three wheelers in table 5 the level effects has seemed to clearly dominate the trend effect showing the negative values for the year 2021-22 at -90595.59 which when seen in the context of sudden drop in sales from 2019-20 to 2020-21,tend to make sense.(see table 5) In this case If MAD is to be trusted then ES method will generate the accurate forecast values for the year 2021-22 (216197) which is doubted given the ongoing situation of the COVID-19.Again, given the irregularities in the recent domestic sales, the forecast value of 12822346.24 seems more realistic in the year 2021-22.

Conclusion

It is concluded that out of all the methods Holt's Double Exponential Smoothing was carrying the least MAPD for the passenger vehicles, for the commercial vehicles and three wheelers and for two-wheelers ,MAD was minimum with DES for the passenger vehicles, for the commercial vehicles and for two-wheelers but not in three wheelers segment, and RMSE value was minimum for ES method in commercial vehicle, three wheelers and two wheelers' forecast estimates for the passenger vehicles, for the commercial vehicles and three wheelers and for two-wheelers. Therefore, based on the accuracy criteria of forecast MAPE it is the DES method generating the forecast values of domestic sales for four main segments of the Indian automobile sector for the year 2021-22.

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