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Analysing the Impact of Covid-19 on Automobile Sales in India Using ARIMA Modelling

Suyash SRIVASTAVA[a,1], Vasu SOOD[a,1], N. YUVRAJ[b]

[a]*Department of Production and Industrial Engineering, Delhi Technological University, Delhi, India*

[b]*Department of Mechanical Engineering, Delhi Technological University, Delhi, India*

Abstract. The Covid-19 pandemic has caused severe economic depression and has disrupted the supply chains of various industries. The automobile industry which contributes significantly to the Indian economy was gravely hit due to the lockdowns, semiconductor shortage and the uncertainty associated with the pandemic. This research paper analyses the effect of Covid-19 on the automobile sales in India using the time series modelling approach. The data recorded by SIAM from 2012 to 2019 was used to develop the Autoregressive Integrated Moving Average (ARIMA) model following the Box-Jenkins methodology. ARIMA model (2, 1, 3) was chosen as it had the lowest AIC and BIC criteria. This model was used to forecast the sales from 2020 to 2021 to give a picture of the expected automobile sales had the pandemic not occurred. The forecasted data from the model developed has then been compared with actual automobile sales data during the pandemic to gauge the level of impact Covid-19 had on the Indian automobile industry. The paper also explores the associated challenges that the automobile industry had to face due to the pandemic.

Keywords. Covid -19, Indian Automobile Industry, Time series, ARIMA, Forecasting

1. Introduction

The Covid-19 pandemic has been one of the most lethal epidemics in the history of mankind. Covid-19 is a contagious disease caused by the SARS-CoV-2 virus [1]. It was declared as a pandemic by the World Health Organisation on 11th March 2020 [2]. The pandemic has caused severe economic depression and disrupted the supply chains across numerous sectors. Many countries imposed lockdowns to help prevent the transmission of the virus. On 30th January, the first case of Covid-19 was reported in India [3]. Soon, a nationwide lockdown was enforced to stop the spread of the pandemic [4]. This pandemic exposed the vulnerability in the global supply chains and severely affected most of the industries across the world. The automotive industry can be considered as the barometer of the economy as it is effectively linked to several other key industries such as semiconductors, plastics, base metals and steel. In general, the automobile industry in India had witnessed significant growth over the past few

decades before the onset of the pandemic. However, since FY19 the industry had been witnessing a rapid fall in sales. This fall was fuelled by weak demand, regulatory issues, unfavourable exchange rates, weak investment scenario and the liquidity crisis [5]. The Covid-19 pandemic worsened the already precarious state of the Indian automobile industry.

2. Research Methodology

2.1. Data Collection

The data for this analysis has been collected from the Society of Indian Automobile Manufacturers (SIAM) from 2012 to 2021 [6]. The automobile sales data represents the number of cars sold in India during the given period. Further, the data has been sorted and the entries till the end of 2019 will be used to forecast the sales for 2020 and 2021. These forecast values will finally be compared to the actual sales data for our analysis. Figure 1 shows the graph of automobile sales across the years from 2012 to 2019.

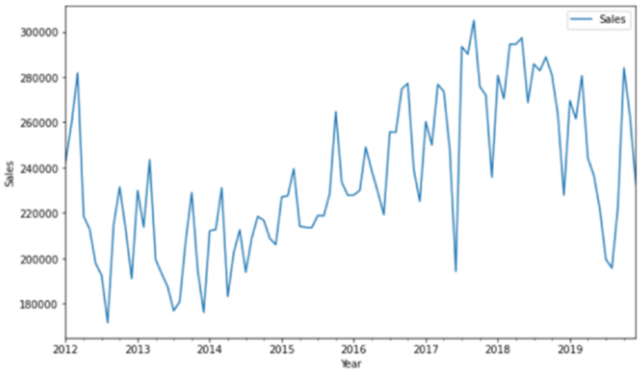

Figure 1. Automobile Sales in India from 2012 to 2019

Here, we will carry out the time series analysis using the Autoregressive Integrated Moving Average (ARIMA) model. It is a combination of Autoregressive (AR) Integrated (I) and Moving Average (MA) terms. In this model, 'AR' signifies that the data is regressed on past values, 'I' shows differencing of observations & 'MA' indicates that the forecast is linearly dependent on past error terms [7]. ARIMA model is denoted as ARIMA (p, d, q) where parameters (p, d, q) specify the type of ARIMA model used. The parameters for the model are as follows:

- p: the number of lag observations or lag order
- d: the number of times the data has been subtracted with past value or the degree of differencing.
- q: number of forecast errors or order of the moving average.

In order to build an ARIMA model, we will follow the Box-Jenkins methodology.

2.2. Model Identification

The second stage of the process is the identification of whether the variable to be forecast shows stationarity or not. The mean, variance, and covariance remain constant over the time in the stationary time series, whereas these values may change with time in non-stationary time series. ARIMA model can only be applied to stationary series. Therefore, we apply the Augmented Dickey-Fuller test to check for stationarity in the data [8]. This test was developed by statisticians David Dickey and Wayne Fuller in 1979. It has the following assumptions:

Null hypothesis (H_0) - series has a unit root. It is non-stationary.

Alternative Hypothesis (H_1) - series does not have a unit root. It is stationary.

For the p-value > 0.05 we fail to reject the null hypothesis (H_0) and for p-value <= 0.05 we accept the alternative hypothesis (H_1).

After applying the ADF test, the p-value is 0.62 which is greater than 0.05, therefore we fail to reject the null hypothesis (H_0) i.e., the series is non-stationary. Thus, we proceed with differencing the time series. After applying the first-order differencing (d=1) and then again using ADF test the p-value comes out to be 0.0025 which is less than 0.05. Hence, we accept the alternative hypothesis (H_1). Since this hypothesis states that the series is stationary, we do not need further differencing and can proceed with applying the ARIMA (p, d, q) model with d=1.

2.3. Estimation and Selection of Parameters

Further, we find the apt 'p' and 'q' values for our model. For this, we plot and examine the Autocorrelation (ACF) and Partial Autocorrelation (PACF) for our stationary time series. The ACF plot is a bar chart of coefficients of correlation between a time series and its lagged values. In other words, it explains how the present value is correlated with a past value in the given time series. The PACF demonstrates the partial correlation between the time series and the lags.

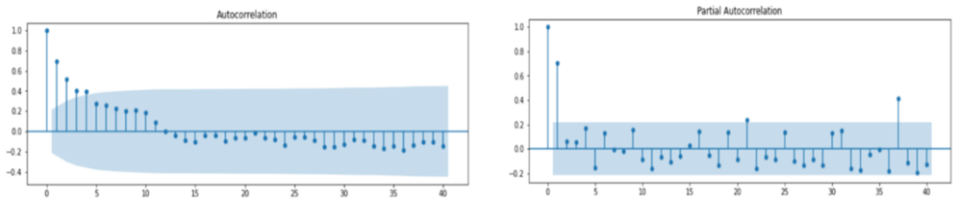

Figure 2. The plot of correlogram (ACF) and partial correlogram (PACF) for lags 1 to 40 of the first order differenced time series

From Figure 2, it can be seen that the Autocorrelation Function gradually decreases while the Partial Auto-Correlation Function has a sharp drop after 2 significant lags so we can conclude that the model is AR (2) i.e., the value of 'p' is 2.

By iterations, several ARIMA models with suitable 'q' values were fitted, the model with minimum Akaike's Information Criteria (AIC) and Bayesian Information Criteria (BIC) values was chosen [9]. The model ARIMA (2,1,3) has the lowest AIC and BIC criteria, hence this model will accurately predict the forecast values for our time series data.

2.4. Forecasting

Figure 3 gives a picture of the automobile sales in India in an ideal scenario had the Covid-19 pandemic not occurred. The blue lines depict the actual sales values till the end of 2019. The orange lines represent the forecast values for years 2020 and 2021 generated by the ARIMA (2, 1, 3) model.

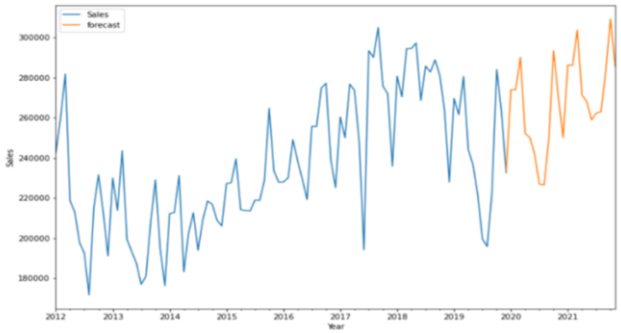

Figure 3. Forecast for the Automobile Sales for the 2020 and 2021 using ARIMA (2, 1, 3) model

3. Results and Discussions

Figure 4 shows the actual sales from January 2012 to December 2021 and the forecasted values for January 2020 to December 2021. Most notably, we can observe three significant negative deviations in the actual sales as compared to the forecasted values. These can be attributed to the first wave (March 2020 – June 2020), second wave (April 2021 – June 2021) and the subsequent semiconductor shortage in the latter part of 2021.

Figure 4. The graph shows actual sales in comparison to the forecasted sales by using ARIMA (2,1,3) model.

The outbreak of Covid-19 in India impacted the already struggling industry. According to SIAM, the drop in sales was 51% y-o-y for March and it was the worst ever decline recorded by the organization. It also estimated a revenue loss of over INR 23 billion per day for the industry due to the shut-down of plants and the piling up of unsold inventory in distribution channels [10]. The complete lockdowns also drove small-scale auto-component manufacturers to bankruptcy along with the 25,000 dealerships that run on very small margins. The pandemic had the greatest impact on the service sector in India which led to losses in employment and pay-cuts. These factors decreased the purchasing power of the Indian customer and thus led to further weakening of automobile sales.

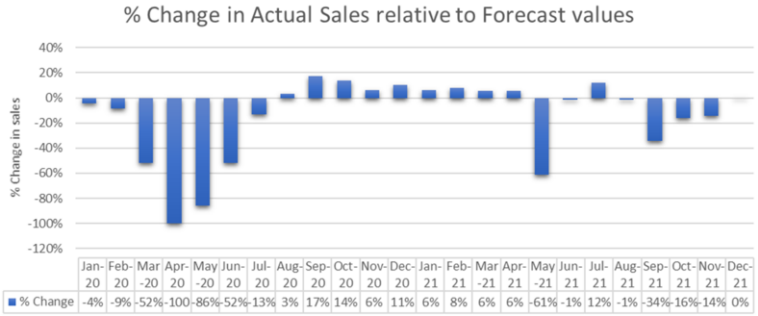

Figure 5. The graph shows percentage increase/decrease in actual sales relative to forecasted sales values for different months

From Figure 5, we can observe that there is an evident decrease in the actual sales since the start of 2020 as compared to our forecasted values through the ARIMA model. The initial decrease in January 2020 and February 2020 may be attributed to the disruption in the supply chain due to the spread of Covid-19 in China. In March 2020, the sales declined significantly (52%) and in April 2020 the sales were absolutely zero. The reason behind this observation is the implementation of lockdowns in mid-March and throughout April 2020. This trend continues throughout July 2020. From August 2020 to April 2021, however, the sales show a slight improvement (3%-17%). This boost is observed due to the gradual removal of restrictions by late 2020 and the festive season in India [11]. The 2nd wave of the pandemic emerged in Mid-April 2021 and it peaked by May 2021, therefore we can observe a steep 61% drop versus the forecast for the month. Going further, the sales rebounded in July but again dipped in comparison to our forecast. This decline was caused due to the growing semiconductor shortage across the globe which was boosted by the pandemic [12].

4. Conclusion

The Indian Automobile industry which is connected to various other important industries such as semiconductors, plastics, base metals and steel was witnessing a decline in sales due to weak demand, regulatory issues, unfavourable exchange rates, and the liquidity crisis in FY19. In March 2020, just as the automotive industry was beginning to recover, the pandemic struck and nationwide lockdowns were imposed which significantly affected the global supply chains. Moreover, the semiconductor shortage in the first quarter of 2021 also had a huge impact on the production capacity

of the automotive industry. This research paper utilises the Box Jenkins' ARIMA model to forecast the Automobile sales in India for the years 2020 to 2021. The model having the lowest AIC and BIC values was selected which was having the order (2, 1, 3). The forecasted data from the ARIMA model was compared with real data of sales of automobiles in India for the years 2020 to 2021 which was drastically affected due to the pandemic. The comparison showed that during the first wave there was a steep decline in actual sales relative to forecasted values for the months of March to June in the year 2020. The months from August 2020 to April 2021 showed a slight increase (3%-17%) in actual sales relative to forecasted values. However, there was a notable decline in the month of May 2021 when the second wave was at its peak. This trend improved slightly but continued till the end of the year. Despite all of these challenges, the sector is set to benefit from the global supply chain rebalancing, incentives from the government and new developmental opportunities which came to light after the tough challenges faced with the Covid-19 pandemic.

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