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# Predicting Present Day Mobile Phone Sales using Time Series based Hybrid Prediction Model

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**Abstract.** In past decades, usually people purchase electronic products or gadgets at nearby retail stores or from direct brand showrooms. The manufacturers collect feedback from the customers via salespoints, calls, messages, emails and feedback forms during service. The customer feedback plays a vital role in improving the product quality as well as to know the need of the customers. These reviews over a time series may not reach the new customers and as well as the originality of the reviews are not ensured. In recent days of thriving information technology, because of huge arrival of shopping portals like Flipkart, Amazon and so on people started to buy products via these portals. These portals beyond sharing the product information also allows the buyers to share their feedback as well as the experience with the purchased product. Novel buyers do read those online reviews or comments and further compare dozens of stores and products before deciding to purchase a product as the customer comments also serve as a source for the companies to predict the sales of their present product and tentative prediction of future sales. By collecting these time series specific reviews and stock market values would help the companies to make an estimation of sales that take place.

## INTRODUCTION

The aspects of personal recommendations and word of mouth references were once the core methodology for customers to collect the information and performance about a specific product [1]. Due to growing online shopping [2] customers have become increasingly keen to share their opinions and feelings in the online shopping portals and in the social media platforms [3]. Beyond the online shopping portals customers convey their voice to the world by sharing their reviews in social media portals like Twitter, Facebook, YouTube and so on [4].

Most of the present-day consumers trust online reviews rather than personal recommendations and tends to hesitate to buy a product that has more negative comments and ratings. The online customer comments contain plenty of knowledge regarding merchandise and services as the customers impart their opinions by reflecting the pros and cons of a product, that understands the views and emotions in user comments is very vital [5]. By performing Time series data mining user reviews is of great significance methodology which not only helps the potential users for making their purchasing decisions but also enable the companies to get their product feedback and to predict the future sales [6].

Sales prediction [8] helps the companies to gauge the demand of their products and to make a strategic plan to increase their growth and quality of the products [9]. Mobile phone sales market has always considered to be one of the competitive aspects in the present day era when compared with the recent growth in new mobile products [10].

Hence it is very challenging to predict the models or brands that tend to dominate the present market by estimating the sales beforehand of the release of product itself which would provide the company with enhanced knowledge that the model will make profit or loss will help the manufacturer to decide the specific quantity of the release in different regions based on the user request that are being imparted and similarly influences the social media comments towards forecasting the sales of any product [11].

The time series data set that comprises of the information that is collected in the form of reviews shows the consumer's opinion towards the product and it acts as the major input for sales prediction [12]. Social media

platforms [13] and e-commerce platforms [14] are the emerging approach to obtain information by analyzing user comments [15]. The process of sales prediction is performed using sentiment analysis of customer reviews based on online comments or from stock market values that tends to influence the aspect of purchasing power of mobile phones as the closing values of a company in a time is used to predict the market's movement over a period [16]. Most of the previous studies on sales forecasting stated that univariate data containing stock market [17] values give less forecasting accuracy [18].

In this paper we cover both the time series model [19] and the multivariate regression model [20] are used to forecast the mobile phone sales of a specific brand or the stock market values prediction using time series analysis which is a process of analyzing historical data to forecast values founded on earlier observed values [17]. In the multivariate regression analysis [18] model two or more variables are used to forecast the assessment of one variable specifically the customer comments and stock markets values are employed to predict sales using multivariate regression model [43-45].

## RELATED WORK

The multivariate regression techniques such as time series models [19] Least Square Support Vector Regression (LSSVR) [21] models predict the total vehicle sales monthly based on the customer reviews from twitter and the values attained in stock market are considered as the input for the forecasting using LSSVR as the time series data models are constructed based on the stock market values [22]. From the tweets the senti-scores are calculated which are further used to denote the positive and negative sentiment information [23].

Hybrid data with de-seasonalizing procedures are employed to compare the forecasting accuracy of monthly total vehicle sales as the results clearly denote that the hybrid approach provides more accuracy when compared to the traditional approaches [24]. The implemented analysis on sentiment analysis based on the mining of opinions which are based on the aspect level sentiment analysis is performed based on the mining of reviews [25]. The information from web pages are extracted using web crawler API [26] extracts information from the webpages. The classifiers which can be utilized for performing classification are Decision trees [27] Naive Bayes (NB) [28] Support Vector Machine [29] and K-Nearest Neighbor [30] and the outcomes are evaluated in terminology of precision and accuracy.

The aspects that are based on sentiment analysis [31] applied over big data by integrating the semantic information classified into various text representation is done by implementing the neural network model [32] and the various attention mechanisms introduced over neural networks tends to mechanize and compare the sentences with the relevant context based vectors are that performs calculations by verifying the weight of each word for making the model that is basically adjustable method of sentiment dictionary tagging which is further used to obtaining the training data effectively improves the accuracy of sentiment analysis [33].

The process of sentiment analysis which is implemented using Transfer Learning (TL) [34] process which is the industry requirement that prefers distinct commodities that are obtained through the product reviews by carrying the internal emotion obtained in the text that are efficiently mined to help the organizations or enterprises for attaining operative future decision brings more opportunities to sentiment analysis using TL algorithms that are employed are based on the "Convolutional Neural Network (CNN) [3] Recurrent Neural Network (RNN) [4] and Hybrid Neural Network (HNN)" [5] models. Applications that are based on of TL put forward to the development trend of sentiment analysis is based on dictionary-based approach that is implemented using NB and Support Vector Machine (SVM) algorithms [33] with small set of opinion words from twitter are collected manually as a seed which is a potentially information that generates pseudo random number [32,37].

A model called Perceived Derived Attributes (PDA) [3] is used to depicts the importance of the customer reviews in product selection given by online shoppers who usually trust the e-commerce portal for providing the customer reviews for customers who checks the reviews frequently before purchasing anything as the analysis clearly shows the online customer reviews which in turn affects the customer decision to buy a specific product can influence sales results [8].

By deploying the novel model that combines the Bass or Norton model [9] and sentiment analysis to predict sales for automotive industry based on time series sales data and online user reviews that are considered for predicting the future sales of the product clearly denotes the integration of novel model generated which higher forecasting accuracy will have a huge impact on sales results [38-42].

## PROPOSED METHODOLOGY

The methodology that we propose in this paper is a HDPM model which is capable of predicting the time series based mobile phone sales using stock market values and customer reviews as HDPM that comprises of various models related to time series and the multivariate regression that includes naive forecasting method for performing the exponential smoothing procedure as the Auto Regressive Integrated Moving Average (ARIMA) procedure [10]. Time series models are utilized to allocate univariate data (stock market values) [12] with multivariate regression model that includes Multiple Linear Regression (MLR) [6] model which is used to implement the multivariate regression data or the multivariate hybrid data [1] as the hybrid data or multivariate regression data comprises of the stock market data and numeric sentiment scores related to online customer reviews by detecting the SentiStrength technique is used to find the sentiment scores of online customer reviews being implemented using Jupiter editor [14].

### The Naive Forecasting Method

As the naive forecasting method is the estimation technique during which the last iteration the definite value is casted as one of the present forecasting value without adjusting them or attempting to determine causal factors. The formula is expressed in the equation (1) [12].

$$Z_t = P_{t-1} \quad \text{ii)}$$

where  $Z_t$  denotes the calculated predicted rate at a specific time  $t$  and  $P_{t-1}$  indicates the actual previous value at time  $(t-1)$  [2].

### The Exponential Smoothing Method

The exponential smoothing method is the statistic forecasting method for univariate data that uses linear combination of past forecast values. This method combines error trend and seasonal component in the calculation. It minimizes the information storage requirements. The formula for calculating forecast value is represented in the equation (2) [18].

$$Z_t = Z_{t-1} + (P_{t-1} - Z_{t-1}) = \alpha P_{t-1} + (1 - \alpha) Z_{t-1} \quad \text{ii)}$$

where  $\alpha$  is the smoothing factor  $0 < \alpha < 1$  and  $Z_t$  is the forecast value as well as  $Z_{t-1}$  is the Previous forecast value and  $P_{t-1}$  is the Actual previous period [19].

### The ARIMA Model

The ARIMA model is a time series analysis model that uses statistical data to predict future scope of a product or future sales value by finding the differences in the time series values instead of actual values by eliminating noise or irregularity attached in a time series [7]. ARIMA model is a combination of two models Auto Regressive (AR) and Moving Average (MA) and the binding part is the integration part based on the AR model that is correlated with the previous time period to the current with three parameters a) auto regressive lags denoted by  $p$  b) order of differentiation denoted by  $d$  and c) moving average denoted by  $q$ . All the plot graphs are attained using Partial Autocorrelation (PA) graph which is used to predict the value of  $p$  and Auto Correlation (CF) graph that uses to predict the value of  $q$  by implementing the formula for calculating AR which is expressed by the equation (3) [15].

$$V_t = X + \sum_{i=1}^q y_i e_{t-i} + e_t \quad \text{iii)}$$

As  $p$  denotes the order with constant  $X$  along with  $e_t$  to indicate the outlier rate at time  $t$  and  $z_i$  is cumulative coefficient quantity of autoregression  $V_{t-i}$  as the outlier accumulation at the autoregressive is calculated using the equation (4) [6].

$$V_t = Y - \sum_{i=1}^q y_i e_{t-i} + e_t \quad \text{iv)}$$

where  $q$  is the order of differentiation,  $Y$  indicates the mean value attained from the series and  $y_i$  is the coefficient of  $e_{t-i}$  when ARIMA( $p, q$ ) is expressed by the equation (5) [6].

$$V_t = X + \sum_{i=1}^p z_i V_{t-i} + Y - \sum_{i=1}^q y_i e_{t-i} + e_t \quad \text{v)}$$

## MLR Model

MLR model is the most typical used regression analysis by most of the researchers for predicting the variable (dependent variable or criterion variable) which is based on the value of two or more variables and correlation is analyzed by implementing multiple regression to clarify the association between one continuous variable and two or more independent variables using the formula for calculating values with k predictor values and q response is given in the equation (6) [24].

$$y = \beta_0 + \beta_1 p_1 + \beta_2 p_2 + \dots + \beta_k p_k + \varepsilon \quad \text{vi)}$$

where  $\beta_0, \beta_1, \beta_2, \dots, \beta_k$  are regression coefficients

## DATA COLLECTION

In this paper, we have used two kinds of time series data for predicting the mobile sales of distinct models available in the market one at a time and the dataset comprises of many attributes with historical monthly stock market values of the brands were obtained from the Yahoo Finance website for the period from April 2017 to January 2021. The dataset contains 24 attributes along with customer reviews of the products for the considered brands which taken from Kaggle website. The noises values like website references and special characters were cleaned and Senti Strength approach [29] is used to calculate the sentiment scores for the preprocessed reviews using the lexicon-based classifier is used to compares text against the sentiments and assign scores from -0.5 to +5.0. The positive number indicates a favorable attitude whereas a negative number indicates negative sentiments.

Further the dataset is separated into training dataset and testing dataset whereas the training dataset is used to train the model for performing different actions and test dataset is used to see how well the machine can predict new values based on its training with 80 and 20 percentages are used [46].

## RESULTS

Prediction results of monthly total mobile phone sales using HDPM are illustrated in this section that forecasts the performance by measuring or calculating error percentage of individual models using Mean Absolute Percentage Error (MAPE) [12] along with Weighted Mean Absolute Percentage Error (WAPE) [32] and Normalized Mean Absolute Error (NMAE) [24] are used to calculate forecasting error and MAPE is used to measure the forecasting accuracy in statistics with an error percentage is calculated using the formula (7) [16].

$$MAPE(\%) = 100 / N \sum_{t=1}^N \left| \frac{Y_t - F_t}{Y_t} \right| \quad \text{b)}$$

The WAPE is a measure of forecast error that controls the infinite error problem of MAPE as the WAPE value is calculated using the formula (8) [6].

$$WAPE(\%) = 100 \frac{\sum_{t=1}^N |Y_t - F_t|}{\sum_{t=1}^N Y_t} \quad \text{c)}$$

The NMAE is the normalized absolute error where average of mean error is normalized and the value is calculated using the formula (9) [6].

$$NMAE = \frac{1}{Y_h - Y_l} \left[ \frac{1}{N} \sum_{t=1}^N |Y_t - F_t| \right] \quad \text{d)}$$

Where N indicates the total number of prediction period as the  $Y_t$  denotes the actual value at time t where  $F_t$  is the calculated forecast value at time t and  $Y_h$  represents the maximum authentic value with the lowest authentic value which is indicated as  $Y_l$ .

**TABLE 1.** Values of MAPE, WAPE and NMAE to predict the total Apple mobile phone sales

Models	Naïve Model	Exponential Smoothing model	ARIMA model	MLR model
MAPE	6.96%	8.97%	10.65%	4.85%
WAPE	2.72%	8.19%	8.66%	1.10%
NMAE	0.16	0.32	0.36	0.06

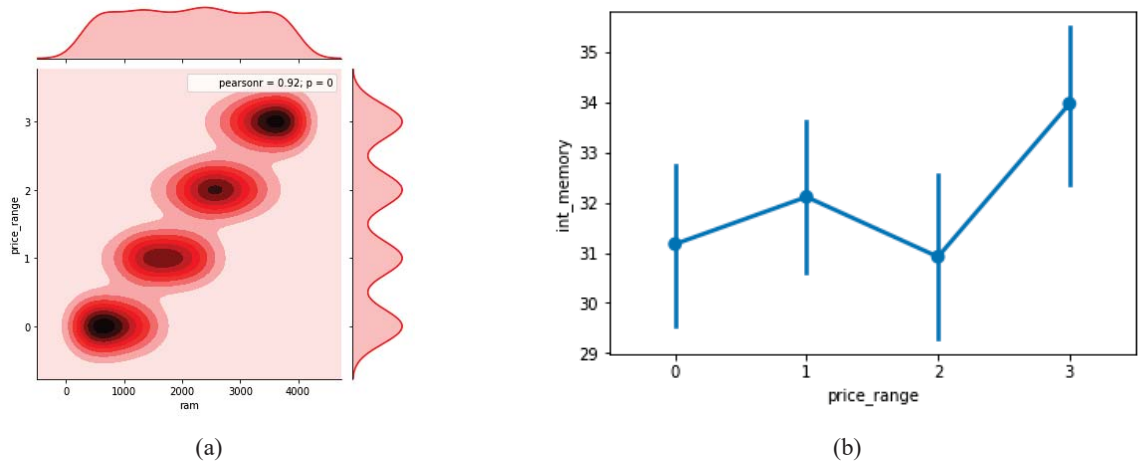
Table 1 illustrates the forecasting error percentage calculated using MAPE, WAPE and normalized absolute error calculated using NMAE for Samsung mobile phone sales where  $\alpha$  value is taken as 0.2 for exponential smoothing model and (p, d, q) value as (1,1,1) for ARIMA model as the time series models obtain an average MAPE of 8.97% and MLR model obtains 4.85%. The approximate error percentage variation between time series models and MLR

models are from 3% to 6%. Timeseries models obtain an average normalized absolute error of 0.18 which is higher than the MLR model as the overall result analysis shows that MLR model gives less forecasting error than its competing time series models

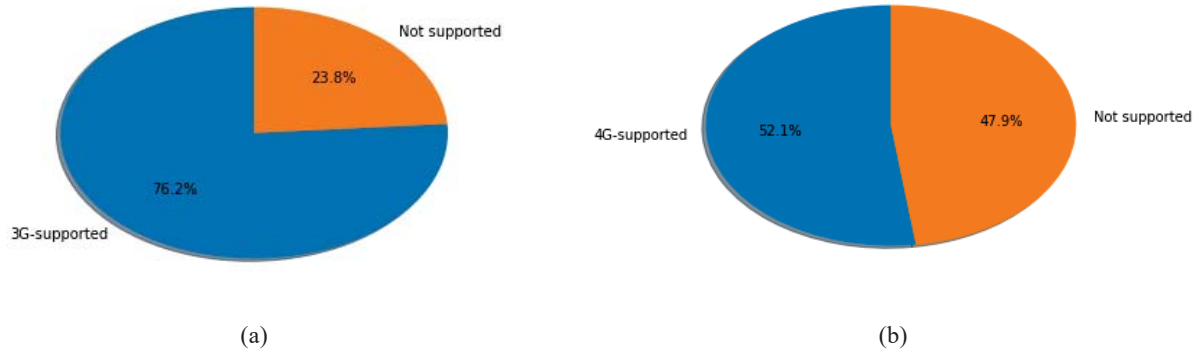
**TABLE 2.** Values of models to predict the total Samsung mobile phone sales

Models	NAïVE Model	Exponential Smoothing Model	ARIMA model	MLR model
MAPE	16.55%	18.79%	17.82%	8.95%
WAPE	7.42%	9.33%	8.42%	6.59%
NMAE	0.23	0.31	0.27	0.16

Table 2 illustrates the forecasting error percentage calculated using MAPE, WAPE and normalized absolute error calculated using NMAE for oppo mobile phone sales where the  $\alpha$  value taken as 0.23 for exponential smoothing model and (p, d, q) value as (2,2,2) for ARIMA model and the time series models obtain an average MAPE of 17.82% and MLR model obtains 8.95% as the approximate error percentage variation between time series models and MLR models are from 8% to 10%. Time series models obtain an average normalized absolute error of 0.25 which is higher than the MLR model and it performs better than other time series models as it gives less forecasting error.



**FIGURE 1.** (a) Denotes reviews related to RAM with price range and (b) Denotes reviews related to internal memory with price range



**FIGURE 2.** (a) Denotes % of positive reviews for 3G models and (b) Denotes positive reviews related to 4G models



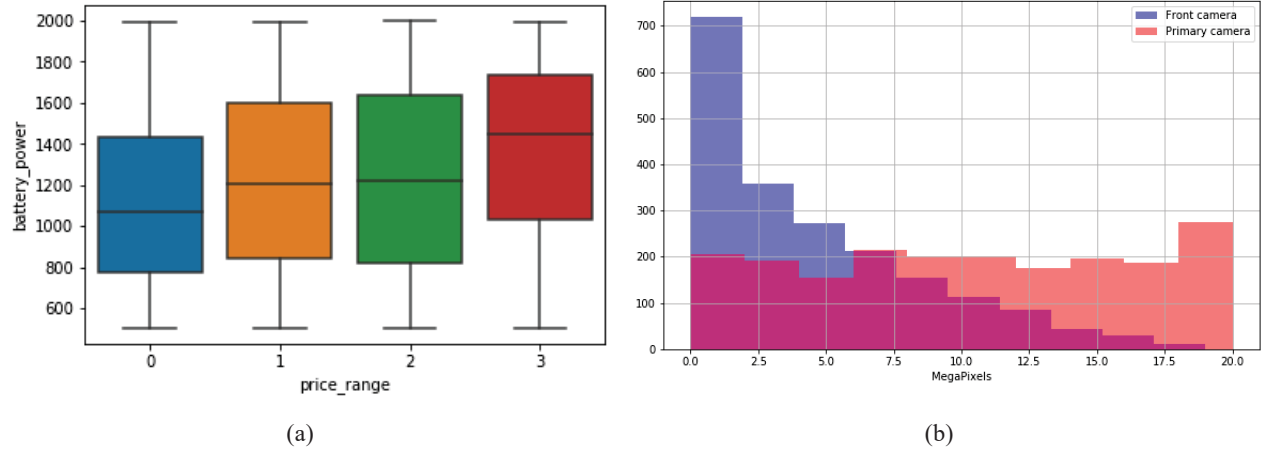


FIGURE 3. (a) Denotes ratings for battery power and (b) denotes reviews for front camera

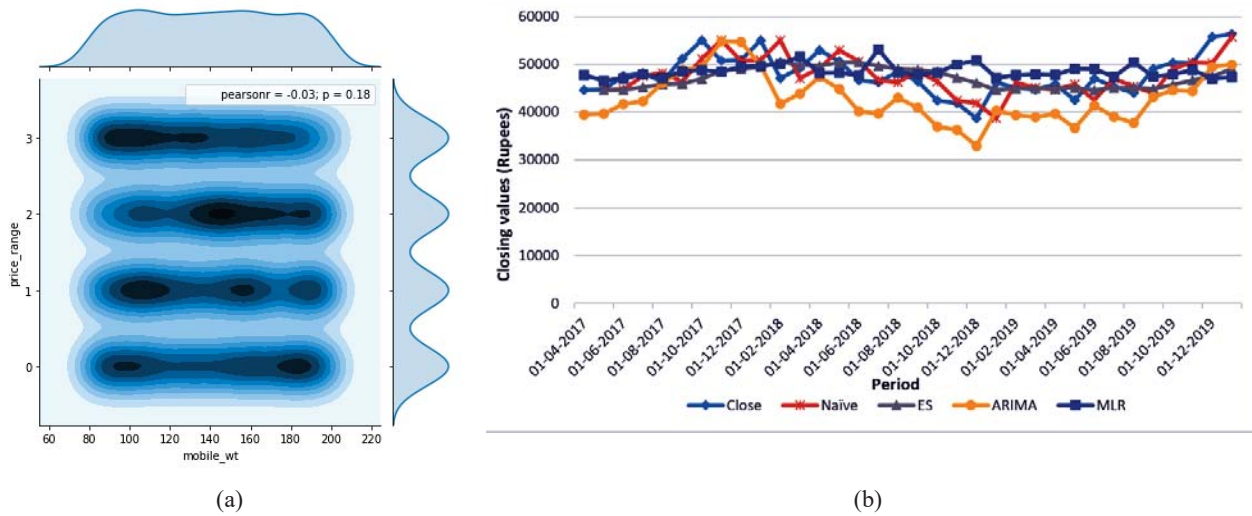


FIGURE 4.(a) Denotes ratings for Talk time vs Price range and (b) denotes the predicted monthly sales of Oppo phones using HDPM till December 2019

Figure 1 represents the outputs attained by implementing the dataset in machine learning and based on the attribute reviews related to RAM with respect to price, and price with respect to Internal memory being reviewed by the user. Figure 2 represents the 3g and 4g support related reviews or issues consists of values either supported or not supported. Figure 3 represents battery power consumption and front camera or primary camera working reviews or issues and Figure 4 denotes the talk time aspect being effectively implemented in a model of mobile phone using HDPM prediction model being proposed mathematically in this paper based on these reviews the sales can be further predicted of a new model of Oppo mobile phone launched in market or about to be launched and results clearly show the hybrid data based approach provides better accuracy than traditional single data based prediction techniques[47].

## CONCLUSION

In this paper we have proposed the HDPM based model with an objective to increase accuracy for short term forecasting using multivariate regression data as the numerical results show that time series forecasting mobile phones sales by MLR model obtains more precise forecasting results when compared with other forecasting models. It is very clear that it represents the use of hybrid data or multivariate data which includes sentiment analysis of consumer comments that would decrease the predicted error percentage by considering the present day most often utilized social media data is considered for forecasting. The results attained are satisfactory with 92% accuracy.

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