# Comparative Analysis of Forecasting Techniques using Automobile Sales Data in Pakistan

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**MASTER THESIS WORK**

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# Abstract

Sales forecasting is an important aspect for business environments in today's competitive and globalized atmosphere, since virtually all the operational decisions require an estimate of the future demand. Reliable forecasts make an important contribution to the production and sales planning. On the other hand, erroneous forecasts can lead to loss of customer satisfaction, decreased sales orders and reputation damage. The automobile industry of Pakistan has seen growth in the new millennium and contributed 3% of the country's Gross Domestic Product (GDP) in the year 2016. As it has become one of the most important sectors of the Pakistan's economy, its development is of utmost interest.

This thesis focuses on the forecasting of the most sold cars in Pakistan. In this regard, various factors that affect the automotive demand have been considered and their correlation with sales data has been established. The neural network method has been used along with other conventional forecasting techniques to evaluate the future demand of vehicles and demand for the next three years is evaluated. The results are then compared to obtain the best forecasting method for the Pakistan's automotive industry.



**Key Words:** *Sales forecasting; Artificial Neural Network; Automobile Industry in Pakistan.*

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# CHAPTER 1: INTRODUCTION

## 1.1 Background

In Automobile companies, there has always been difficulty in predicting the highly fluctuating customer demands. Although the demand of the customer is difficult to predict with high accuracy, but an absence of the figure of production rate for the next production run or a period can severely damage the company's reputation, market share and financial position. Furthermore, the accuracy of the forecast affects the whole supply chain [1]. Armstrong et al [2] comment that forecasting is essential for decision making unless insurance or hedging is selected to secure the future.

## 1.2 What is forecasting?

There are different definitions of forecasting in literature, from which some of the selected definitions are as presented below:-

a) A projection into the future of expected demand, given a stated set of environmental conditions [3].
b) The process of making predictions of the future based on past and present data and analysis of trends [4].
c) A prediction of some future event or events [5].
d) Forecasting is the process of predicting the future [6].

To say that (something) will happen in the future: to predict (something, such as weather) after looking at the information that is available [7].

It can be seen that there is quite an agreement with literature that forecasting is the prediction of some future event. Forecasting is a difficult and challenging task, as it involves the interrelated nature of data series and level and trend shifts [8]. Forecasting accuracy can lead to significant savings, competitiveness, and customer satisfaction along with enhanced relationships [9]. Whereas, it can be used as a competitive advantage, but when used wrongly, it can really damage the whole business. It may also cause the loss of certain strategic and important orders due to the capacity overrunning. On one side, damage can be caused to the enterprise for under-planning or over-planning, and on the other side, customer satisfaction can be really hampered when orders are not delivered in time.

## 1.3 Classification

Forecasting can be classified into two broad but different categories ranging from intuitive to formal methods. Figure 1 shows the classification of forecasting methods. The intuitive methods are further divided into individual and collective expert judgements. The individual judgments are made on data obtained through Interviews, Questionnaire and Analytic hierarchy process, whereas collective judgments are made through Brainstorming, Commission of experts, Delphi Method and Scenario building [10]. Formal methods are further divided into four categories mainly System structural methods, Associated methods, Mathematical models, and methods of advance information [10].

Mathematical models are of three types Statistical, Extrapolative and Combination of the two above mentioned. Statistical methods comprise of Regression Analysis, Correlation Analysis, Adaptive Models and Time-Series Models [11]. Moving Average and Exponential Smoothing are primary Extrapolative methods [6, 12]. System structural methods comprise of Functional hierarchal modeling, Morphological Analysis, Matrix modeling and Network Simulation. Associative methods are Method of historical analogies, Simulation and Data Mining (Group method of data handling and Artificial Neural Networks). Method of advance information comprises of Flow analysis of publications, Importance of the invention and Analysis of patents [10].

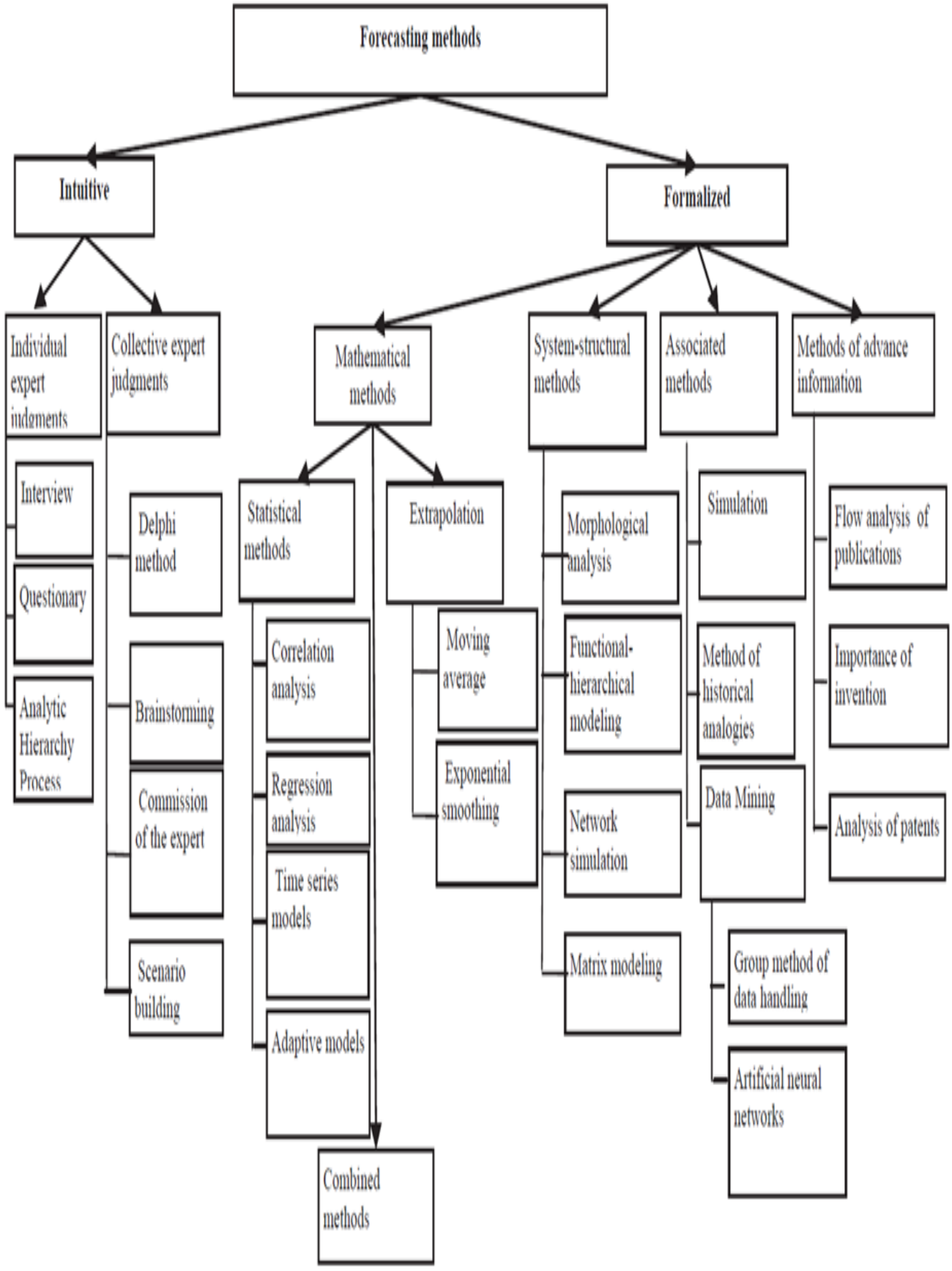



Figure 1: Classification of Forecasting Methods

## 1.4 Sales forecasting

Sales forecasting is of utmost importance in the ever competitive world of globalization. The margins for mistakes are dropping and the level of competitiveness is increasing with each technological advancement. Sales forecasts help companies better understand their business and are basis of planning for the future. These forecasts help establish an ideal inventory level, making purchases of raw materials easy and more effective, all of which combined, increase the profit of an organization [13]. Sales forecasting has been identified as an important input to almost all decisions affecting the future of the organization [14]. Fildes et al. [15] argue that lost orders, poorly utilized production capacity and inadequate services can result without a forecast, making the organizational existence a question in the long term.

## 1.5 Methods used in sales forecasting

A number of different methods are used to forecast sales of a particular product. Methods vary from product to product. A method may forecast the sales of toothpaste effectively, whereas it might not have the same efficiency forecasting sales of automobiles. The primary methods used in sales forecasting are Mathematical methods that are basically Statistical, Extrapolative or a combination of the two. All the above mentioned methods need historical data to make forecasts [5, 11].

## 1.6 Why forecasting?

The critical need for forecasting for effective operation of a company has already been recognized by the experts [16]. An increased level of commitment with regards to forecasting has been noted in terms of investment, operations research specialist hiring and purchasing of forecasting software and has been duly noted, for example, in [15, 17, 18]. Similarly, Makridakis et al. [19] has pointed out following factors which imply the increase in the need of forecasting:-

a) Organizations have increased in complexity (e.g., Number of products offered in many markets) and decision makers have felt difficulty in deciding the road towards future growth of the organization.

b) More systematic decisions have been undertaken by the organizations, and forecasting has been used as a tool to support decisions.

c) The forecasting methods have been developed to address the requirements of managers.

## 1.7 Why study car sales forecasting

Automobiles are one of the primary economic goods in the world. They ensure ease of transportation and ascertain that the products are delivered safely and in a timely manner [20]. Good forecasts make sure that the automobile industry is ever striving for new technology and make the journey safe, comfortable and cheap without compromising on quality [21]. Sales forecast ensures that the budget of automobile companies remains in check and the ultimate goal of maximizing profits is fulfilled effectively. An effective forecast will also ensure the employment of a number of workers, push the other industries to produce and invest in new technologies and prove highly beneficial in inventory and production management [22].

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Forecasting literature

The history of forecasting literature is fairly old, nearly a century now. The first textbook on statistical business forecasting can be found as early as 1934 [23]. A series of forecasting books can be found thereafter e.g., 1961 [24], 1976 [25], 1989 [26], 1994 [27], 2004 [28] and 2015 [29]. A book of forecasting principles has also been published [30] and an attempt has also been made to compile a handbook of the subject [16]. A quarterly peer reviewed international research journal on the subject of forecasting with an impact factor of 1.33 is also being published [31].

## 2.2 Forecasting in sales

A number of different methods are used to forecast automobile sales. Forecasting can be classified into two broad but different categories ranging from intuitive to formal methods. The primary methods used in sales forecasting are mathematical methods that are basically statistical, extrapolative or a combination of the two [32-35]. Huo et al [36] has forecasted sales of passenger cars in China using a log normal distribution function where input parameters were population, per-capita income and mean income using historical data of 6 years.

Shahabudin et al [13] used stepwise regression to forecast sales of foreign cars, trucks and concluded the results could be further enhanced if vehicles were segmented according to their size, the input parameters were durable personal consumption, durable industrial demand, discount rate, GDP, personal consumption, GNP, population, non-durable industrial goods demand, leading economic indicators. Hulsmann et al [21] compared support vector machining with Quantile Regression, Classical Moving Average (CMA), Past Moving Average (PMA), Exponential Smoothing Moving Average (ESMA), while forecasting US vehicle sales using yearly data from 1992 to 2009 where input parameters were Consumer prices, GDP, Unemployment rate, Personal Income, Gasoline Prices Interest Rate and Private Consumption. MAPE was found to be 14.8%.

Yuan et al [37] proves genetic algorithm based support vector regression to be superior in forecasting vehicle sales of Taiwan using input parameters stock index, GDP per person, jobless rate, CPI, US dollars, Yen, Euro, CCI and gasoline price, during period from 2003~2009. Sa-ngasoongsong et al [38] implemented vector error correction model (VECM) on monthly sales from 1975 to 2010 to find the best economic indicators impacting vehicle

sales. The indicators contesting were Small-vehicle segment sales, Large-vehicle segment sales, Unemployment rate, Consumer price index, Gas Prices.

Demiroglu et al [39] did regression analysis on annual data of vehicle sales from 1994 to 2015 of Turkey to estimate sales trend where parameters used were Household expenditures, Per capita car ownership, Operational leasing firms. Kitapci et al [40] did multiple regression, neural network method to reveal the effects of economic policies, as one of the macro environmental factors that affect the marketing, on the sale of automobiles, using parameters inflation rate, euro rate, oil prices, new car price index, vehicle loans, total advertising expenses and GDP.

Hsu et al [22] uses a classical factor model and the Peña-Box model to examine the contemporary and time-varying relationships of different brands/models of cars in Taiwan on monthly sales of 32 brands/models of automobile in Taiwan. Fantazzini et al [41] proposes new multivariate models to forecast monthly car sales data using economic variables and Google online search data using (VEC) Vector Error Correction models, (BVAR) Bayesian Vector Auto-Regressive models, (VAR) Vector Auto-Regressive models, having parameters Consumer Confidence Indicator (CCI), Building Construction (BC), Consumer Price Index (CPI), Gross Domestic Product(GDP), Euro Interbank Offered Rate (EURIBOR) Unemployment Rate(UR), Production Index(PI), Petrol Price(PP).

Qian et al [42] proposes a novel approach that applies diffusion models using car ownership data to forecast car sales. He used Gompertz model, Logistic model, The Bass model on data from 2001 to 2009. Vahabi et al [32] Addresses the problems and proposes a way that forecasts future automobile sales by combining two artificial intelligence algorithms.

Etkin et al [43] substantiates the economic significance of forecasting the sales volume of mass-produced cars through function with an equation on parameters Population, Number of households, Average annual household income, Average family wages, Average expenses for the purchase of a new car, Amount of weekly wages in the expenses for the purchase of a new car, Conditional purchasing capacity of the car market, Annual sales volume of mass-produced cars, Annual specific sale of cars. Susanti et al [44] Gave the plan to make car sales forecast for the next few months, using Adaptive Spline Threshold Auto-regression (ASTAR) considering monthly data from June 2013 until May 2015.

Emre et al [45] estimated the demand for new automobiles in Turkey immediately following its entry to Custom Union with the European Union in 1996, through dynamic Generalized Least Squares Estimation method having parameters the model's own price,

average quality and the competitors' average price, real growth rate, real interest rate, real consumer credits, price of gasoline inflation rate, and volatility of flation variables.

Hülsmann et al and Yuan et al [21, 37] have used support vector regression (SVR) as a method to forecast automobile sales. Whereas, Vahabi et al and Wang et al [32, 46] have used adaptive network-based fuzzy interface system (ANFIS) to forecast automobile sales. Neural networks have also been used often to forecast automobile sales mainly by [37, 40, 47].

Vector error correction model (VECM) has been used by [38, 41] to forecast automobile sales. Yuan et al and Emre Alper et al [37, 45] used least mean square algorithm to forecast automobile sales. Exponential smoothing and moving average has been used by [21]. Whereas, Snyder et al [48] used autoregressive integrated moving average to forecast automobile sales. Hsu et al [22] used Pena Box approach, Qian et al and Fan et al [42, 49] used Bass/ Norton models, Susanti et al [50] used adaptive spline threshold auto-regression model and [36] used a log normal distribution function to forecast automobile sales.

## 2.3 Overview of car market in Pakistan

Automobiles are one of the major contributors to the economies around the globe. They ensure ease of transportation and ascertain that the products are delivered safely and in a timely manner [20]. Good forecasts make sure that the automobile industry is ever striving for new technology and make the journey safe, comfortable and cheap without compromising on quality [21]. An effective forecast will also ensure the employment of a number of workers, push the other industries to produce and invest in new technologies and prove highly beneficial in inventory and production management [22].

In the modern and advanced industrial era, the need for automobiles has grown to the heights never seen before. Sales of all kinds of vehicles, including vans and jeeps, rose by 31% in the financial year 2016, compared with 1% in the preceding year and a 5.3% on average growth in the last five years [51].

In Pakistan, around 500 different auto part manufacturers provide supply to original equipment manufacturers. Presently there are 82 vehicle assemblers, which are producing trucks, tractors, buses, passenger cars, commercial vehicles, and 2/3 wheelers. However, there are 12 automobile companies listed on the Karachi Stock Exchange under the sector of Auto & Allied. It is being estimated that the recently announced auto policy will provide the country with an investment of around $4.09 billion in next 5 years [52] with a target to produce half a million cars per annum. Despite having the 5$^{th}$ largest population in the world and a share of

2.67% of the world population [53], the share of its automobile market is less than 1% of the total automobile market of the world. The primary reason for such dismal numbers is the non-development of the local market and offering of globally retarded models and lacking essential safety features [52].

## 2.4 Major market players of Pakistan

Primary automobile giants of Pakistan include Pak Suzuki Motor Company Ltd, Honda Atlas cars Ltd, Indus motor company Ltd, Ghandhara Nissan Ltd and FAW [52]. Major models sold for these respective manufacturers are shown in Table 1.

Table 1: Primary automobile manufacturers in Pakistan

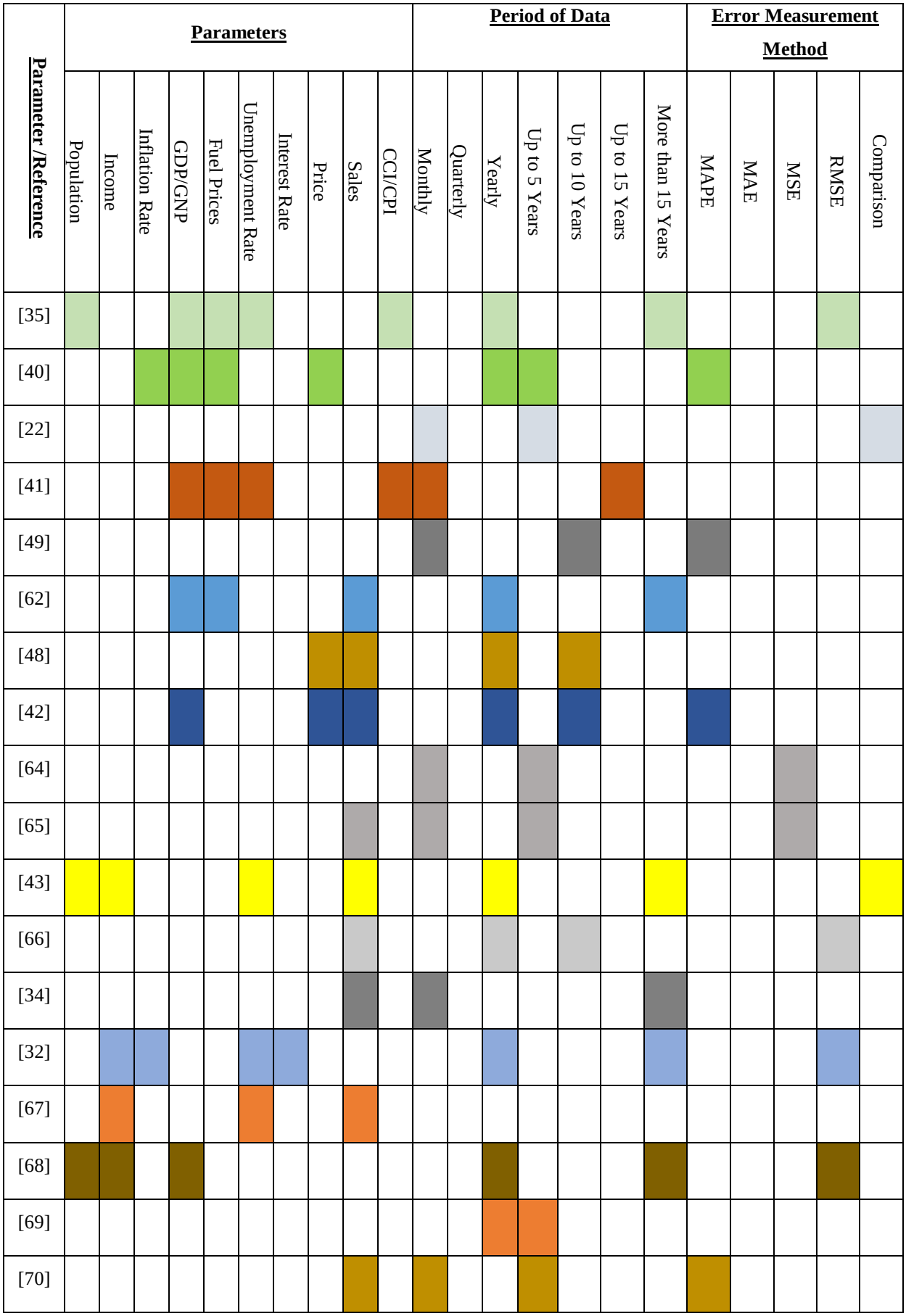
| Company | Detail | Models |
|---|---|---|
| Pak Suzuki Motor Company Ltd. | Founded in 1983 as a joint venture between Suzuki Motor Corporation (SMC) -Japan and Pakistan Automobile Corporation Limited (PACO). Has largest sales in industry with over 60% share. | Mehran, Baleno, Cultus, Wagon R, Liana, Swift, Kizashi, Carry, Alto (Discontinued in 2012), |
| Indus Motor Company Limited | Initiated in December 1989, joint venture between the Toyota Motor company, House of Habib & Toyota Tsusho Corporation. The company started production in May 1993. It has a market share of 33% | Corolla, Fortuner, Hilux, Prius (Import), Vigo Champ, Prado, Vitz (Import) |
| Honda Atlas Cars Limited | Honda Atlas started Commercial production in July 1994, joint venture between Atlas Group of Companies, and Pakistan Honda Motor Company, Japan. | Honda City, Honda Civic, Honda Accord |
| Ghandhara Nissan Limited | It was founded in 1981. The company has yet to make a mark in Pakistani market as evident from its low sales all over the country. | Pick up, Patrol x-trail, Juke (import), Urvan civilian, Moco (import), Sunny (discontinued) |
| FAW | Local production was started in 2011. | FAW Carrier, XPV, V2, SIRIUS S80 |

# CHAPTER 3: RESEARCH GAP

Table 2 shows the research gap found after undergoing literature review of 34 research papers taken from various sources. All of these papers were related to sales forecasting in general and automobile forecasting in particular. In the table CPI (Consumer Price Index), CCI (Consumer Confidence Indicator), GDP (Gross Domestic Product), GNP (Gross National Product), MAPE (Mean Absolute Percentage Error), MAE (Mean Absolute Error), MSE (Mean Squared Error) and RMSE (Root Mean Square Error) are used as abbreviations.

Table 2: Summary of Literature Review

| **Parameter /Reference** | **Parameters** | | | | | | | | | | **Period of Data** | | | | | | | **Error Measurement Method** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Population | Income | Inflation Rate | GDP/GNP | Fuel Prices | Unemployment Rate | Interest Rate | Price | Sales | CCI/CPI | Monthly | Quarterly | Yearly | Up to 5 Years | Up to 10 Years | Up to 15 Years | More than 15 Years | MAPE | MAE | MSE | RMSE | Comparison |
| [36] | | | | | | | | | | | | | | | | | | | | | | |
| [54] | | | | | | | | | | | | | | | | | | | | | | |
| [13] | | | | | | | | | | | | | | | | | | | | | | |
| [56] | | | | | | | | | | | | | | | | | | | | | | |
| [21] | | | | | | | | | | | | | | | | | | | | | | |
| [37] | | | | | | | | | | | | | | | | | | | | | | |
| [59] | | | | | | | | | | | | | | | | | | | | | | |
| [60] | | | | | | | | | | | | | | | | | | | | | | |
| [46] | | | | | | | | | | | | | | | | | | | | | | |
| [38] | | | | | | | | | | | | | | | | | | | | | | |
| [39] | | | | | | | | | | | | | | | | | | | | | | |


Parameter /Reference
Parameters
Period of Data
Error Measurement Method
Population
Income
Inflation Rate
GDP/GNP
Fuel Prices
Unemployment Rate
Interest Rate
Price
Sales
CGI/CPI
Monthly
Quarterly
Yearly
Up to 5 Years
Up to 10 Years
Up to 15 Years
More than 15 Years
MAPE
MAE
MSE
RMSE
Comparison
[35]
[40]
[22]
[41]
[49]
[62]
[48]
[42]
[64]
[65]
[43]
[66]
[34]
[32]
[67]
[68]
[69]
[70]

| Parameter /Reference | Parameters | | | | | | | | | | Period of Data | | | | | | Error Measurement Method | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Population | Income | Inflation Rate | GDP/GNP | Fuel Prices | Unemployment Rate | Interest Rate | Price | Sales | CGI/CPI | Monthly | Quarterly | Yearly | Up to 5 Years | Up to 10 Years | Up to 15 Years | More than 15 Years | MAPE | MAE | MSE | RMSE | Comparison |
| [20] | | | | | | | | | | | | | | | | | | | | | | |
| [45] | | | | | | | | | | | | | | | | | | | | | | |
| [71] | | | | | | | | | | | | | | | | | | | | | | |
| [47] | | | | | | | | | | | | | | | | | | | | | | |
| [72] | | | | | | | | | | | | | | | | | | | | | | |
| [73] | | | | | | | | | | | | | | | | | | | | | | |
| N | | | | | | | | | | | | | | | | | | | | | | |

Table 3 shows the legend of the forecasting methods used. Each research paper is assigned a specific color based on the method used. The black portion represents the area of our research, whereas the white boxes show the research gap after the literature review.

Table 3: Legend for Forecasting Methods

| **Forecasting Method Legend** | **Color** |
|---|---|
| ARIMA | |
| Hybrid Models | |
| Logit Model | |
| Regression | |
| Support Vector Machine (SVR) + Regression | |
| Support Vector Machine + Quantile Regression + Classical Moving Average (CMA) + Past Moving Average (PMA) + Exponential Smoothing Moving Average (ESMA) | |
| Moving Average (MA) | |
| Exponential Smoothing | |
| Least Mean Square | |
| Artificial Neural Network (ANN) | |
| Naïve Forecasting | |
| Adaptive Network Fuzzy Interface System (ANFIS) | |
| Vector Error Correction Model (VECM) | |
| Vector Auto-Regressive (VAR) | |
| Vector Error Correction(VEC) models + Vector Auto-Regressive (VAR) models+ Bayesian Vector Auto-Regressive (BVAR) models | |
| Bass/Norton Model | |
| State Space | |
| Gompertz model + Logistic model + The Bass model | |
| Adaptive Spline Threshold Auto Regressive (ASTAR) | |
| Genetic Algorithm (GA) | |
| GM (1,1) Model + ARIMA + Hybrid | |
| Log Normal Distribution Function | |

| Forecasting Method Legend | Color |
|---|---|
| Least-Mean Square Algorithm (LMS) + Support Vector Regression (SVR) + Artificial Neural Networks (ANNs) | |
| Neural Network (ANN) + Regression | |
| Peña-Box approach | |
| Fuzzy Neural Network (FNN) | |
| Statistical Time Series + Judgmental Forecasting techniques | |
| Research Based Analysis | |
| Equation System | |
| Extrapolation | |
| Gap | |
| Proposed research area | |

# CHAPTER 4: RESEARCH METHODOLOGY

## 4.1 What methods will be used and why?

This thesis presents future forecasts of the automobile industry for the upcoming 3 years. In this regard, data of automobile industry of Pakistan has been collected from 1998 to 2016 using Pakistan Automotive Manufacturers Association website [74]. Classical forecasting methods of Moving Average and Double Moving Average were chosen because of their ability to "smooth out" fluctuations that often occur with each reporting period. Exponential Smoothing was chosen because it takes into account all past data and only needs the most recent forecast value to be kept. Other methods of Brown's Double Exponential Smoothing and Holt's Double Exponential Smoothing are considerably advanced and have never been used to forecast automobile sales. In order to complement this work Neural Network has been trained on the same data and forecast errors have been calculated.

## 4.2 Assumptions for Research

The research will be conducted keeping in view the dismal condition of public transport at present. The difficulty and unease in public transport often compel people to buy their own cars. The research does not include the effects of CPEC since it will be fully operational only after 2020. The research keeps into account only local sales data available from local manufacturers. It will not include the effects on sales that may be caused by hybrid imported vehicles. The research does not take into account any legislation which may take place in the future due to hazardous environmental conditions. People as a whole are moving towards hybrid and more fuel efficient cars this trend may have a significant effect on sales of automobiles which run on fossil fuels.

## 4.3 Input Parameters and methodology for their selection

In conclusion of the literature review, 19 parameters affecting automobile forecast were identified. The data of these 19 parameters were collected from year 1998 to 2016 from World Bank Website [75]. Some of the major economic indicators of Pakistan's economy are shown in Table 4 [52, 75].

Table 4: Major economic parameters of Pakistan's economy and their respective values

| Parameters | Values (Pakistan) | Parameters | Values (Pakistan) |
|---|---|---|---|
| Pakistan's economy ranking | 24th | Net national income per capita (current US$) | 1513 |
| Contribution of automobile sector to economy | 3% | Official exchange rate (LCU per US$, period average) | Pakistani rupees (PKR) per US dollar - 104.76 |
| Gross sales of vehicles | $2.67 billion | GDP growth (annual %) | 5.74% |
| Population | 207,774,520 | GDP per capita (current US$) | $1,468 |
| Inflation, consumer prices (annual %) | 3.75% | Pump price for gasoline (US$ per liter) | 0.62 |
| Labor force, total | 68052003 | Foreign direct investment, net inflows Percentage of GDP) | 0.36% |
| Unemployment, total (Percentage of total labor force) | 5.86% | Consumer price index | 150.75 |
| Current account balance (Percentage of GDP) | -0.59% | Gross savings (Percentage of GDP) | 23.29 % |

Regression is used to make predictions about a single value. Simple linear regression involves discovering the equation for a line that most nearly fits the given data. That linear equation is then used to predict values for the desired points of the future data, for which forecast has to be calculated. The following term is derived from the heredity studies performed by Sir Francis Galton in which he compared the heights of sons to the height of their fathers. The equation is a mathematical equation that can be used to predict the values of one dependent variable from known values of one or more independent variables. Here,

Dependent Variable = Y

Independent Variable = X

Then for a linear equation, Y = a + bX, to fit on this data,

$$b = \frac{\sum XY - nX'Y'}{\sum X^2 - nX'^2}$$

And,

$$a = Y' - bX'$$

Linear regression analysis was carried out on these parameters and 5 parameters were shortlisted having $R^2$ above 0.8 i.e. Total population, net national income per capita (current US$), GDP per capita (current US$), labor force, total car sales. Table 5 shows their respective values. These parameters, which were proven to be highly correlated with sales trend were used as an input to the Neural Network.

Table 5: Parameters and their respective R square values

| **Parameter** | **R Square** |
|---|---|
| GDP per capita (current US$) | 0.8424 |
| Total Labor force | 0.8304 |
| Sales Against Net national income per capita (current US$) | 0.8333 |
| Sales Against Population, total | 0.8001 |
| Time (Years) | 0.8103 |

## 4.4 Models to be forecasted

The automobile models having sales above a threshold of 100,000 units were selected for forecast. In order to understand the sale of vehicles in Pakistan it is imperative that we look at the number of units sold by each company. Figure 2 shows the sum total of all models which have been sold by each company during last 17 years. An analysis of the graph shows that Suzuki has been the most successful company with sales of more than 1000000 units during the said period, followed by Toyota (600000 units) and Honda (200000 units). The sales of the other 3 companies are negligible when compared to these successful manufacturers [74].

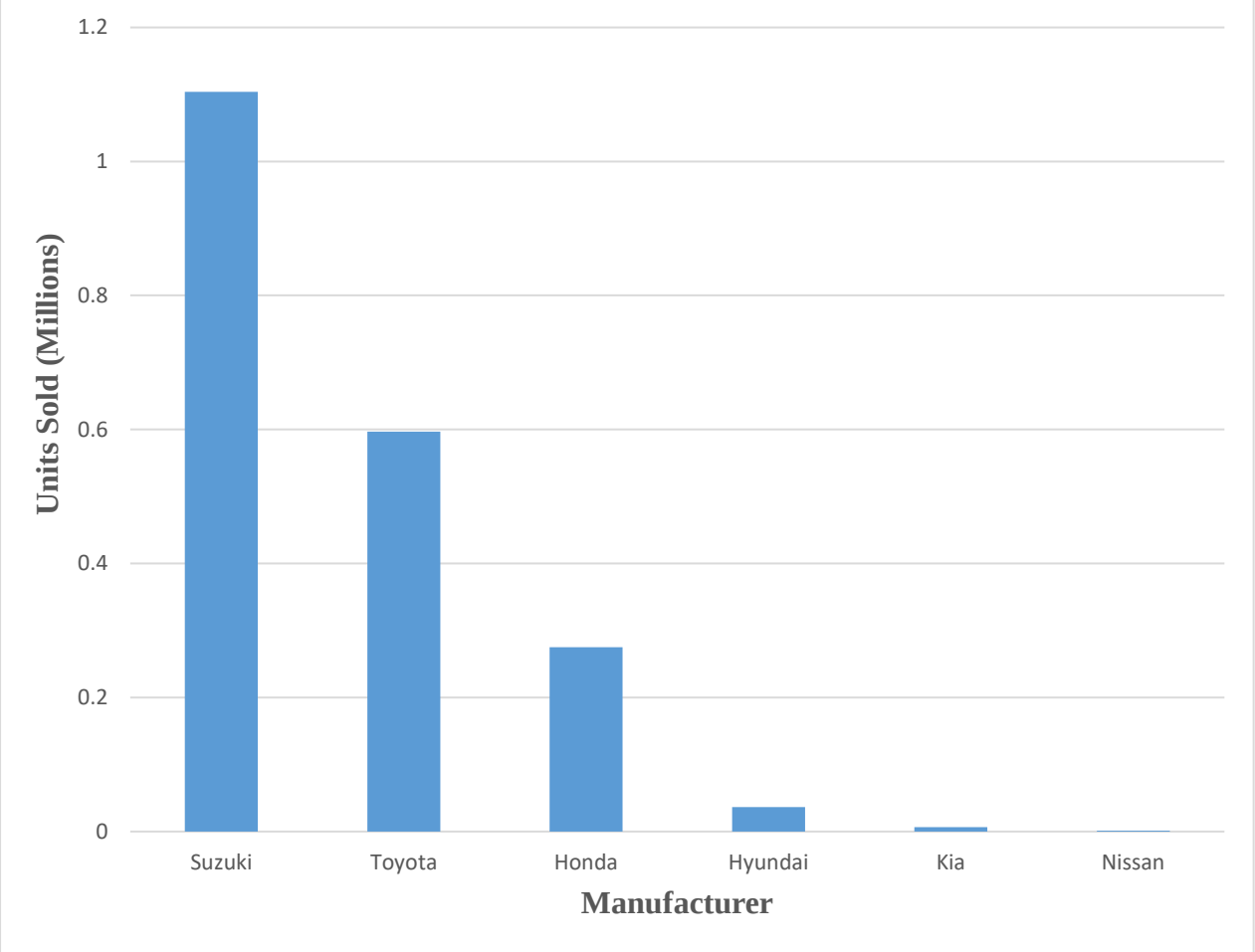



Figure 2: Sum sales of all models from 1998 to 2016

Figure 3 presents the division of models sold for the respective manufacturers. There are few models which largely contribute to the overall sales of each manufacturer. As evident, Toyota generates all of its sales from Corolla, whereas Suzuki's most successful model is Mehran owing to its cheap sales price and low maintenance and running costs followed by

Honda's civic and city which are bought by loyal clients only. Suzuki's other variants also generate high sales making it the most successful manufacturer in Pakistan [74].

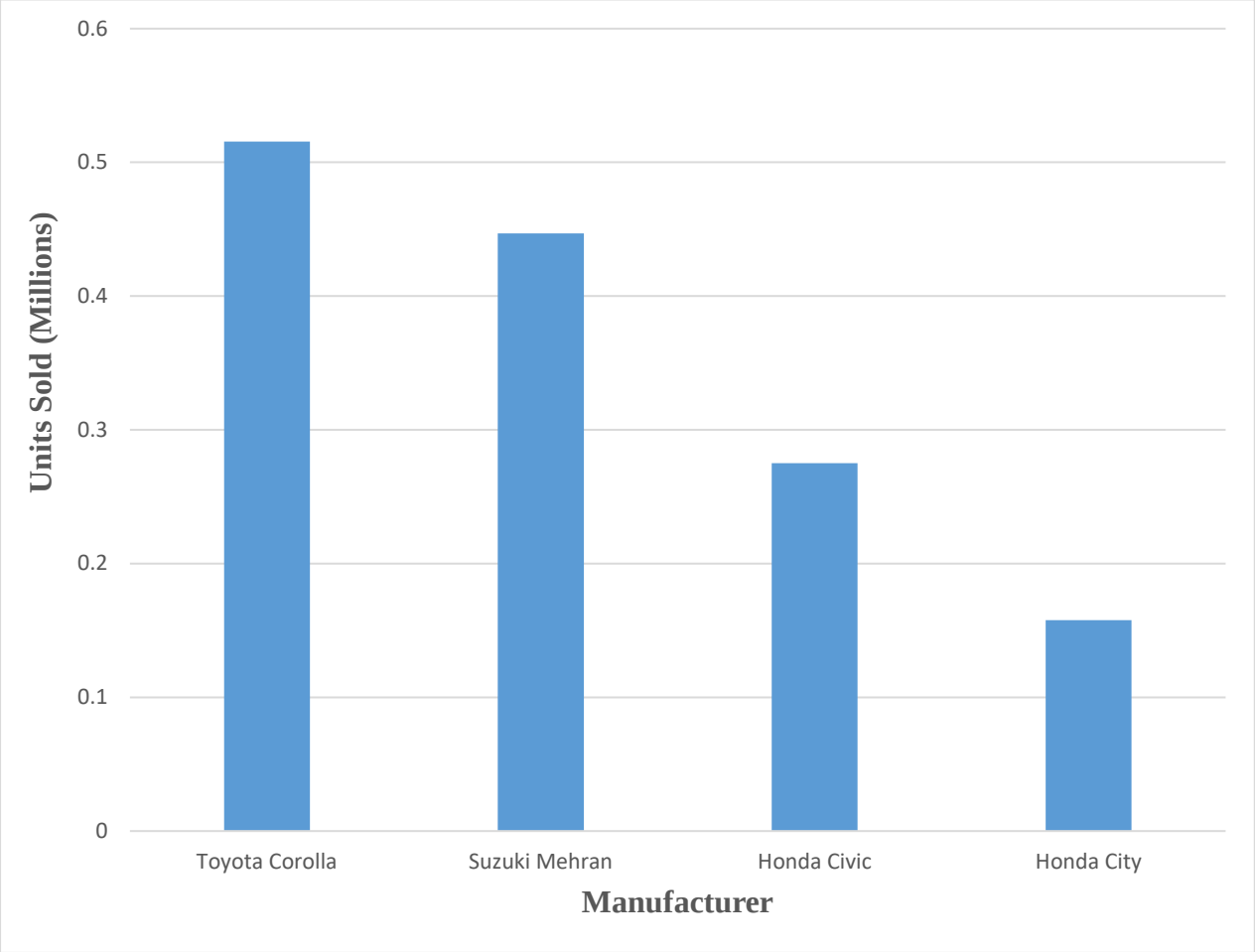



Figure 3: Most sold models from 1998 to 2016

It is necessary to discuss here the year wise trend of the performance of various manufactures. The changing of various factors severely affects the purchasing power of people. In order to support this claim, a mere look at Figure 4 shows how the sales took a hit during the economic crisis which hit the world markets in 2008 [76]. Though Pakistan's economy was not that affected as was that of other developed nations, but still a drastic decrease in sales is evidence of the fact how the economy affects the sales of vehicles.

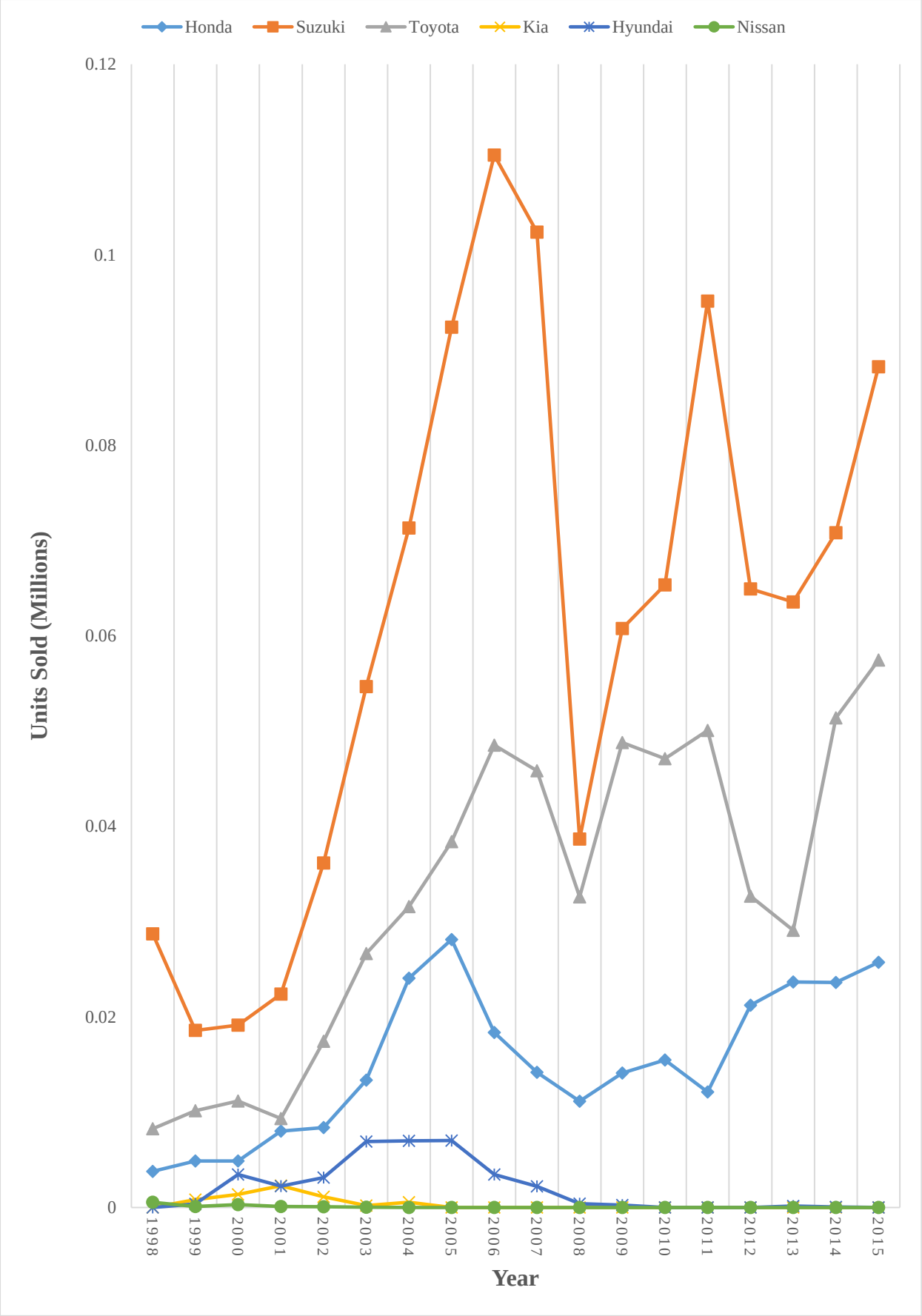



Figure 4: Units sold by each company from 1998 to 2016

Figure 5 shows that, Toyota is a world's leading automobile manufacturer with a total of 9.2% market share. Volkswagen stands in second place with a share of 7.1%, whereas, Ford stands at third position with 6.8% market share [77]. It is evident that Toyota which has the largest share of sales globally has a considerable share of sales in Pakistan's market as well. This holds true for Honda and has a reciprocal share of sales in Pakistan to that of its global share. However the most successful manufacturer in Pakistan i.e. Suzuki is nowhere to be seen on the world market share.

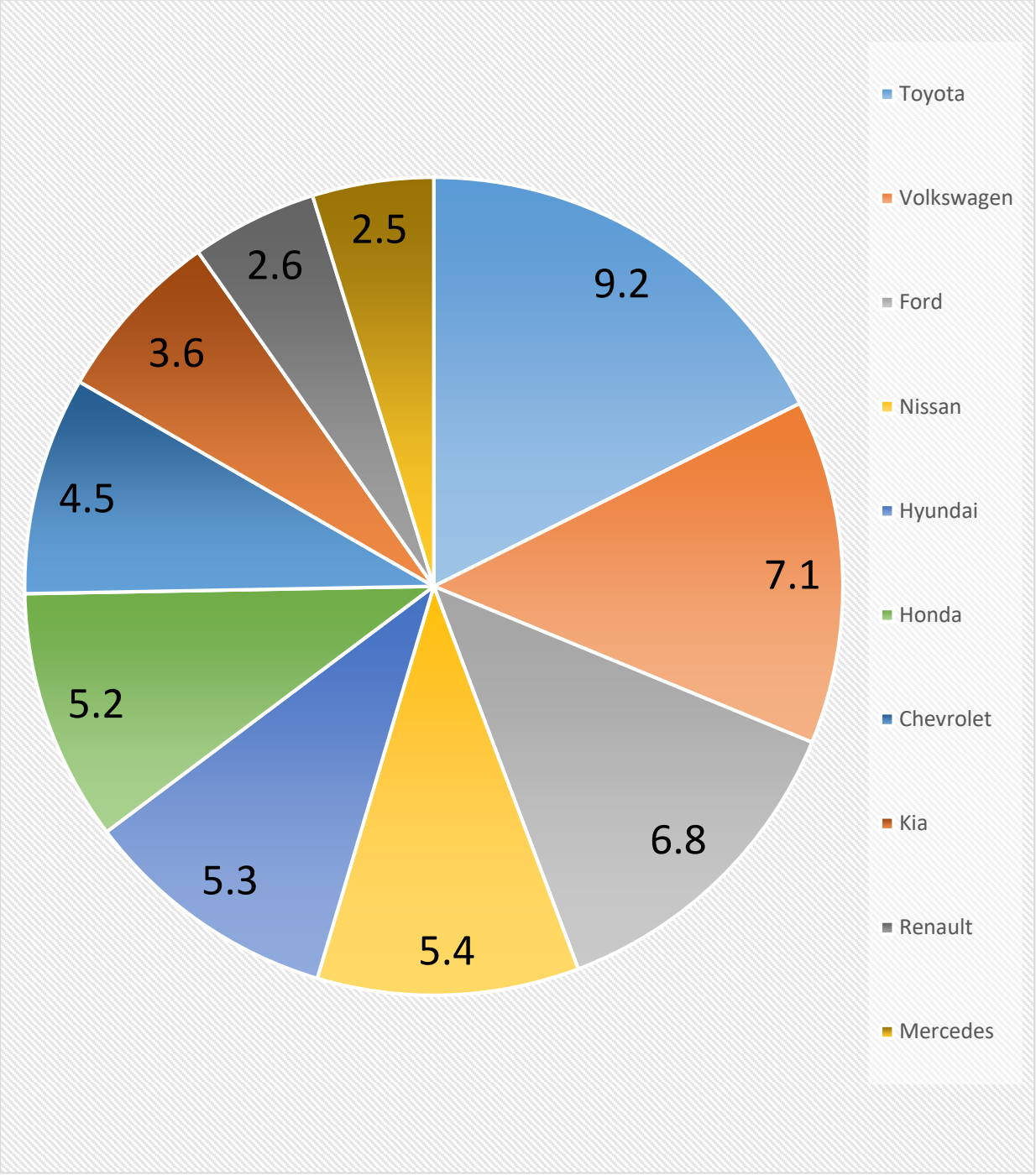



Figure 5: Market share of major automobile companies in global car sales

## 4.5 Methodology flowchart

The research methodology has been depicted in a flowchart in Figure 6. The work has been divided into four phases, namely, preparation, forecasting, comparison of techniques and research outcomes.

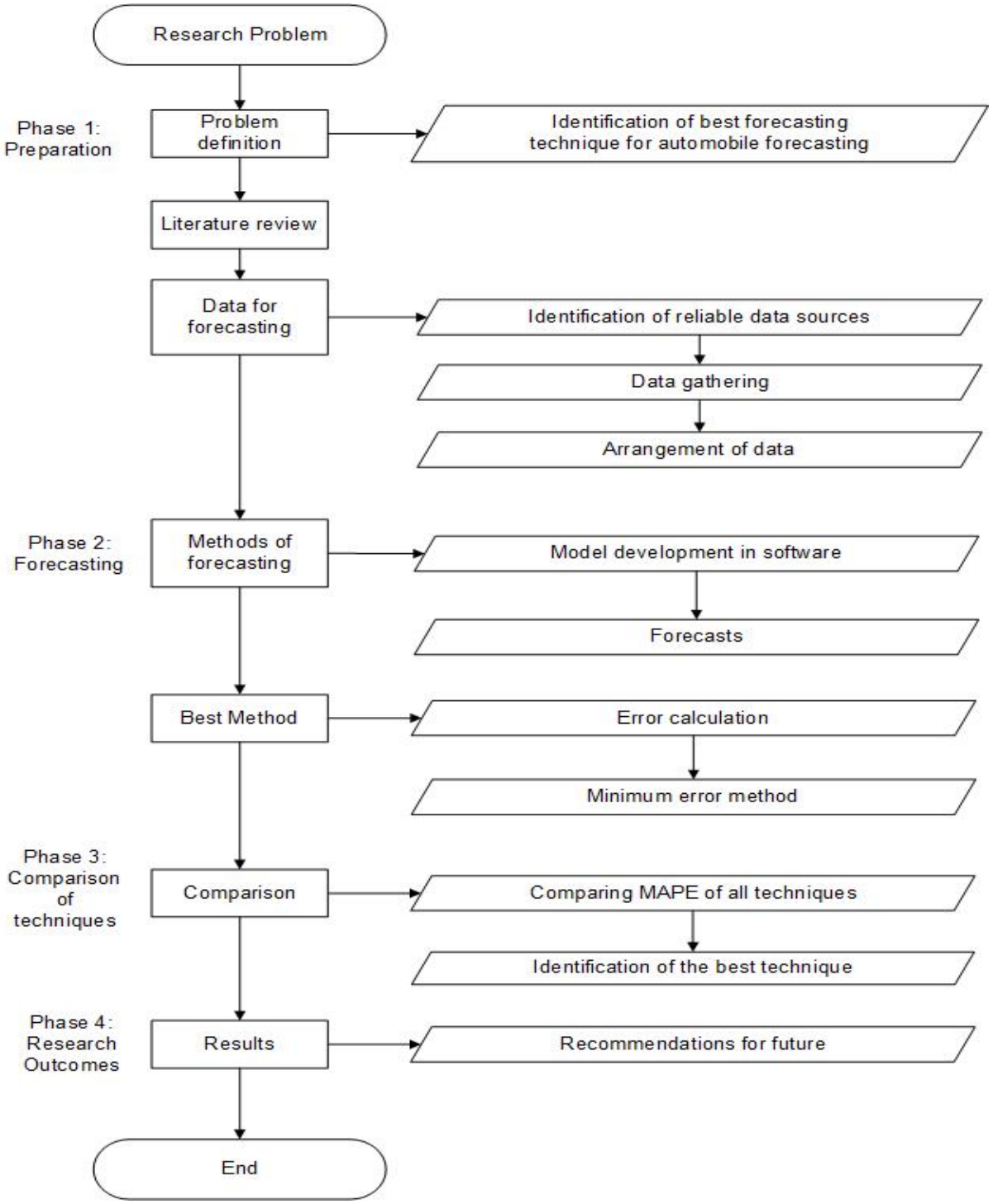



Figure 6: Research flowchart

## 4.6 Forecasting methods used

### 4.6.1 Moving Average and Double Moving Average

The Classical forecasting methods of Moving Average (MA) and Double Moving Average (DMA) were chosen because of their ability to "smooth out" fluctuations that often occur with each reporting period. MA calculates the average demand for the *n* most recent time periods in a demand time series, and uses it as the forecast for the next time period.

$$F_{t+1} = \frac{D_t + D_{t-1} + D_{t-2} \dots \dots + D_{t-n+1}}{n}$$

The formula for a moving average forecast of order **k,** is:

$$F_{t+1} = \frac{Y_t + Y_{t-1} + Y_{t-2} + \cdots \dots + Y_{t-k+1}}{k}$$

$$L'_t = \frac{Y_t + Y_{t-1} + Y_{t-2} + \cdots \dots + Y_{t-k+1}}{k}$$

As can be seen, $F_{t+1} = L'$, which implies that the moving average forecast (one period ahead) is equal to the moving average for time period t. As a result, the moving average forecast lags the series by one period, thus being one period behind in capturing any trend component. In our work the moving average forecasts, $F_{t+1}$, and actual moving average, $L'$, of order *3*, are computed.

$$\text{lag2} = L'_t - L'_{t-(\frac{k-1}{2})}$$

$$L^n{}_t = \frac{L'_t + L'_{t-1} + L'_{t-2} + \cdots \dots + L'_{t-m+1}}{m}$$

$$F_{t+1} = L'_t + [L'_t - L^n{}_t] + b_t$$

$$b_t = \frac{2}{k-1}(L'_t - L^n{}_t)$$

$$F_{t+m} = a_t + b_t m$$

$$a_t = 2L'_t - L^n{}_t$$

$$b_t = \frac{2}{k-1}(L'_t - L^n{}_t)$$

### 4.6.2 Exponential Smoothing

Exponential Smoothing was chosen because it considers all past data and only needs the value of most recent forecast to be kept. Unlike the WMA method, which requires *n* weights and *n* periods, ES method requires only three items of data: the demand for this period; the last period's forecast; and a smoothing parameter, α, which has a value between 0 and 1.0.
Here,

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

Thus, ES simply calculates a weighted average of the most recent demand and the forecast calculated last period.

### 4.6.3 Brown's Double Exponential Smoothing

Brown's Double Exponential Smoothing are considerably advanced and have never been used to forecast automobile sales. Brown's double exponential smoothing (DES) approach adds a smoothed value to measure the trend. Hence, Brown's double exponential smoothing forecast is:

$$F_{t+m} = a_t + b_t m$$

$$a_t = 2L'_t - L^n{}_t$$

$$b_t = \frac{\alpha}{1-\alpha}(L'_t - L^n{}_t)$$

### 4.6.4 Holt's Double Exponential Smoothing

Holt's double exponential smoothing (DES) approach extends the simple exponential smoothing method to consider a trend by using two parameters, α and β (both of which must be between 0 and 1). The level is calculated as:

$$L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + b_{t-1})$$

The other parameter, β, is used to smooth the estimate of the trend which is calculated as:

$$b_t = \beta(L_t - L_{t-1}) + +(1-\beta)b_{t-1}$$

The above equation estimates the level of the data by smoothing the randomness in the data such that the difference provides an estimate of the trend, to provide a smoothed estimate of the trend. Holt's DES forecast is:

$$F_{t+m} = L_t + b_t m$$

Holt's DES is applied, using an $\alpha = 0.5$ and $\beta = 0.9$

As with Brown's DES method, Holt's DES requires determination of initial first period values.

$$\alpha_H = 2\alpha_H - \alpha^2{}_B$$

$$\beta_H = \frac{\alpha_B}{2 - \alpha_B}$$

Table 6 shows the major notations used in the classical methods with their respective meanings.

Table 6: Nomenclature

| **Notation** | **Meaning** | **Notation** | **Meaning** |
|---|---|---|---|
| F | Forecast | $D_t$ | Demand of this period |
| D | Demand | m | Number of periods ahead to be forecast. (In our case 3) |
| t+1 | Next period | $\alpha_t$ | smoothed value at end of period t. |
| n | Total number of periods | $\beta_t$ | estimate of the trend at end of period t. |
| $F_{(t+1)}$ | Forecast of period t+1 | m | Number of period ahead to be forecast. |
| $Y_t$ | Actual value of period t | $F_t$ | Forecast calculated for last period. |

### 4.6.5 Neural Network

In order to complement this work Neural Network has been trained on the same data and forecast errors have been calculated. In conclusion of the literature review, 19 parameters affecting automobile forecast were identified. The data of these 19 parameters were collected from year 1998 to 2016 from World Bank Website [75] Linear regression analysis was carried

out on these parameters and 5 parameters were shortlisted having $R^2$ above 0.8 i.e. Total population, net national income per capita (current US$), GDP per capita (current US$), labor force, total car sales. These parameters, which were proven to be highly correlated with sales trend were used as an input to the Neural Network. The automobile models having sales above a threshold of 100,000 units were selected for forecast.

In this study, neural network toolbox of MATLAB is used to create artificial neural network models. In this regard, a network with 3 hidden layers and 5 neurons in each layer was formulated. Figure 7 presents the pictorial representation of the implemented neural net. The network was trained till the convergence of Mean Squared Error (MSE). It was observed that the solution always converged before 500 iterations. Five input parameters as presented in Table 5 were used as input to the neural network and sales was estimated as an output.

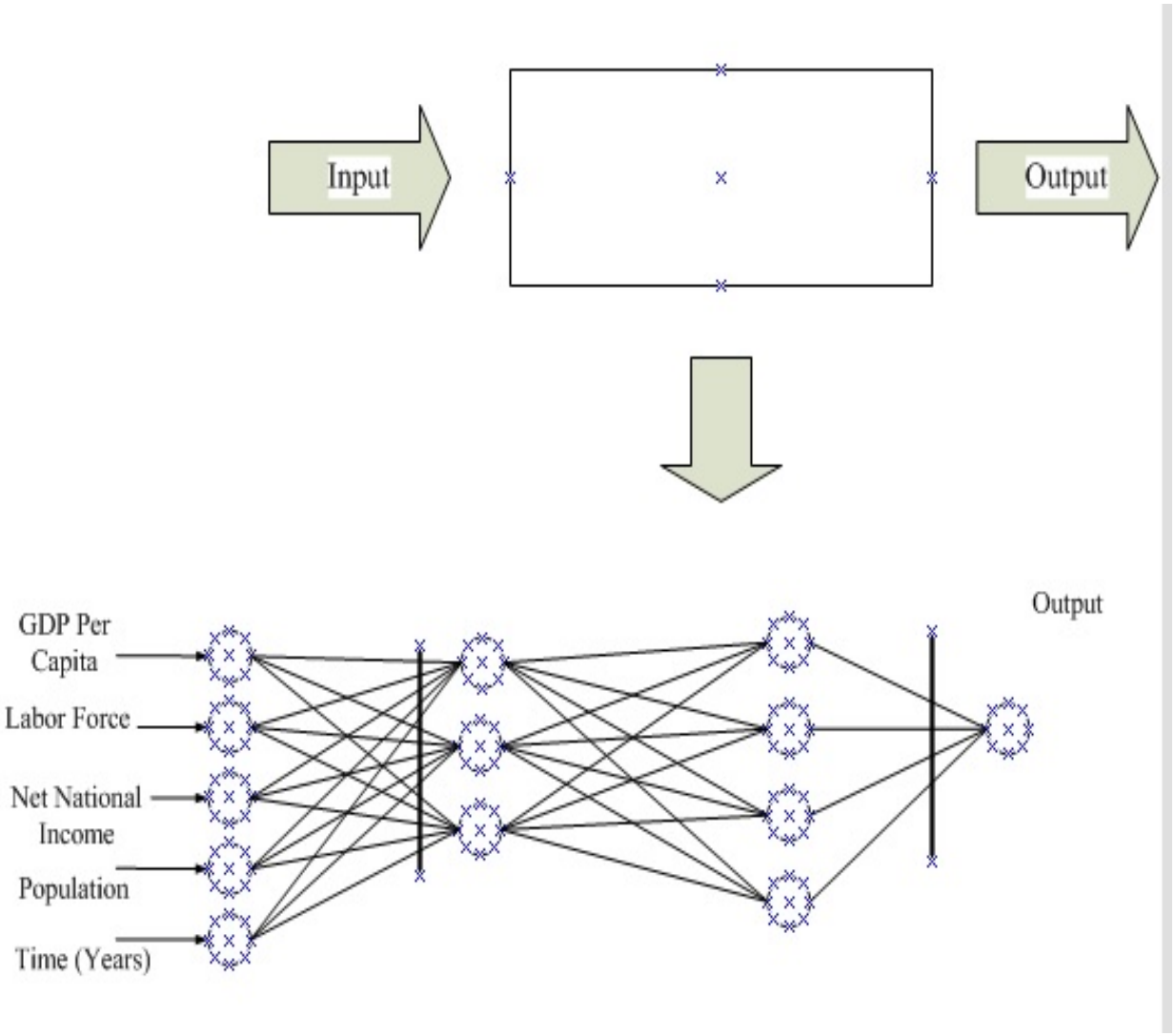



Figure 7: Neural Net model for sales forecast system

## 4.7 Coding

```
close all;clc;clear all;

data = xlsread('Regression Analysis File 19 Parameters.xlsx',5);

% --- NN I/Ps and Training ----
IP =  data(1:end-3,1:end-1)';
OP =  data(1:end-3,end)';

IPx = data(:,1:end-1)' ; %

% change number of neurons and layers e.g.
% [5] means 1-layer with 5-neurons
% [2 6] means 2-layers with 2 and 6 neurons
% [1 4 6] means 3-layers with 1,4 and 6 neurons and so on.
net = fitnet([5 5 5]);
figure('Name','NN Training Health','NumberTitle','Off');

MSE = zeros(1000,1);
for i=1:1000

    net = train(net,IP,OP);

    OPx = net(IPx);

    MSE(i) = mean((OPx(1:end-3)-OP).^2);

    % view(net);
    % --- NN Results ---
    % pause(2);

    subplot(211);cla;grid on;hold on;box on;
    plot(MSE(1:i));
%     hist(net(IP)-OP);
    subplot(212);cla;grid on;hold on;box on;

    plot(data(1:end-3,1),OP,'r*-','DisplayName','Actual Data');
    plot(data(:,1),OPx,'bO--','DisplayName','Trained Data');
```

```
    drawnow
    % plot(data(:,1),data(:,end),'ko--','DisplayName','Mov Avg');

    legend location best;

end
```

## 4.8 Prediction Time how and why?

It is evident from the literature review that forecasts greater than 3 years are rendered obsolete in the globalized world of today. We will be forecasting for 3 years to come because, the currency of Pakistan is unstable and prices can jump considerably, this in turn affects the purchasing capacity of the people. The starting of CPEC has made Pakistan an attractive market for automobile manufacturers with the new auto policy and new vehicle manufacturers entering the competition the sales of existing companies are bound to take a hit. The fuel prices are also unstable that combined with law and order situation in the country makes it extremely difficult to forecast sales of periods longer than 3 years.

## 4.9 Software Used

MATLAB has been used as the primary software to make calculations Neural Network. Excel was used for all other methods. The results of the forecast have been summarized, for more clear understanding, the superb graphical utility of Excel has been used.

## 4.10 Error Measurement how and why?

A mean absolute percentage error is considered the most effective way to calculate the accuracy of forecasts. It has been used by [21, 37, 38, 40, 42, 46] in their respective studies regarding forecasts of automobiles.

### 4.10.1 Mean Absolute Percentage Error

The Mean Absolute Percentage Error (MAPE), also known as a mean absolute percentage deviation (MAPD), is a measure of predictive accuracy of a forecasting method in statistics, for example in trend estimation.

$$MAPE = \frac{\sum \left[ E_t \left| (100) \right] \right] / D_t}{n}$$

### 4.10.2 Mean Squared Error

It measures the average of the squares of the errors, that is, the difference between the estimator and what is estimated.

$$MSE = \frac{\sum E_t^2}{n}$$

# CHAPTER 5: RESULTS AND DISCUSSION

This section presents results of forecast methods used in total 6 forecasting methods were used, 5 of these were classical and advanced classical forecasting methods whereas 6th was artificial neural network. Neural Network was found to be the most accurate of all the methods used in all models. The accuracy of all the methods were checked by MSE and MAPE after which the percentage errors were calculated for all the models.

## 5.1 Toyota Corolla forecast and errors

Figure 8 presents the results of all forecasting methods used for Toyota Corolla. As evident from the graph each method gives a different forecast using the same sales data. This is due to the fact that method like moving average only uses the most recent data, whereas advanced methods like Holt's and Brown's use data from over the past several years which makes them more accurate compared to basic classical methods. Moving Average predicts the sales in 2017 to be around 45980 units and moves to 47043 units in 2019. Holt's predicts the sales to be 71571 units in 2017 and moves to 92820 units in 2019. However, neural net was found to be the most accurate method. It predicts 53604 unit sales in 2017 and moves to 77078 units in 2019. Neural Net predicts values between two extreme values. This is because the

neural net trains itself over the past data and takes into consideration the behavior and impact of parameters.

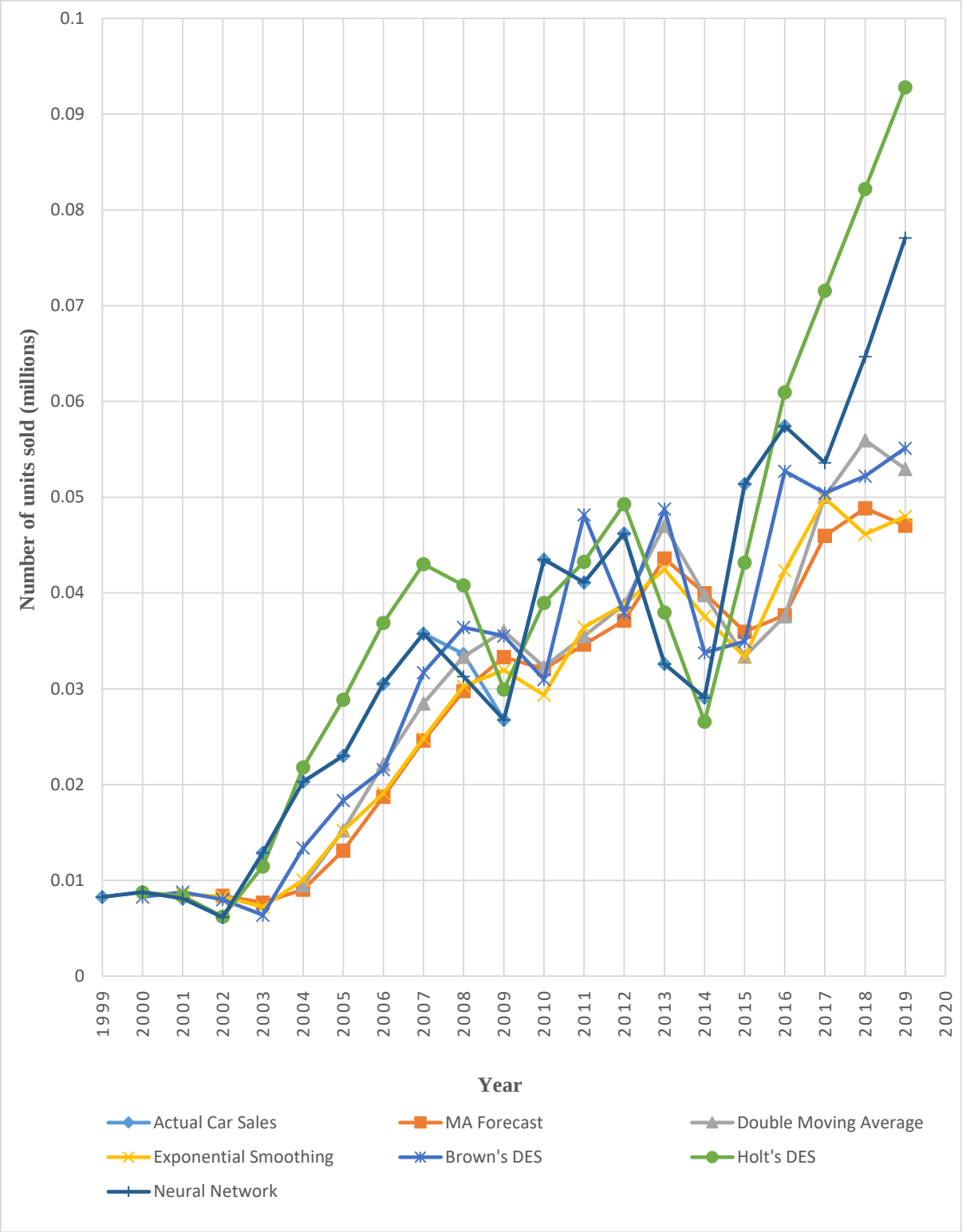



Figure 8: Forecasting results along with original data of Toyota Corolla

Figure 9 presents the percentage error calculated annually for all the methods Holt's double exponential smoothing was found to be the most accurate of all the conventional methods and the maximum error at given point (Year 2005) was 25%. Whereas neural nets were found to be the most accurate of all the methods with a maximum point (Year 2008) percentage error of 7%.

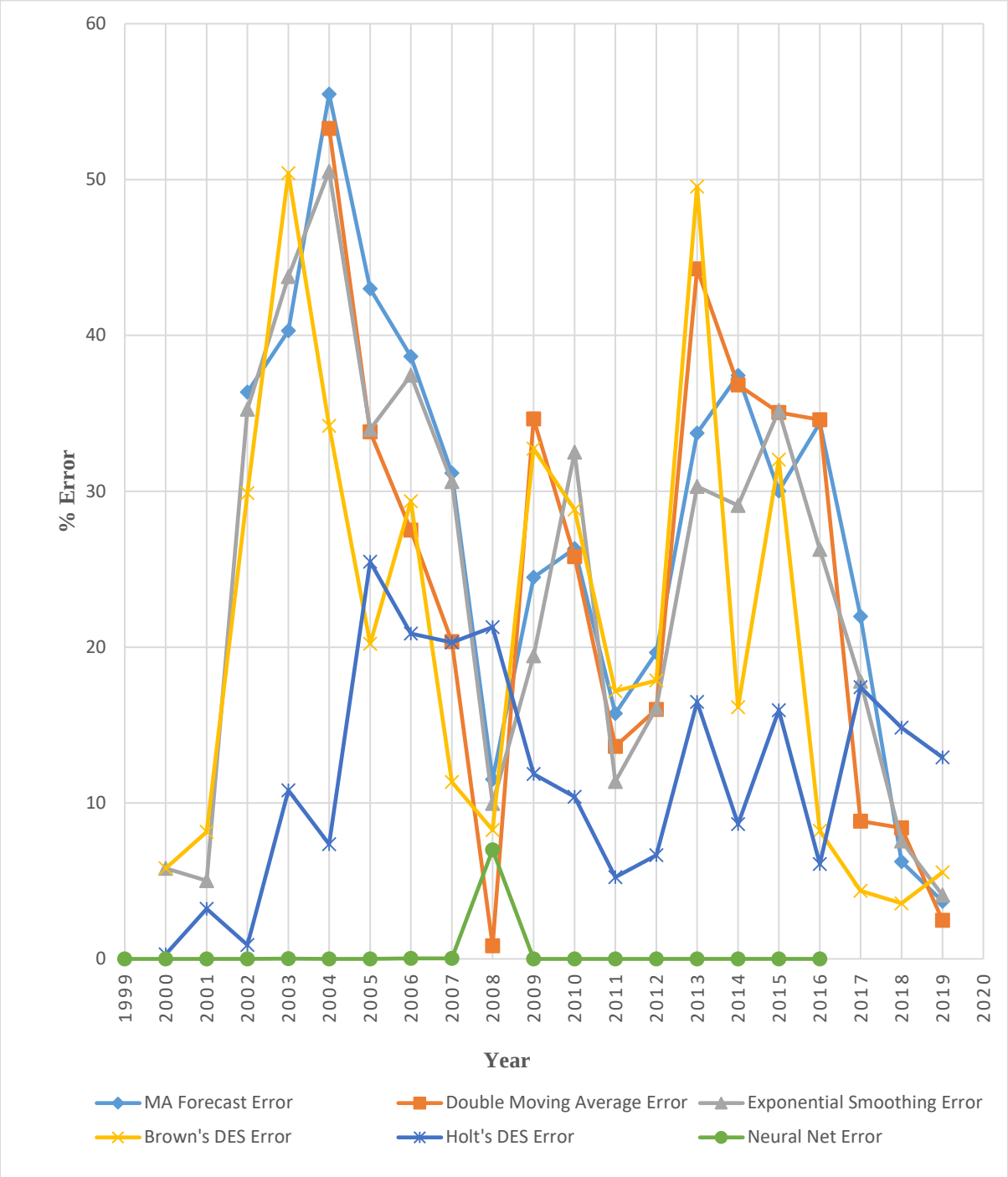



Figure 9: Annual percentage error of all methods for Toyota Corolla

## 5.2 Suzuki Mehran forecast and errors

Figure 10 represents the forecasting results of Suzuki Mehran as evident from the graph neural net has trained itself for the best possible outcome the decline in the forecast is because it has trained itself according to the data which means that a after a period of 10 years sales drop significantly. Neural Net predicts that sales could drop to 9435 units in 2017 and keep on dropping to 6918 units in 2019. Whereas, the classical methods based on most recent data show that a spike in sales is to be expected. Holts DES shows that sales will spike to 38218 units in 2017 and reach 41167 unit sales in 2019.

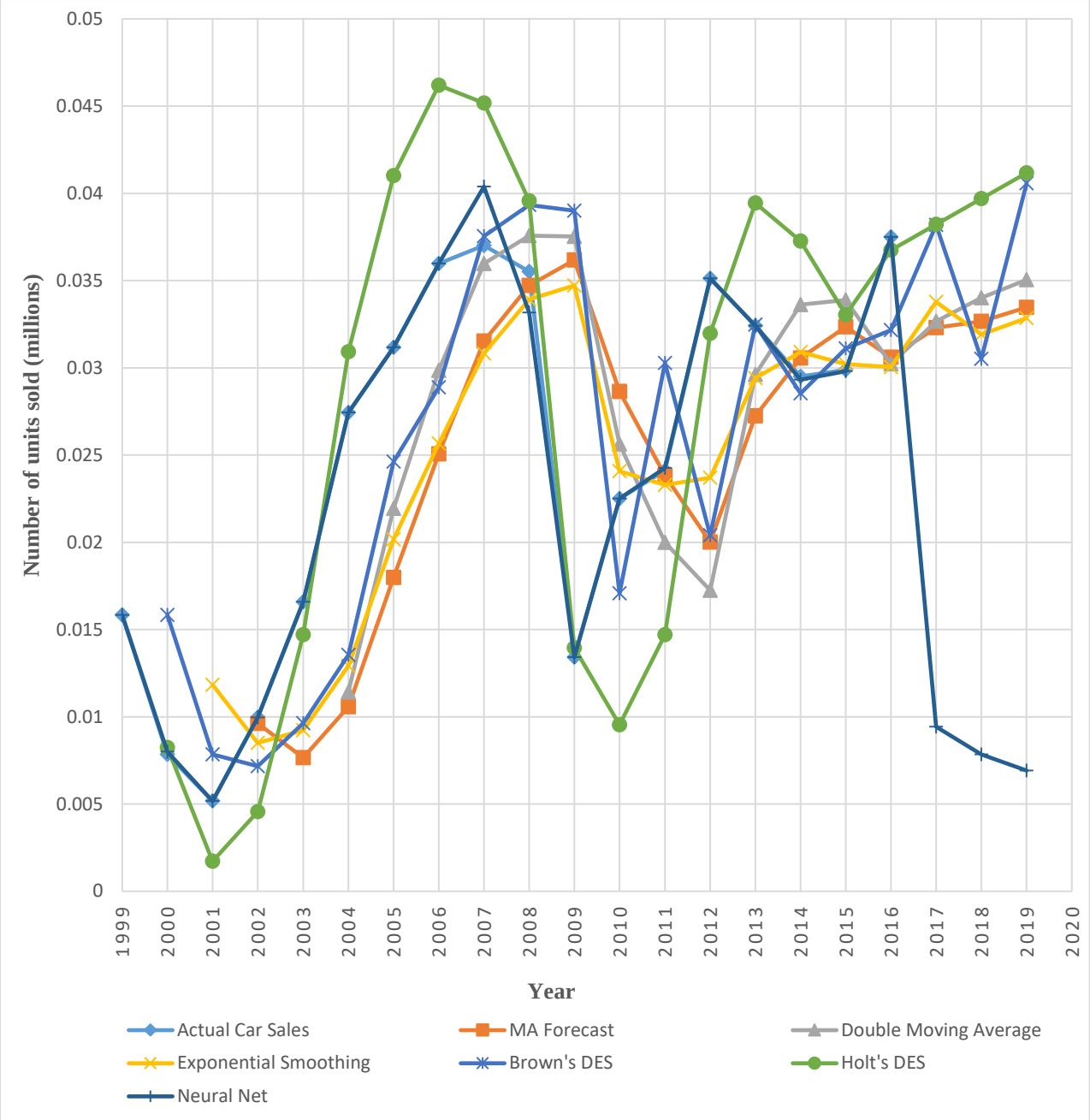



Figure 10: Forecasting results along with original data of Suzuki Mehran

Figure 11 presents the annual percentage error, the unusual spike around the year 2009 is due to the sharp decline in sales due to the economic crunch which started in 2008. Mehran being the car of middle man was the most affected as people lost their jobs and economy declined overall. Neural Net shows a max error of 8.36% in the year 2007. Whereas, Moving Average shows max error of 169% in the year 2009. Brown's DES shows an error around 190%. This is due to the fact that both these methods incorporate most recent data and are unable to adjust according to the rapid fall in sales.

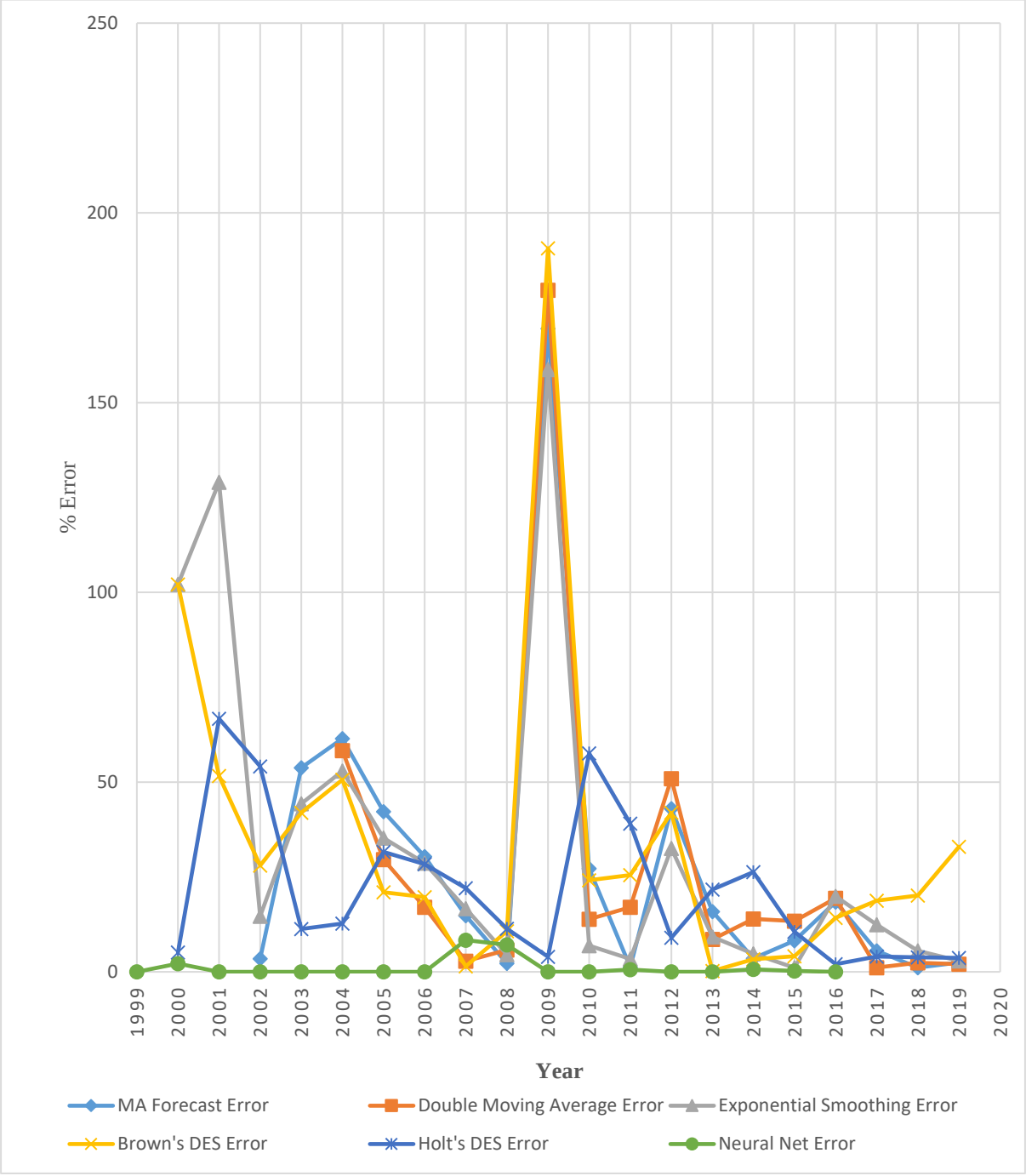



Figure 11: Annual percentage error of all methods for Suzuki Mehran

## 5.3 Honda Civic forecast and errors

Figure 12 shows the sales of Honda Civic as evident neural nets show a gradual increase in sales over the period of 3 years. The sales will increase from 26160 units in 2017 to 27187 units in 2019. Whereas, Holt's DES shows a spike in sales. It predicts unit sales in 2017 to be around 38218 units which will further increase to around 46167 units in 2019. According to the previous data, neural nets are considered to be more accurate as their graph has a minimal difference with the graph of past sales.

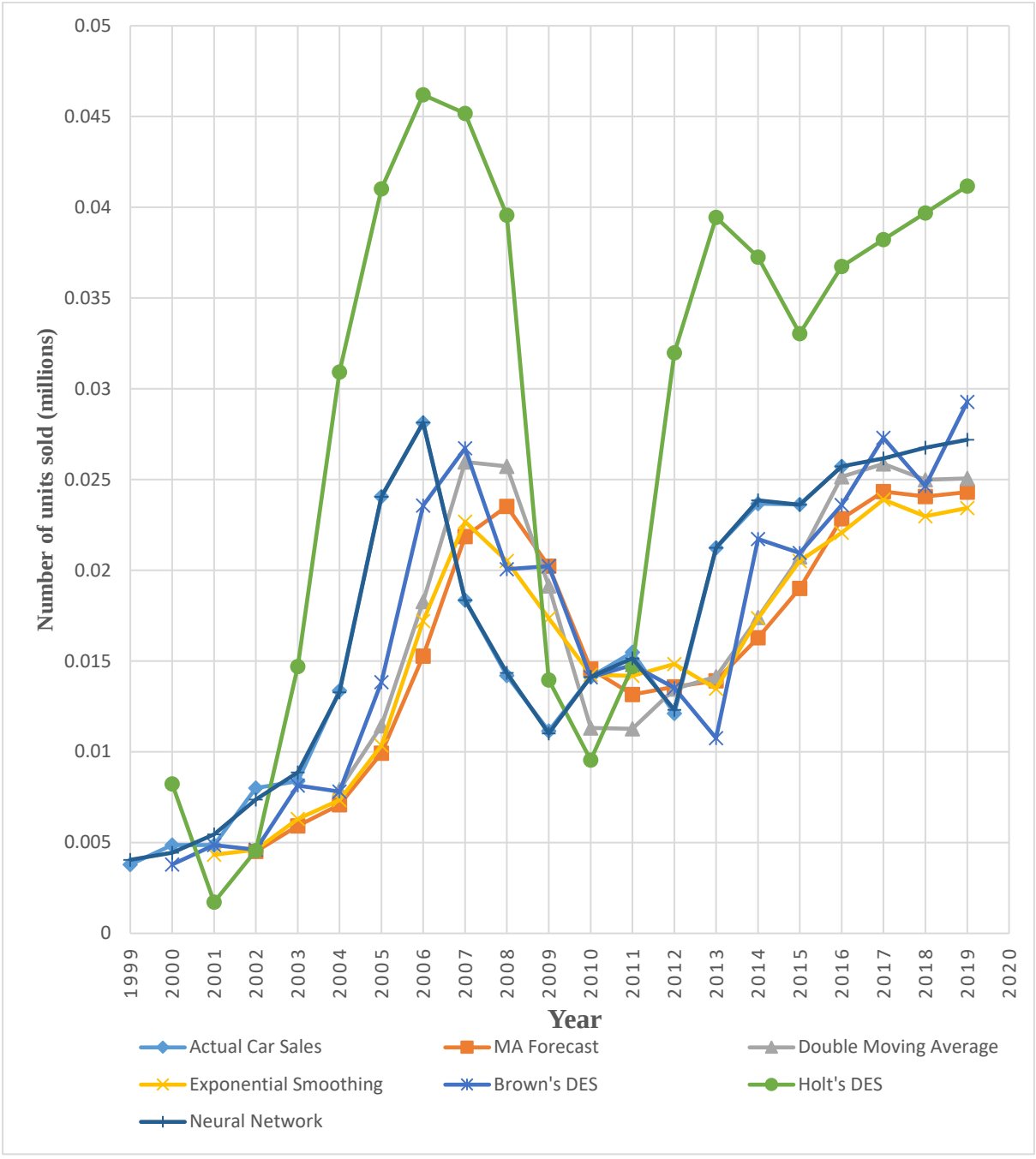



Figure 12: Forecasting results along with original data of Honda Civic

Figure 13 shows the annual percentage error of all methods it presents a similar story as that of Mehran where due to the economic crunch sales declined rapidly and the classical methods based on most recent data were unable to predict the sharp decline in sales. Maximum error was calculated to be around 81% in year 2009 for both Moving Average and Brown's DES. Whereas, neural nets being trained were more able to predict the changes and has the least errors. Its maximum error was around 10% in the year 2002.

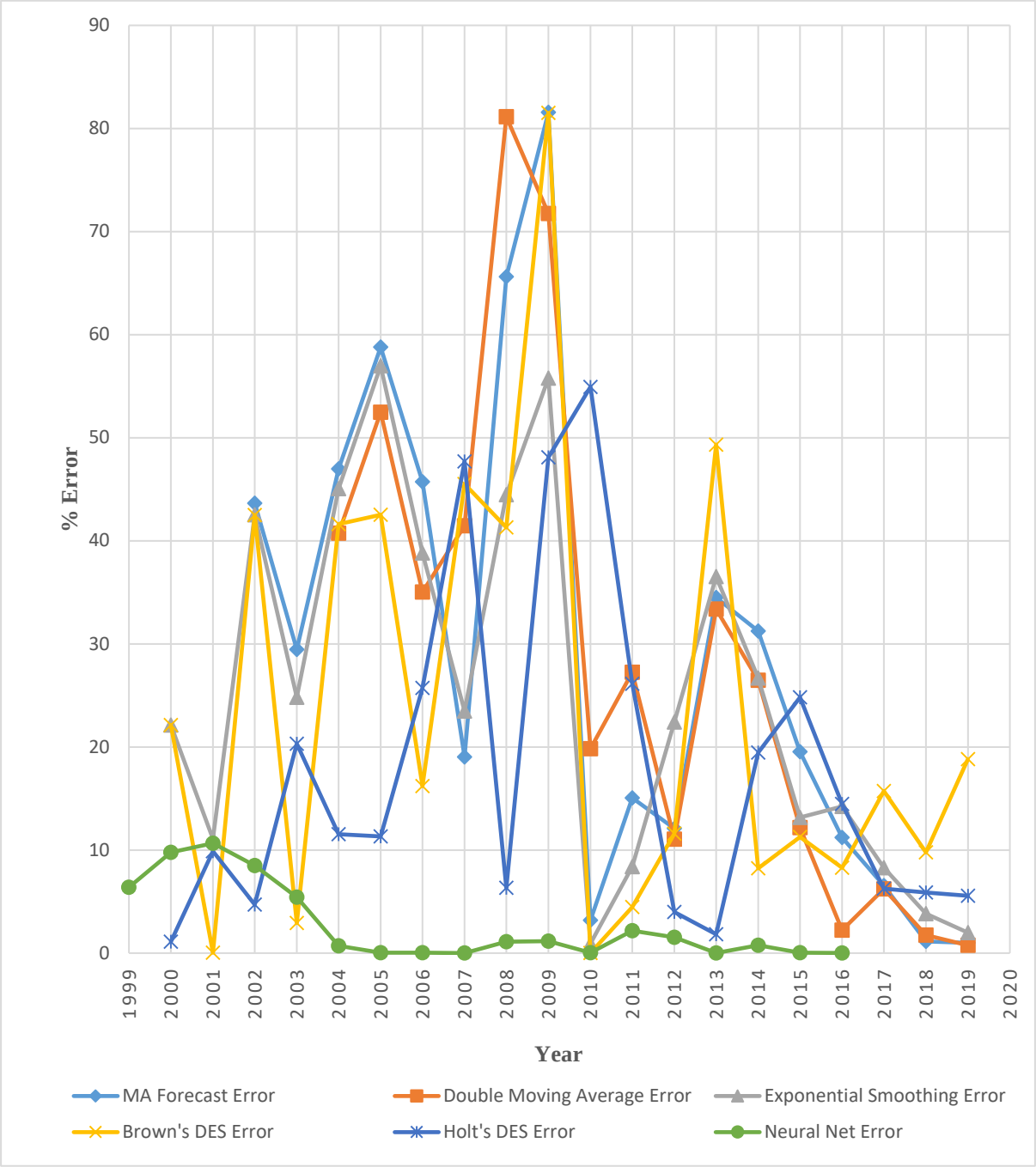



Figure 13: Annual percentage error of all methods for Honda Civic

## 5.4 Honda City forecast and errors

Figure 14 shows the forecast for Honda City. The production of the car started in 2002 hence, the first sales were also in the same year. As evident, Neural net is the most accurate method here as well. At certain points it behaves absurdly because it does not have the detailed past data as in other cases. Moreover, qualitative factors have contributed a lot to uneven sales of the said car. It predicts that sales will increase to 32956 units in 2017 and show a maximum sales of 41891 units in 2019. Among the other methods Holt's DES is the closest to Neural Net as it predicts the sales to be maximized in year 2019 at around 41892 units.

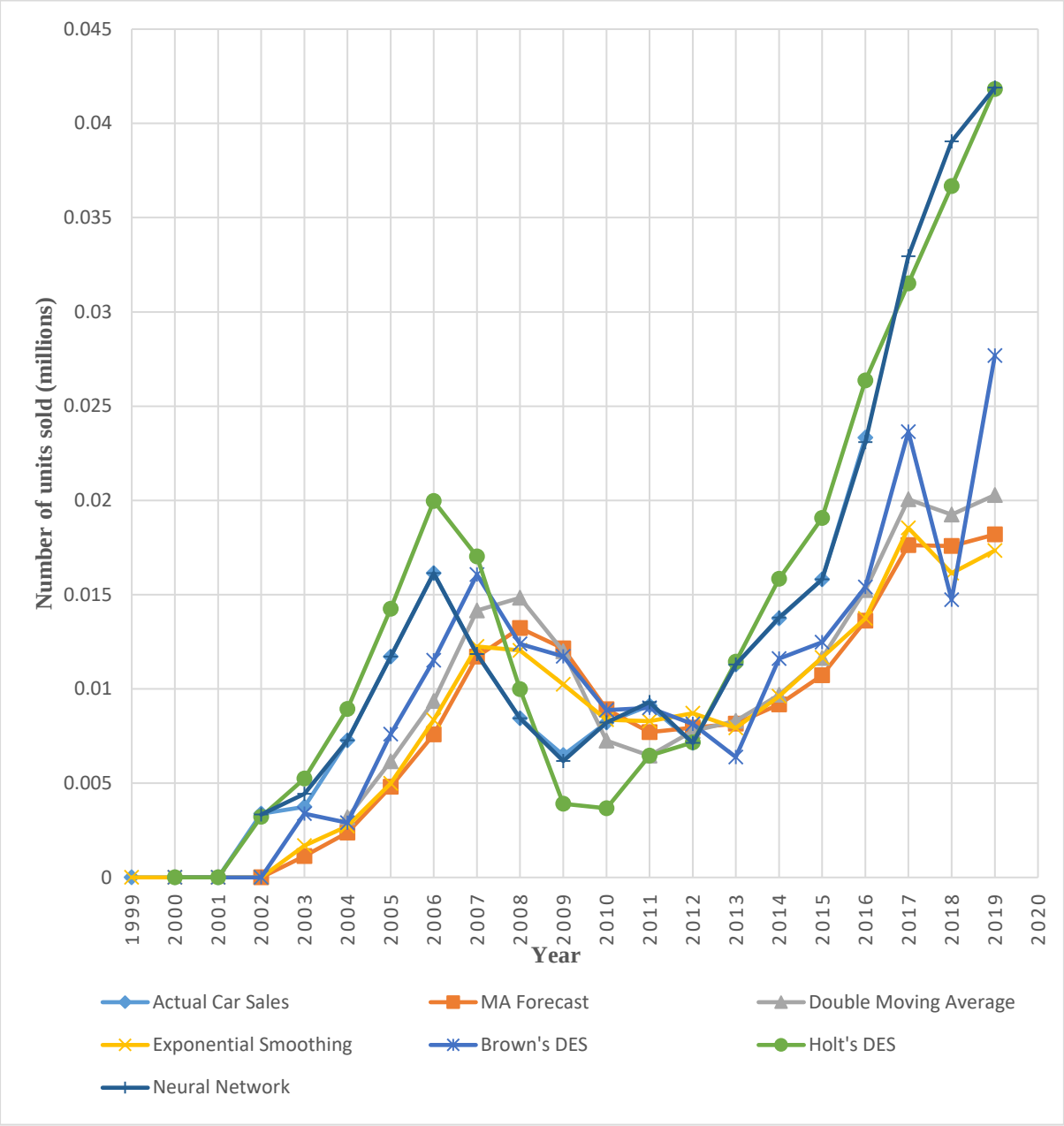



Figure 14: Forecasting results along with original data of Honda City

Figure 15 shows the percentage errors of forecast of Honda City. It is the only model which presents greater fluctuations of errors in Neural Network due to non-availability of past data. Neural Network needs previous data to be trained effectively and accurately for forecasting of next periods. Hence, it is less effective compared to other methods. It shows a maximum error of 683% in the year 2003. The reason being that it only has last year's data to train itself and it's unable to forecast effectively. Classical methods have low errors in this case because they use the most recent data. This enables them to cope effectively with fluctuations in sales. Maximum error was calculated to be around 55% in the year 2010 in Holt's DES.

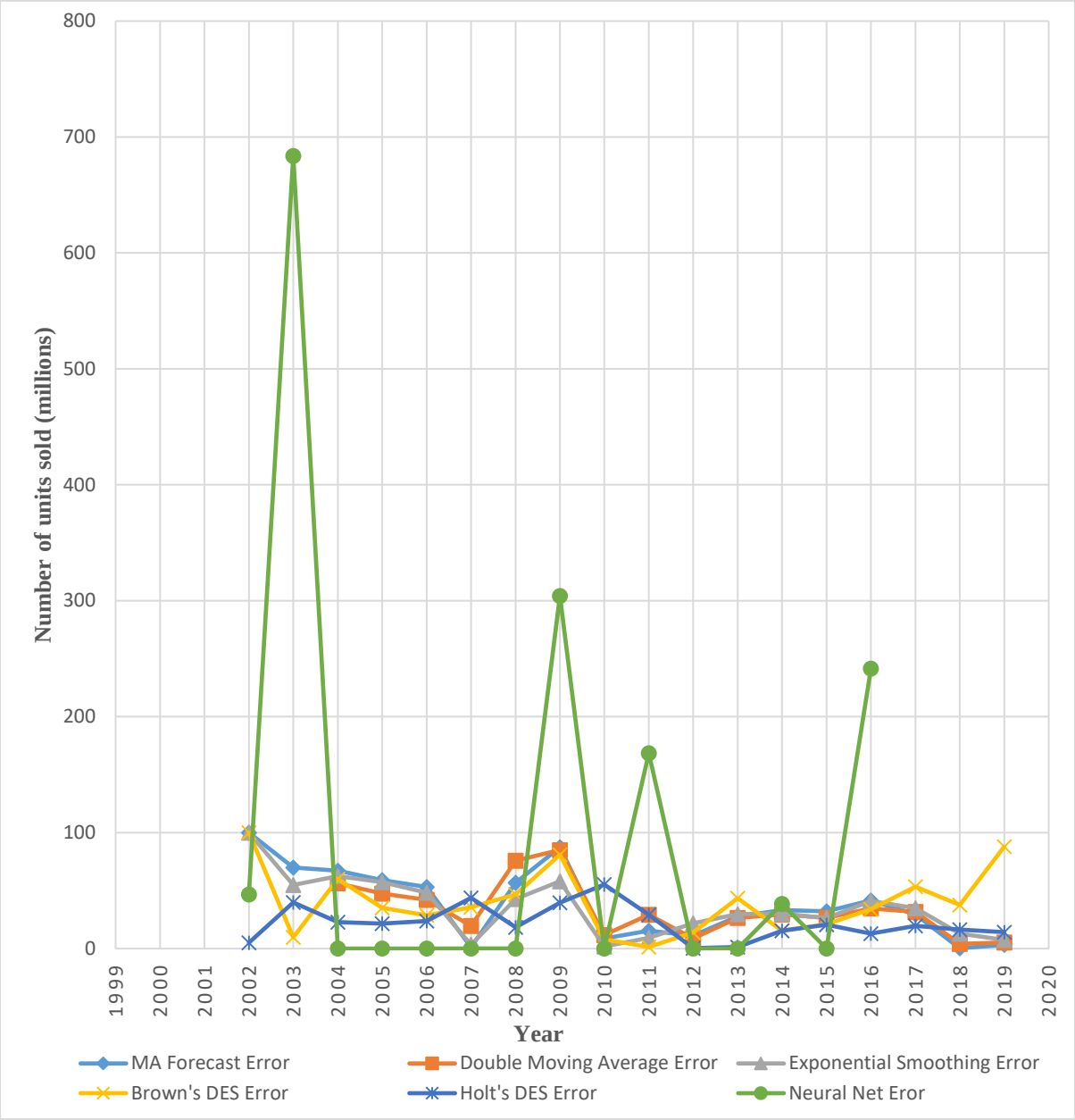



Figure 15: Annual percentage error of all methods for Honda City

# CHAPTER 6: CONCLUSION

This section presents the summary, research outcomes and provides the way forward for future research work in this field.

## 6.1 Summary

This research presents the forecasting for the most sold models of Pakistan's automobile industry. Classical methods were used for forecasting, along with some non-conventional methods. A neural network was then trained on the data and percentage errors have been calculated for each point along with the overall MAPE. It has been found that Neural Network has trained efficiently with a maximum point percentage error of 10%. As for the classical methods the percentage errors at certain point ranges from 0.83% in the case of Toyota Corolla to 82% in Suzuki Mehran. Hence, classical methods are not very reliable when forecasting automobile sales. This research serves as an initial study towards the forecasting of automobile industry in Pakistan.

## 6.2 Research outcomes

This research clearly states that the sale of automobiles will continue to rise in Pakistan except Suzuki Mehran. This is due to the fact that Neural Net has trained on past data which shows a rapid decline in sales in 2008. Since it trains itself on such data it predicts the sales will fall again in 2019. A decrease of 69% in sales of Mehran is predicted by neural net. Corolla, Civic and City will experience a further increase in their sales as the economy of Pakistan continues to improve. The biggest increase in sales will be experienced by Honda City as it continues to be the favored choice of luxury car buyers. Neural net predicts a 28% increase in sales of City. Toyota Corolla will experience an increase of around 15% in its sales. Whereas the sales of Honda Civic are expected to rise by 3%. However, Suzuki Mehran's sales will drop because the improvement in economic conditions of the general public will compel them to buy bigger and better vehicles having better fuel economy as well as more safety features.

## 6.3 Future recommendations

Future research may be conducted on this topic keeping in consideration the fact that an improvement in conditions of public transport may have a considerable effect on the sales of automobile vehicles.

The research may also be done on the effects CPEC will have on the sales of automobile cars. Once fully operational it is bound to have an effect on the purchasing power of customers and considerably improve the economic conditions of Pakistan as a whole.

Future research may include the effect of any environmental legislation on sales of cars. Sooner rather than later and hazardous environmental conditions are bound to compel legislators to make laws which can cut down on emissions. This will significantly impact automobile sales.

Future research on this topic may include the effect that imported vehicles will have on sales of locally manufactured vehicles. Since, the imported vehicles have more safety features with better fuel efficiencies they are bound to impact the sales of vehicles.

The effect of improvement of local manufacturers can considerably decrease the prices of vehicles, which can be incorporated in future research focusing on forecasting of automobile sales.

A lot of automobile companies are planning on entering the Pakistani market, with the inclusion of these companies the competition is bound to increase, which in turn will have an effect on sales of automobiles discussed in this research. Future research may include the impact on sales that these companies will have once they start manufacturing their vehicles locally.

No research in this field has been carried out on Pakistani automobile sales data, keeping in view its economic conditions. Still, some areas have a lot of room for improvement and research. One of these areas is the effect of new auto policy that can impact the sales of vehicles, since very few papers have addressed these issues.

An algorithm and Graphical User Interface considering multiple objectives like inclusion of various parameters as they begin to have considerable effect on the economy and forecasting of sales of all vehicle manufacturers can be developed since nearly no paper has addressed this.

Effort can be made to forecast other vehicles like three wheelers, buses, trucks, tractors etc.

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