

Statistical Analysis on Impact of Economic, Social and Environmental Variables on Automotive Industry Using Linear Regression

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Abstract— Automotive sector is considered as one of major industry in any country and plays significant role in its growth. Competitiveness of this industry has recently gained exceptional importance in this globalized era and depends upon internal and external factors. India's automobile industry is likely to contribute 12 per cent to the country's GDP over the coming decade, from 7.1 per cent at present. The size of the automotive sector is so huge that it shows dependency on various macro variables from other aspects like Economic conditions, Social variability and Environmental problems. Changes in the aforementioned fields corresponds to a change in the automotive industry. This study quantifies the dependency and impact of various Economic, Social and Environmental factors on automotive vehicle sale across India by using Linear Regression model. This research covers the time period from 2000 to 2016 for all the parameters involved. The results are in accordance with the other researcher's findings and common consensus.

Index Terms— GDP, FDI, Vehicle Sales, Linear Regression, Inflation, Tariff.

I. INTRODUCTION:

Automotive industry has been emerging as a sunrise sector in the non-core sector of the country. Automotive industries have been especially recognized as a sector having potential for creating employment on a large scale. India has risen to be the second largest two-wheeler manufacturer in the world, seventh in global production in motor vehicles, and every automobile manufacturer in the world has manufacturing facilities in India. According to the Society of the Indian Automotive Manufacturers (SIAM), Indian automotive sector today is a \$74 billion industry and by 2026, the industry is expected to achieve a turnover of \$300 billion – clocking a compound annual growth rate (CAGR) of 15 percent. The Indian automobile industry account for 22% of the country's manufacturing GDP and is one of the biggest job creators, both directly and indirectly. The Indian automotive industry has the potential to emerge as one of the largest in the world. With the growing industrial production, growth of the economy and increasing spending power of the Indian middle-class households, the country is expected to make it to the top five markets in cars and commercial vehicles by 2020.

Statistical analysis is the science of collecting data and uncovering patterns and trends. Two main statistical methods are used in data analysis: descriptive statistics, which summarize data from a sample using indexes such as the mean or standard deviation, and inferential statistics, which draw conclusions from data that are subject to random variation. Descriptive statistics are most often concerned with two sets of properties of a distribution (sample or population): central tendency (or location) seeks to characterize the distribution's central or typical value, while dispersion (or variability) characterizes the extent to which members of the distribution depart from its center and each other. Inferences on mathematical statistics are made under the framework of probability theory, which deals with the analysis of random phenomena.

Abdul Hannan [1] have examined the impact of economic, social and environmental factors on the competitiveness of automotive industry. They have used Fixed effect model and the results show that competitiveness of automotive industry is positively related to economic performance, human capital development, urbanization and tariff rate while negatively affected by lending rate and carbon emission both in developed and developing nations of Asia. Buckley [2] contributes to the existing literature by empirically investigating the effect of FDI inflows on the aggregate labor productivity of China's automotive industry. They have suggested that efforts to increase capital intensity and average firm size in the industry will also improve labor productivity. Islam [3] investigated the relationship between macroeconomic variables and number of car sales in Malaysia. The analysis methods that have been applied in this study include descriptive statistics, multiple regression statistics and correlation analysis. Their results showed that only GDP has positive relationship with the car sales. Babatsou [4] examines the correlations between several socioeconomic indicators and car market indicators in EU15. The results indicates that a regression in GDP will lead to a decrease of total passenger cars in use, the new passenger cars registrations increases linearly with income. Sivak [5] have first modeled the effects of GDP and population size on sales of new cars in 2006 for the following 25 developing countries. They have used a multiple regression to model the influences of the current GDP and population on current sales of new cars. The deviations of the actual sales from projected sales were quantified.

II. METHODOLOGY:

Regression estimates are used to describe data and to explain the relationship between one dependent variable and one or more independent variables. At the center of the regression analysis is the task of fitting a single line through a scatter plot. For this study we have selected Total Vehicle Sales as the dependent variable. The reason for selecting the aforementioned variable is that

the data is available for analysis and vehicle sales gives the actual picture of how the automotive market is reacting to the economic, social and environmental constraints or conditions. Total vehicle sales comprises of sales across all the automotive sectors namely Passenger Vehicles, Commercial Vehicles, Three Wheelers and Two Wheelers.

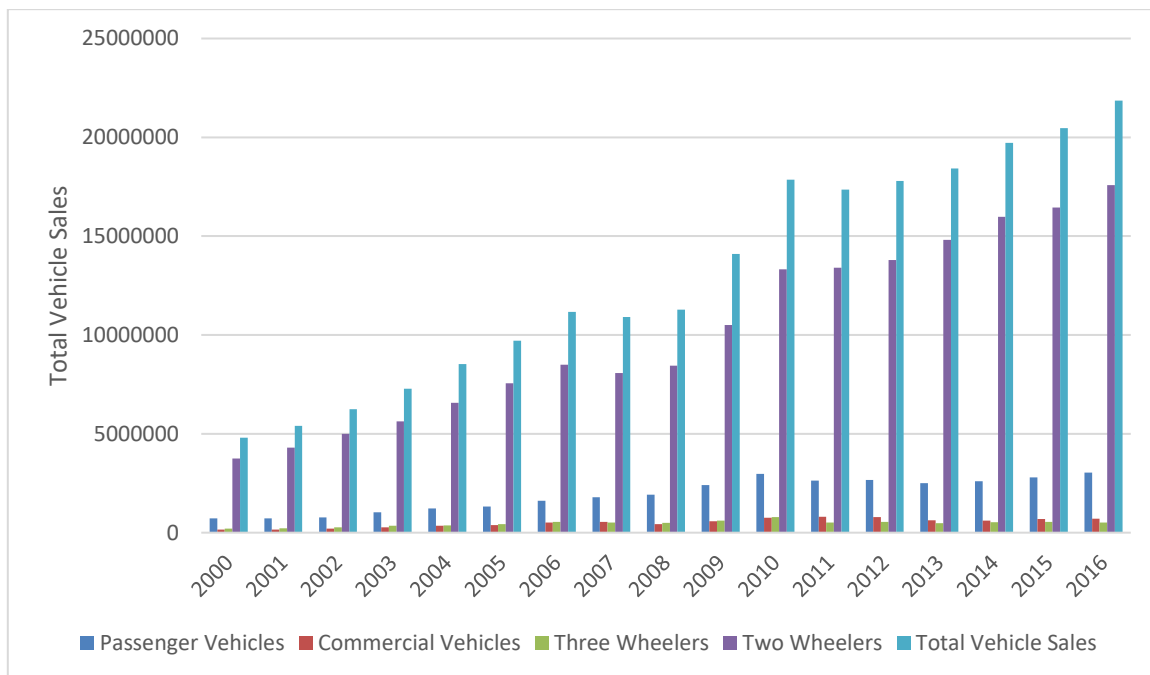


Fig. 1 Category-wise Vehicle Sales Breakdown for the period 2000 to 2016

Three types of independent variables are used in this study namely- Economic, Social and Environmental. This research covers the time period from 2000 to 2016.

Table 1. List of Independent parameters

Economic Parameters	Social Parameters	Environmental Parameters
Foreign direct investment, inflow	Unemployment (% of total labor force)	CO ₂ emissions
Inflation rate, consumer prices	Urban Population	CO ₂ emissions from Transport
Lending interest rate	Adjusted Net National Income	NO _x emissions
Tax revenue	Total Labor Force	
Tariff rate (%) year-wise	Electric Power consumption (kWh per capita)	
Petrol prices year-wise	Access to Electricity	
Diesel price year-wise	Employment to Population Ratio	
Rupees per 10 gram of gold year-wise	Wage and Salaried workers	
Rupees per 1kg of silver year-wise	Accidental Deaths	
Imports of goods and services		
Export value index year-wise		
Exports of goods and services (in Rs.) year-wise		
GDP		
Official exchange rate		
Wholesale price index year-wise		

The analysis methods that have been applied in this study include descriptive statistics, linear regression statistics and correlation analysis. In this study we are going to list out and define dependent and independent variable, carry out Regression Analysis to understand the impact of various economic, social and environmental variables on automotive industry. We will derive the equations for relationship between the independent variable and Vehicle Sale using JASP software package.

III. RESULTS AND DISCUSSION:

A. Descriptive Statistics:

The standard deviation is a description of the data's spread, how widely it is distributed about the mean. A smaller standard deviation indicates that more of the data is clustered about the mean. A larger one indicates the data is more spread out. It indicates the structure of the data, the way it is distributed.

Table. 2 Descriptive Statistics of Economic, Social and Environmental Variables

Variables	Mean	Std. Deviation	Minimum	Maximum
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a. Economic Variables				
Total Vehicle Sales	1.311e +7	5.701e +6	4.812e +6	2.186e +7
Foreign direct investment, net inflows (US\$)	2.316e+10	1.540e+10	3.584e +9	4.446e+10
Inflation, consumer prices (annual %)	6.66	2.836	3.685	11.99
Lending interest rate (%)	11.09	1.287	8.333	13.31
Tax revenue	6.974e+12	4.358e+12	1.870e+12	1.370e+13
Tariff rate, manufactured products (%)	15.03	9.521	5.57	32.34
Petrol prices	53.07	16.64	27.28	77.69
Diesel price	38.99	13.96	14.04	63.91
Rupees per 10 gram of gold	1.58E+04	1.02E+04	4474	3.02E+04
Rupees per 1kg of silver	2.69E+04	1.76E+04	7447	5.76E+04
Imports of goods and services	1.759e +13	8.477e +12	5.670e +12	2.880e +13
Export value index	416	246.9	100	761.4
Exports of goods and services	1.555e +13	7.400e +12	5.020e +12	2.510e +13
GDP	7.326e +13	2.639e +13	3.970e +13	1.220e +14
GDP per capita	6.02E+04	1.76E+04	3.77E+04	9.21E+04
Official exchange rate	50.12	7.818	41.35	67.2
Wholesale price index	92.65	25.66	59.07	130
b. Social Variables				
Unemployment, total (% of total labor force)	3.876	0.3113	3.5	4.4
Urban population	3.630e +8	4.667e +7	2.913e +8	4.388e +8
Adjusted net national income (constant 2010 US\$)	1.283e +12	4.318e +11	7.260e +11	2.040e +12
Labor force, total	4.650e +8	2.881e +7	4.055e +8	5.128e +8
Electric power consumption (kWh per capita)	592.4	158.3	395	838.5
Access to electricity (% of population)	70.5	8.029	55.8	82.34
Wage and salaried workers, total (% of total employment)	17.01	2.729	12.5	20.4
Accidental death	113000	25900	80100	149000
c. Environmental Variables				
CO2 emissions from transport (% of total fuel combustion)	11.28	0.7257	10.4	12.38
CO2 emissions (metric tons per capita)	1.322	0.3081	0.9674	1.837
Nitrous oxide emissions (thousand metric tons of CO2 equivalent)	224000	18000	196000	252000

From the result, it can be seen that the mean are greater than standard deviation for all the variables. This implies that the data is closely dispersed.

B. Correlation Matrix:

To determine the level of relationship between each tested variables, correlation analysis has been carried out. Correlation of +1 or -1 shows perfect positive or perfect negative relationship. When the value is 0, it means that there is no relationship.

Table. 3 Correlation Matrix of Economic, Social and Environmental Variables

Independent Parameter	Pearson's r with Total Vehicle Sales		P
a. Economic Variables			
Foreign direct investment, net inflows (US\$)	0.834	***	< .001
Inflation, consumer prices (annual %)	0.552	*	0.022
Lending interest rate (%)	-0.685	**	0.002
Tax revenue (in INR)	0.968	***	< .001
Tariff rate, manufactured products (%)	-0.873	***	< .001
Petrol prices	0.929	***	< .001
Diesel price	0.945	***	< .001

Rupees per 10 gram of gold	0.958	***	< .001
Rupees per 1kg of silver	0.893	***	< .001
Imports of goods and services	0.954	***	< .001
Export value index	0.944	***	< .001
Exports of goods and services	0.978	***	< .001
GDP	0.981	***	< .001
GDP per capita	0.983	***	< .001
Official exchange rate	0.741	***	< .001
Wholesale price index	0.977	***	< .001
b. Social Variables			
Unemployment, total (% of total labor force)	-0.815	***	< .001
Urban Population	0.988	***	< .001
Adjusted net national income (US\$)	0.984	***	< .001
Labor force, total	0.92	***	< .001
Electric power consumption (kWh per capita)	0.984	***	< .001
Access to electricity (% of population)	0.937	***	< .001
Wage and salaried workers, total (% of total employment)	0.92	***	< .001
Accidental deaths	0.979	***	< .001
c. Environmental Variables			
CO2 emissions from transport (% of total fuel combustion)	0.774	***	< .001
CO2 emissions (metric tons per capita)	0.97	***	< .001
Nitrous oxide emissions (thousand metric tons of CO2 equivalent)	0.979	***	< .001

* $p < .05$, ** $p < .01$, *** $p < .001$

- Lending interest rate (%) and Tariff rate, manufactured products (%) are negatively correlated while the rest of the variable are positively correlated.
- Inflation, consumer prices (annual %) is significant at 5% level of significance.
- Lending interest rate (%) and are significant at 1% and 5% level of significance.
- Rest all other variables are significant 0.1%, 1% and 5% level.

Above comments shows that all the selected variables are strongly correlated which in turn implies that the results we obtain will be reliable and relevant.

C. X-Y Scatterplot:

For sake of explanation, Tax Revenue vs Total Vehicle Sales in India is plotted.

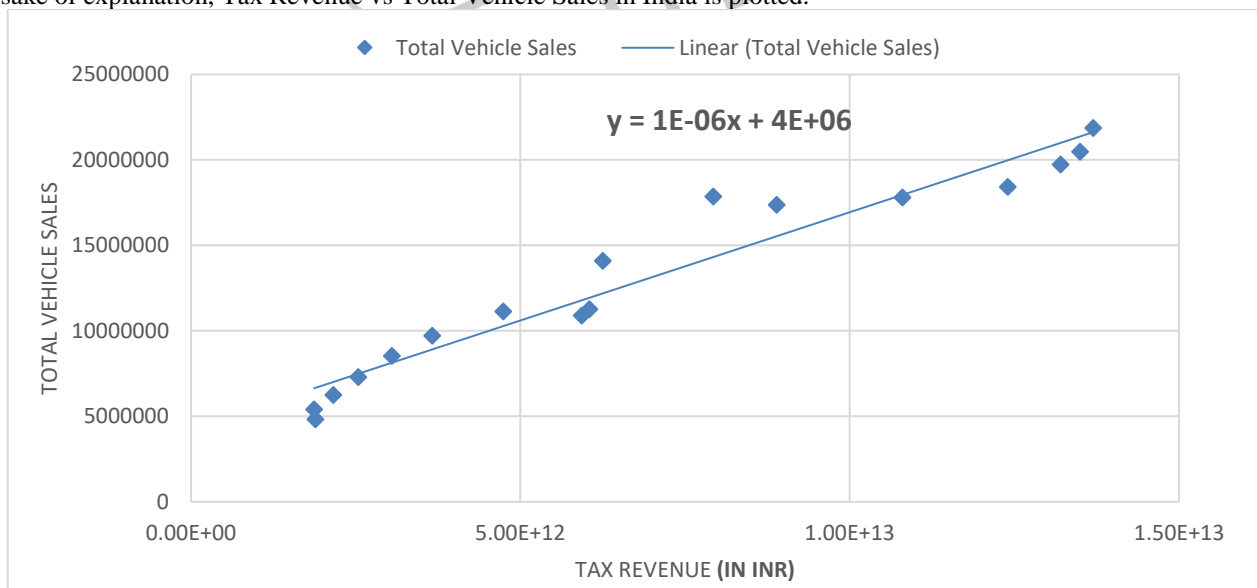


Fig. 2 Data of Total Vehicle Sales against Tax revenue (in INR)

D. Model and Coefficient Summary:

Table. 4 Model Summary of Total Vehicle sales against Tax revenue (in INR)

R	R ²	Adjusted R ²
0.968	0.937	0.933

In this model, R² is 93.7%, so this means that the Vehicle sales in India (dependent variable) are explained by the independent variables up to 93.7%. . Adjusted R² in this context is 93.3%.

Table. 5 Coefficient Summary of Total Vehicle sales against Tax revenue (in INR)

	Unstandardized	Standard Error
(Intercept)	4.278e +6	691723.782
Tax revenue (in INR)	1.266e -6	8.482e -8

When Tax revenue (current LCU) increases by Rs.100 crore (Rs.1000000000) the Vehicle Sales increases by 1266 units. Tax revenue increment essentially implies higher income or sell of products leading to higher revenue there by it certainly implies an increase in spending power of the population.

Table. 6 Summary of all the parameters

Independent Parameter	Value of R ²	Equation	Findings
a. Economic Variables			
Foreign direct investment, net inflows (US\$)	0.696	$y = 0.0003x + 6E+06$	When FDI increases by \$1m (\$1000000) the Vehicle Sales increases by 308 units. This implies that when India attracts an FDI of \$1million the spending power of people increases due to some reasons like increased salary which in turns leads to greater vehicle sales marginally.
Inflation, consumer prices (annual %)	0.305	$y = 1E+06x + 6E+06$	When Inflation increases by 1% Vehicle Sales increases by 1,110,000 units. This results shows an insight which contradicts the common acceptance, it is seen that an increase in inflation reacts to more vehicles being sold. Inherent factors like increased inflation leading to services being charged more for which in turn leads to money reaching to select few who can than influence the automotive industry. By statistics it feels like an anomaly which would need more proof to be proven.
Lending interest rate (%)	0.470	$y = -3E+06x + 5E+07$	When Lending interest rate increases by 1% the Vehicle Sales decreases by 3,037,000 units. Even though the results show logical conclusion that a decrement of lending rates increases the automobile purchase number but the value of R ² is very low to be able to depend on linear distribution of the scatterplot.
Tariff rate, manufactured products (%)	0.762	$y = -522787x + 2E+07$	When Tariff rate, applied, simple mean, manufactured products (%) increases by 1% the Vehicle Sales decreases by 522,787 units. The value of R ² is fairly good for this parameter, and the trend line suggest that an increment in tariff rates leads to decrement in number of vehicles sold which is fair as the spending power reduces since the commodities of foreign origin are priced out but people with taste for them will somehow purchase them as a result leaving a deficiency of money when it comes to automobile purchase.
Petrol prices	0.863	$y = 318171x - 4E+06$	When Petrol prices increases by Re.1 the Vehicle Sales increases by 318,171 units. Petrol price per liter is insignificant in comparison to the cost of purchase of a vehicle but the average fuel consumption per liter is a significant parameter here. Due to geopolitical reasons the prices of the fuel is on the rise but that is not stopping the population from buying new vehicles.
Diesel price	0.893	$y = 385955x - 2E+06$	When Diesel price increases by Re.1 the Vehicle Sales increases by 385,955 units. Similar inference is true for diesel as it is for petrol.
Rupees per 10 gram of gold	0.918	$y = 536.1x + 5E+06$	When Rupees per 10 gram of gold increases by Rs.1000 the Vehicle Sales increases by 536,100 units. With 91.2% accuracy we can infer that the increment in price of gold leads to parallel increase in vehicle sales. As globalization is happening people are moving towards luxury and vehicle sales depicts that.

Rupees per 1kg of silver	0.798	$y = 289.26x + 5E+06$	When Rupees per 1kg of silver increases by Rs.100 the Vehicle Sales increases by 289,300 units. Silver shows similar trends as seen with gold although the R ² values decreases.
Imports of goods and services	0.910	$y = 6E-07x + 2E+06$	When Imports of goods and services (constant LCU) increases by Rs.1000 crore (Rs.10000000000) the Vehicle Sales increases by 6417 units. As the preceding line mentions it is clear that import of goods and services have very less impact on the car sales.
Export value index (2000 = 100)	0.891	$y = 21800x + 4E+06$	When Export value index (2000 = 100) increases by 10 points the Vehicle Sales increases by 218,000 units. The increment in export index shows significant increment in the sales of vehicles.
Exports of goods and services	0.956	$y = 8E-07x + 1E+06$	When Exports of goods and services (constant LCU) increases by Rs.1000 crore (Rs.10000000000) the Vehicle Sales increases by 7532 units. As is the case with imports, the export of goods and services don't really have a huge impact on the vehicle sales in India and that can be concluded with very high assuredly as R ² value is very high.
GDP	0.961	$y = 2E-07x - 2E+06$	When GDP increases by Rs.1000 crore (Rs.10000000000) the Vehicle Sales increases by 2119 units. GDP is a very broad concept. It comprises of anything and everything. Automotive industry is huge but in comparison with everything sold across the nation the number is around 7% of GDP. The model above shows high correlation between the two factors and implies that an increase in the GDP value certainly increase the number of vehicles sold due to increase in the spending power of the population in general.
GDP per capita	0.967	$y = 318.43x - 6E+06$	When GDP per capita increases by Rs.100 the Vehicle Sales increases by 31,840 units. GDP per capita is very crucial economic parameter. As per the results of the linear regression we can safely infer that per capita GDP of a country like India with a population of over 100 crore shows very little increment in vehicle sales with a healthy increment of Rs.100 in GDP per capita. This shows the gulf in priorities of the peoples need in India.
Official exchange rate	0.549	$y = 540381x - 1E+07$	When Official exchange rate (LCU per US\$, period average) increases by Rs.1 the Vehicle Sales increases by 540,381 units. As seen from the R ² value the dependent variable cannot be accurately defined with the given independent variable.
Wholesale price index	0.954	$y = 217049x - 7E+06$	When Wholesale price index increases by 1point the Vehicle Sales increases by 217,049 units.
b. Social Variables			
Unemployment, total (% of total labor force)	0.664	$y = -1E+07x + 7E+07$	When Unemployment increases by 1% of the total work force then the Vehicle Sales decreases by 14,930,000 units. The value of R ² is close to 67% which is not reliable enough in terms of linear regression model. Although the results does makes sense as we see a massive decrement in vehicle sales with an increase in unemployment which is logical inference.
Urban Population	0.976	$y = 0.1206x - 3E+07$	When Urban Population increases by 1000 the Vehicle Sales increases by 121 units. The reliability of the trend line is impressively high. As for conclusion we can see that an increase in urban population leads to an impressive increase in number of vehicles sold. Urban Population increment indirectly hints at improved standard of living which in turn leads to urge to own a vehicle, thereby increasing the sales figure.
Adjusted net national income (US\$)	0.968	$y = 1E-05x - 4E+06$	When Adjusted Net national Income increases by \$10 million the Vehicle Sales increases by 130 units. Although the figures seems skewed but it makes sense as the net national income is huge
Labor force, total	0.846	$y = 0.182x - 7E+07$	When Labor force increases by 1000 the Vehicle Sales increases by 182 units. This implies that any increment in labour force leads to decrement in unemployment which in turn leads to financial rewards thereby increasing vehicle sales.
Electric power consumption	0.967	$y = 35429x - 8E+06$	When Electric Power Consumption increases by 1 kWh per capita the Vehicle Sales increases by 35429 units.

(kWh per capita)			Electric power consumption indirectly linked to development of the society as a whole. It is a sign of a developing nation or region. Developing nation leads to better standard of living which caters to the need of owning a vehicle, thereby increasing vehicle sales.
Access to electricity (% of population)	0.879	$y = 669501x - 3E+07$	When Access to electricity increases by 1% of the total population the Vehicle Sales increases by 665722 units. The reasoning for this parameter is same as the preceding one.
Wage and salaried workers, total (% of total employment)	0.847	$y = 2E+06x - 2E+07$	When Wage and salaried workers as % of total employment increases by 0.5% the Vehicle Sales increases by 961,500 units. The results show that even a minor change as small as 0.5% in the waged and salaried workers as a total of employed population leads to massive increase in vehicle sales.
Accidental deaths	0.957	$y = 210.39x - 1E+07$	When Accidental Deaths increases by 1 person the Vehicle Sales increases by 216 units. This result is to be interpreted in a reverse manner, which means that for every 216 units of vehicle sold there is one accidental death which takes place. This study also shades light that even though the number of accidental deaths is increasing year-on-year, the number of vehicles sold is also increasing hand in hand. This means that accidental deaths is not deterring the consumer to purchase new vehicles. Although any death is tragic, accidental deaths can have number of human behavioral reasons for occurrence and that cannot be blamed solely on the increment in number of vehicles produced or sold.
c. Environmental Variables			
CO2 emissions from transport (% of total fuel combustion)	0.599	$y = 6E+06x - 6E+07$	When CO2 emissions from transport (% of total fuel combustion) increases by 0.5% the Vehicle Sales increases by 3041500 units. This result cannot be relied on as the value of R2 is very small compared to the other models. Linear regression is not the right model to understand the relationship between the two variables. Even though the results are not reliable but the model does shades a light on the dire situation of the environment and the lack of respect we show for it.
CO2 emissions (metric tons per capita)	0.941	$y = 2E+07x - 1E+07$	When CO2 emissions (metric tons per capita) increases by 0.001 metric ton the Vehicle Sales increases by 17,950 units. This result is more reliable than the previous one as the R2 value is very high. The model shows that even though there is increment in the CO2 levels which are blatantly visible, there is no decrement in number of vehicles being produced or sold, instead the sales are steadily increasing.
Nitrous oxide emissions	0.959	$y = 303.24x - 5E+07$	When Nitrous oxide emissions (thousand metric tons of CO2 equivalent) increases by 1 metric ton the Vehicle Sales increases by 303 units. This model has similar conclusion as the preceding parameter.

IV. CONCLUSIONS:

This study successfully quantifies the expected changes in the Total Vehicle Sales when there is a change in the independent parameter. When tax revenue be it income tax, profit, or capital gain, the total vehicle sales in India is observed to increase. Tax revenue increment essentially implies higher income or sell of products leading to higher revenue there by it certainly implies an increase in spending power of the population. Fuel price per litre is insignificant in comparison to the cost of purchase of a vehicle but the average fuel consumption per litre is a significant parameter when it comes to calculating the recurring cost for a vehicle sustenance. Due to geopolitical reasons the prices of the fuel is on the rise but that is not stopping the population from buying new vehicles. The export or import of goods and services is a very large spectrum and from the results we can conclude that vehicle sales being very small fraction of import or export, it is not impacted by the rise or fall.

Automotive industry is huge but in comparison with everything sold across the nation the number is around 7% of GDP. The results implies that an increase in the GDP value certainly increase the number of vehicles sold due to increase in the spending power of the population in general. The results conclude that India being a densely populated country, Unemployment increase by even 1% has massive downfall on the total vehicle sales figures. The results also show that an increase in urban population leads to an impressive increase in number of vehicles sold. Urban Population increment indirectly hints at improved standard of living which in turn leads to urge to own a vehicle, thereby increasing the sales figure.

Labor force and unemployment stand at the opposite ends of the same spectrum. This implies that any increment in labor force leads to decrement in unemployment which in turn leads to financial rewards thereby increasing vehicle sales. Electric power consumption indirectly linked to development of the society as a whole. It is a sign of a developing nation or region. Developing nation leads to better standard of living which caters to the need of owning a vehicle, thereby increasing vehicle sales. The study also shades light that even though the number of accidental deaths is increasing year-on-year, the number of vehicles sold is also increasing hand in hand. This means that accidental deaths is not deterring the consumer to purchase new vehicles. Although any death is tragic, accidental deaths can have number of human behavioural reasons for occurrence and that cannot be blamed solely on the increment in number of vehicles produced or sold.

REFERENCES

- [1] Abdul Hannan, Faheem Haider, Nisar Ahmad, Tahira Ishaq. (2015), "Impact of Economic, Social and Environmental Variables on Competitiveness of Automotive Industry: Evidence from Panel Data", *International Journal of Economic Behavior and Organization*, vol. 3, pp 10-17, 2015
- [2] Peter J. Buckley, Jeremy Clegg, Ping Zheng, Pamela A. Siler, Gianluigi Giorgioni, "The Impact of Foreign Direct Investment on the Productivity of China's Automotive Industry", *Journal of the Operational Research Society*, Vol. 2, pp. 24 – 33, 2007
- [3] Rabiul Islam, Ahmad Bashawir Abdul Ghani, Bobby Kusuma, Eric Teh Yew Hong, "An Analysis of Factors that Affecting the Number of Car Sales in Malaysia", *International Review of Management and Marketing*, Vol. 6, pp.872-882, 2016.
- [4] Christina Babatsou and Efthimios Zervas, "EU Socioeconomic Indicators and Car Market", *International Journal of Economics and Management Engineering*, Vol. 5, pp.1616-1621, 2011.
- [5] Michael Sivak, Omer Tsimhoni, "Future demand for new cars in developing countries: going beyond GDP and Population size", Research Article, The University of Michigan Transportation Research Institute, Michigan, 2008.

