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An Enquiry Into The Impact Of Macro-Ec0nomic Factors On Domestic Demand For Two Wheelers In India

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Abstract: The production and sale of Indian two-wheeler automobiles play a crucial role in the automobile market within India. Two-wheeler automobiles constitute, on an average, 79.5% of total automobile sales in the country since 2001. The average number of two-wheelers per 1000 people in India is 31. India is the second-largest two-wheeler market in the world next to China, with annual sales of about 16 million units in 2022-23. A multiple linear regression model has been adopted to examine the impact of macroeconomic variables on demand for two-wheelers. Ordinary least square method is used to estimate the impact of macroeconomic factors after duly taking care of the assumptions of linearity, normality, multi-collinearity, homoscedasticity and autocorrelation to have consistent and efficient estimates of the regression parameters. The regression model initially considers 13 macroeconomic factors as explanatory variables. After dropping certain macro-economic variables which do not satisfy the tests of linearity, normality, multicollinearity, homoscedasticity and autocorrelation, it is found that per capita income, interest rate of borrowing, vale added in retail trade sector and two-wheeler prices have significant impact on the demand for two-wheelers.

Key words: macro-economic variables, two-wheelers, multiple regression, least square method. Linearity, normality, multicollinearity, homoscedasticity, autocorrelation

I. INTRODUCTION

Indian automobile sector contributes immensely towards the growth of GDP and employment and also creates strong backward and forward linkages in rest of the economy (Baruah and Kakati, 2024). Currently, the contribution of the entire automobile sector to India's GDP stands at 7.1 percent of overall GDP and 49 percent of the manufacturing GDP in 2022-23. (Press Information of Ministry of Heavy Industries and Public Enterprises dated 17th February,2023). It generates direct and indirect employment for 37 million people (Economic Survey, Vol.-I, 2022-23). India has also become an automobile exporting hub, exporting mainly to Asian and African countries. Export destinations also include United States, United Kingdom, South Africa, United Arab Emirates etc.

In the global perspective, Indian automobile industry holds a respectable position in terms of production and sales. Among the different variants of automobiles , passenger vehicles, occupies fourth rank leaving behind Germany in 2021 (Annual Report, 2021-22, Society of Indian Automobile Manufacturing) while two-wheelers is the second-largest producer in the world, next only to China.

During the first two decades of the present century (2000-01 to 2022-23), automobile sector has increased its production by more than five times, from 48 lakh units in 2000-01 to about 260 lakh units in 2022-23 (www.siam.in/statistics). Two-wheelers and passenger vehicles dominate the market share of production. During this period, two-wheelers accounted for roughly 75% to 80% of total automobiles production in our country, followed by passenger vehicles sharing 14% to 18% of production.

The movement of macroeconomic factors exerts influence on the demand for the products any major industry of an economy including the automobile industry. The relevant macroeconomic factors usually considered to influence the demand for automobiles are gross domestic products, gross value added, gross domestic savings, gross fixed capital formation, per capita income, inflation rate, borrowing rate of interest, fuel price, price of automobiles, industry growth rate, urban population, total population etc. The identification of macroeconomic factors and their impact in stimulating the domestic demand for Indian automobile industry is of paramount importance as it enables the policy makers, both manufacturers and government agencies - to take appropriate policy decisions for its expansion and sustainability. Keeping this background in mind, it is intended to empirically carry out this exercise to identify the macroeconomic factors and assess their impact on the domestic demand for two-wheelers in Indian market. Although there are large number of studies on the impact of macroeconomic factors on the sales of passenger vehicles globally as well as in India, such studies on two-wheelers are limited as indicated in the following section on review of literature.

II. REVIEW OF LITERATURE AND RESEARCH GAP

Most of the existing studies, globally as well as within India, on the impact of macroeconomic factors on the demand for automobiles are concentrated on passenger cars only while such studies are very limited in case of two-wheelers and other segments of automobiles, viz., commercial vehicles and three-wheelers.
A number of studies are found to be carried out on the status, prospects and factors influencing the of two wheeler markets in India and abroad. Batra (2015) in his study attempted to identify certain economic and other external factors influencing the demand for two-wheelers in India using regression models. The author found that higher per capita income, increase in petrol price, lower borrowing rate of interest etc. have positive impact on the sales of two-wheelers. Weeraiari and Mendis (2016) carried out a study on the demand for Indian two-wheeler in Sri Lankan market. The authors attempted to find out the factors responsible for demand for Indian two-wheelers in Sri Lanka carrying out a survey in four districts They found that five factors, namely price of the product, technology , product awareness, after-sale service and economic condition have affected the demand for Indian two wheelers in Sri Lanka. They also found that demographic factors like age, gender, income level, education level also influenced the demand for two-wheelers. Balakrishna S. and K. Banana (2018) attempted to find out the consumer's buying behavior for two-wheeler in Prakasam district of Andhra Pradesh. The study found that consumer's buying behavior is influenced by personal, cultural, social and psychological factors. Personal factors such as buyer's age, lifestyle, occupation, economic condition etc. and other factors like price, design, easy finance, updated technology etc. influenced the purchase behavior of the two-wheeler consumers. Chowdhury (2019) made a study to identify the factors influencing the demand for two-wheelers in Dhaka city of Bangladesh. A survey was carried out on respondents comprising male consumer of different age group in Dhaka . The result of the survey indicated that fuel consumption, design and brand are three most important factors influencing the demand for two-wheelers. Considering age, marital status and occupation as influencing factor, the study further revealed that occupation played significant impact compared to age and marital status in demand for two-wheelers in Dhaka city. Babu et. al. (2023) carried out a study on the impact of various economic, social, technological and regulatory factors on the demand for two-wheeler industry in India. They found that economic factors like income levels, inflation rates and interest rates, and social factors like lifestyle, urbanization and population influenced the demand for two wheelers. Similarly, technological factor like fuel efficiency, safety also guided the demand for two-wheelers. Somireddy (2018) carried out a study to identify the factors that influenced the buying behaviour of the two-wheeler customers in Hyderabad city. The author carried out a sample survey (137 samples) and used ANOVA and multiple regression technique. The results of the study indicated that consumers' purchase behaiour is influenced by brand name , price, better look and style, good mileage, offer scheme etc. Ghosh and Kumar (2025) carried out a study to focus on the factors that influenced the buying behaviour of consumers towards purchase of two-wheelers in Delhi NCR. Their study indicated that factors like fuel efficiency, maintenance service, spare parts availability safety etc. influenced the buying behaviour of consumers. Choudhury (20119) made a study on the buying behaviour of consumers of two-wheelers (motorcycles) of Dhaka city of Bangladesh. The author carried out

a survey of male consumers of different age groups and using multivariate analysis of variances (MANOVA) found that fuel consumption, design, brand image were three most important factors to select a motorcycle. Swarna and Banana (2018) made a study on consumer buying behaviour towards two-wheelers in Prakasam district of Andhra Pradesh. The authors carried out a survey of 500 samples of two-wheeler customers and adopted ANNOVA and other simple statistical tools for analysis of data. Small manageable size, low maintenance cost, low price, easy loan repayment etc. are found to have influenced the buying behaviour of customers in the district. Raj and Kannan (2020), based on a sample survey data, attempted to explore the factors influencing the purchase of two-wheeler with special reference to Chennai city. Majority of the two-wheeler purchasers prefered the model with comfort, good after-sale service, smooth suspension , fuel efficiency, price and resale value. Simple statistical tool like percentage was used to indicate the preference for two-wheeler model. Mahera and Lamoria (2024) made a study on consumer perception towards electric two-wheeler in Vadodara city of Gujrat. Based on a sample survey they found that consumers preferred electric two-wheeler due to rise in the cost of fuel and also global warming. Babu et.al. (2023) made an study on economic, social, technological and regulatory factors influencing two-wheeler industry in India. The researchers found that two-wheeler demand was significantly influenced by economic factors like income level, inflation, interest rate and social factors like shifting lifestyle, urbanisation and population growth. Sunitha (2021) made a market analysis of electric two-wheeler fleet in India for fiscal year 2020-21based on a consumer survey on electric vehicles and internal combustion engine users. The researcher identified the key challenges, concerns and expectations of consumers of electric two wheeler.

It appears from the literature review that some of the studies are focussing the influence of economic, social, demographic and technical factors on demand for two wheeler. But none of these studies has focussed exclusively on the impact of macroeconomic factors such as GDP, GDS, GVA, per capita income, inflation, borrowing rate of interest, population growth, urban population, employment rate etc. on demand for two-wheeler at the national level in a comprehensive manner. In view of this, it is intended to identify and assess the impact of macroeconomic factors on demand for two wheeler in India based on secondary data.

III. METHODOLOGY ADOPTED

A multiple regression model is adopted to trace out the impact of macroeconomic and other factors on domestic demand for two-wheelers,

$$Y_t = \beta_1 + \beta_2 X_{2t} + \beta_{3t} X_{3t} + \ldots\ldots\ldots\ldots\ldots + \beta_{kt} X_{kt} + U_t \ldots\ldots\ldots\ldots (1)$$

where, the dependent variable Y_t represents the demand for automobiles and the explanatory variables X_2, X_3, $\ldots\ldots X_k$ represent the macroeconomic factors and U_t is the random variable. Ordinary least square method is applied to estimate the regression parameters β_2, β_3, β_4, $\ldots\ldots\beta_k$ after duly carrying out statistical tests to conform the assumptions of least square method. With 'n' observations (t = 1, 2, 3, ……..n), equation (1) turns out to be in matrix form

$$\mathbf{Y = X\beta + U} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

and the estimation of β parameters using ordinary least square (OLS) method (Johnston, 1984) is given by

$$\hat{\boldsymbol{\beta}} = (\mathbf{X^T X})^{-1} \mathbf{X^T Y} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

subject to the satisfaction of the usual assumptions of normality, linearity, multi-collinearity, homoscedasticity and autocorrelation. The assumptions of OLS method are tested before estimation of the regression parameters using the following methods:

(a) For testing linearity, scatter plot of the observations and their R^2 values are taken into account;
(b) Shapiro-Wilk and Kolmogorov-Smirnov tests are carried out for testing normality;
(c) The presence of multicollinearty is tested using Variance Inflation Factor (VIF) and Tolerance Values.
(d) Durbin-Watson d-statistic is used to test the presence of autocorrelation.
(e) White test and Breusch Pagan test for homoscedasticity

Based on the existing literature of impact of factors on the sales of automobiles as well as our own assessment and perception, the multiple regression model (equation-1 above) is reformulated for empirical analysis of the impact of thirteen macroeconomic variables on the demand for two-wheelers as

$$TWS_t = \beta_0 + \beta_1 GDP_t + \beta_2 GDS_t + \beta_3 PCI_t + \beta_4 INF_t + \beta_5 FPI_t + \beta_6 IRB_t + \beta_7 UER_t + B_8 \quad VAP_t + \beta_9 VAR_t + \beta_{10} VAT_t + \beta_{11} URP_t + \beta_{12} PCPITW_t + \beta_{13} TWP_t + U_t \quad \ldots\ldots (4)$$

where, abbreviated dependent and independent variables are

TWS ⇨ Sales of two wheelers
GDP ⇨ Gross domestic product
GDS ⇨ Gross domestic savings
PCI ⇨ Per capita income
INF ⇨ Inflation rate
FPI ⇨ Fuel price index
IRB ⇨ Interest rate of borrowing
UER ⇨ Unemployment rate
VAP ⇨ Gross value added (Primary sector)
VAR ⇨ Gross value added (Retail trade, hotel , transport)
VAT ⇨ Gross value added (Tertiary sector)
URP ⇨ Urban population
PCPITW ⇨ Per capita income / TW price index ratio
TWP ⇨ Two wheeler price index

The initial set of thirteen macroeconomic variables taken for analysis of their impact on the demand two-wheelers are GDP, GDS, per capita income, GVA(tertiary Sector), GVA (primary Sector), GVA (retail trade, hotel etc.), urban population, fuel price index, interest rate of borrowing, inflation rate, unemployment rate, 'per capita income/ TW price index' ratio, and two-wheeler price index. The study is based on secondary source of time series data from 1995-96 to 2021-22 provided by Economic survey of India, World Bank report and Society of Indian Automobile Manufacturers (SIAM).

IV. RESULTS AND DISCUSSION

4 (a) : Linearity test: The linearity test using scatter dot plots were performed on the dependent variable. Two wheeler sales and the independent variables. The R^2 values of the plots are summarized in the table below

Table-1: Summary of relationships of the independent variables with two wheeler sales

Dependent Variable	Independent Variable	Type of relationship	R^2 linearity
Two Wheeler sales	Per capita income (PCI)	Linear	.288
	per capita / price index ratio (PCPI)	Non linear	.066
	Gross domestic savings (GDS)	Linear	.418
	Gross domestic products (GDP)	Linear	.232
	GVA (retail trade etc.) (VAR)	Linear	.328
	Inflation rate (INF)	Non linear	3.119E-5
	Fuel price index (FPI)	Non linear	.023
	Interest rate of borrowing (IRB)	linear	.135
	Unemployment rate (UER)	Non linear	.054
	Urban population (URP)	Non linear	.012
	GVA (primary sector) (VAP)	linear	.429
	GVA (tertiary sector) (VAT)	linear	.351
	Two wheeler price index (TWP)	linear	.125

Source : Estimated

Eight variables namely, GDP, GDS, PCI, IRB, VAR, VAP, VAT, TWP are found to have linear relationship with two wheelers sales. Here, the variables that are found to have non-linear relationship with two wheeler sales (or demand) are fuel price, inflation rate, per capita income/price index ratio, urban population and unemployment rate. These variables exhibiting non-linear relationship are log transformed and again tested

for linearity assumption using scatter plots. The summary of the results of linearity tests for log transformed variables are presented in the table – 2 below.

Table-2: Summary of relationships of the non-linear independent variables with two wheeler sales after log transformation

Dependent Variable	Independent Variable	Type of relationship	R^2 linearity
Two Wheeler sales	Per capita / price index ratio	Non linear	.069
	Inflation rate	Non linear	3.119E-5
	Fuel price	Non linear	.024
	Unemployment rate	Non linear	.052
	Urban population	Non linear	.006

Source : Estimated

As these five variables are still having non-linear relationships with two wheeler demand, they are dropped from further analysis in the multiple linear regression model.

4 (b) :Normality tests: The normality tests have been performed on the eight variables which are found to clear linearity tests. After eliminating all the non-linear macroeconomic variables , the remaining linear variables are subjected to normal distribution tests of Shapiro-Wilk and Kolmogorov-Smirnov. The results of Shapiro-Wilk and Kolmogorov-Smirnov tests are furnished in the table-3.

Table-.3: Significance values of Shapiro-Wilk and Kolmogorov-Smirnov tests

Independent Variable	Shapiro-Wilk Test		Kolmogorov-Smirnov Test	
	Shapiro Wilk Statistic	Significance Value / P value	Kolmogorov Smirnov Statistic	Significance Value / P value
Two wheeler price	0.979	0.888	0.118	0.200
GVA(Tertiary)	0.916	0.059	0.165	0.10
Per capita income	0.919	0.063	0.136	0.103
GDS	0.922	0.065	0.102	0.200
GVA (retail trade etc.)	0.975	0.788	0.112	0.200
IRB	0.918	0.056	0.169	0.056
GDP	0.949	0.252	0.102	0.252
GVA(Primary)	0.919	0.062	0.150	0.192

Source : Estimated

Since the p values of all the eight variables are greater than 0.05 for both Kolmogorov-Smirnov test and Shapiro-Wilk test, so all these eight variables are considered to be normal. Hence the final list of variables after dropping the non-linear and non- normal variables that are to be analysed in multiple linear regression include GDP, GDS, PCI, IRB, VAP, VAT, VAR and TWP The following steps are taken to obtain an unbiased and consistent multiple linear regression model with low multi-collinearity and low autocorrelation.

Step 1: After obtaining this final set of eight linear macroeconomic variables, the multiple linear regression is performed using these eight independent variables and the corresponding VIF(variance inflation factor) and Tolerance values are calculated in the regression model to assess the amount of collinearity among these eight independent macroeconomic predictors. In case, high multi-collinearity is detected, the variables with VIF values around 10 and greater than 10 are eliminated and the multiple regression analysis is performed again with the remaining variables.

Table-4 : R^2 value and Durbin-Watson d-statistic

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Durbin-Watson
Regression	.831	.690	.513	5.18893E5	2.167

Source : Estimated

Table-5 : VIF and Tolerance value

Independent Variable	Tolerance value	VIF
Per capita income	.002	427.052
Lending interest rate	.571	1.750
GVA (retail trade etc.)	.024	41.208
Two-wheeler price index	.578	1.729
GDS	.059	16.893
GDP	.002	461.266
GVA (primary)	.074	13.542
GVA (tertiary)	.039	25.830

Source : Estimated

This multiple linear regression using the eight variables has very high multi-collinearity as 6 of the independent variables namely GDP, GDS, per capita income and GVA(tertiary), GVA(retail trade) and GVA(primary) have high VIF values exceeding 10. Out of these six variables, GDP has the highest VIF score of 461.33. Hence the variable GDP is dropped from the model and the multiple regression along with multi-collinearity test is performed using the remaining seven independent variables.

Step 2:

Table-6: Tolerance level and VIF after dropping GDP variable

	Tolerance level	VIF
Per capita income	0.374	2.672
Lending interest rate	0.645	1.550
VAR	0.039	25.817
T-W price index	0.593	1.687
GDS	0.076	13.153
VAP	0.082	12.240
VAT	0.034	28.99

Source : Estimated

In this step, four variables namely VAR, GDS, VAP and VAT has high VIF values greater than 10. Among them, VAT has the maximum VIF of 28.99. Hence VAT is dropped from the predictor variables set and multi-collinearity is tested again using the remaining 6 variables, namely, PCI, IRB, VAR TWP, GDS , VAP. In next step (step-3), we compute the following:

Table-7: VIF and Tolerance level after dropping GVA(tertiary)

Independent Variable	Tolerance level	VIF
Per capita income (OCI)	.449	2.229
Borrowing interest rate (IRB)	.656	1.524
VAR	.092	10.852
Two wheeler price index (TWP)	.629	1.590
GDS	.076	13.149
VAP	.087	11.528

Source : Estimated

Here, high multi collinearity is still present although it has slightly decreased as compared to previous step 2. VAR , GDS , VAP have VIF values greater than 10 and GDS has the highest VIF of 13.149 and hence it is dropped. The regression analysis along with multi collinearity test using the remaining five predictors GDP per capita , lending interest rate, VAR, two wheeler price index, VAP are shown in step 4 below and obtain the relevant statistics in the following tables:

Table-8: VIF and Tolerance level after dropping GDS variable

Independent Variable	Tolerance level	VIF
PCI	.624	1.603
IRB	.851	1.175
VAR	.142	7.021
TWP	.640	1.562
VAP	.094	10.550

Source : Estimated

In this step, VAP) has the maximum VIF of 10.55 which is greater than 10 and hence it is dropped from the regression model. The regression analysis along with multi-collinearity tests are then performed using the remaining four variables namely PCI, IRB, VAR , TWP as shown in step 5 below

Step-5:

Table 9: R^2 value and Durbin-Watson d-statistic after dropping GVA(primary)

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Durbin-Watson
Regression	.773	.597	.507	5.22090E5	2.31

Source : Estimated

Table-10 : VIF and Tolerance level after dropping GVA(primary)

Independent Variable	Tolerance level	VIF
PCI	.834	1.199
IRB	.910	1.099
GVA (retail trade erc.)	.772	1.296
Two-wheeler price index	.874	1.144

Source : Estimated

Table – 11: Regression coefficients after dropping GVA(primary)

	Unstandar-dized coefficient β	Unstandar-dized std. error	Standar-dized coefficient β	t-value	Sig. level
(Constant)	-3150.815	206827.827		-.015	.988
PCI	2714.043	1505.451	.295	1.803	.088
IRB	-233151.379	102339.622	-.357	-2.278	.035
GVA(R)	3.530	1.264	.476	2.792	.012
TW price index	-25742.424	40895.410	.101	.629	.075

Source : Estimated

Table-12: White test and Breusch Pagan test results for homoscedasticity:

White test			Breusch Pagan test		
LM stat	P value	F stat	LM stat	P value	F stat
1.452	.520	.674	8.064	0.0853	2.429

Source; Estimated

This regression model based on the remaining four predictors, namely per capita income, borrowing interest rate, GVA (retail trade etc.), two-wheeler price index, has no multi-collinearity as the VIF values of all the independent variables are less than 5 and the tolerance values are quite higher than the minimum value of 0.20. The Durbin-Watson d-statistic of 2.31, which is within the range of 1.5 to 2.5, indicates low auto-correlation in the model. Further, the p values of both White test and Breusch-Pagan tests are greater than 0.05 indicating that the regression model satisfies homoscedasticity assumption. The R^2 and adjusted R^3 of 0.597 and 0.507 respectively signifies a good fitting of the multiple regression model. On substitution of the estimated parameters of the relevant macroeconomic variables in equation-4 as furnished in table-11, the following final estimated regression equation is obtained

$$TWS_t = -3150.81 + 2714.04\ PCI_t - 223151.38\ IRB_t + 3.53\ GVAR_t - 25742.42\ TWP_t \quad \ldots\ldots\ldots (5)$$

On observing the significance level (or p values) of each of the macroeconomic variables, the p values of IRB and VAR are less than 0.05 while for per capita income , the p value is 0.088 which is greater than 0.05 but less than 0.10. Therefore, borrowing interest rate and GVA (retail trade etc.) are found to be significant at 5 percent level whereas per capita income is significant at 10 percent level. Interest rate of borrowing exerts significant negative impact whereas GVA (retail trade) and per capita income exerts strong positive impact on demand of two wheelers. The relationship between two wheeler price index and demand is negative but significant at 10 % level only as the p value is 0.075 which is less than 0.10. This negative effect signifies that rise in the two-wheeler price dampens its demand.

V. CONCLUDING REMARKS

From the foregoing numerical results , the final estimation of regression (equation-5) indicates the nature and strength of the impact of macroeconomic factors on demand for two-wheelers. In order to ascertain the impact of macro-economic factors on the demand for two-wheelers, 13 macroeconomic variables are incorporated in the multiple regression (equation-4). About nine macroeconomic variables have failed to fulfil the least square conditions of linearity, normality, muilti-collinearity, homoscedasticity and autocorrelation, for which they are dropped from the final regression equation to make the estimates consistent and unbiased. Only four macroeconomic variables are finally found to have influenced the demand for two-wheelers as indicated in the table-20 below:

Table -13: Impact of macroeconomic variables on demand for two-wheelers

Dependent Variable	**Independent variable**	**Relationship with dependent variable**	**Significance level at 5% or 10%**
Two-wheeler sales	Per capita income	Positive	Significant at 10%
Two-wheeler sales	Borrowing interest rate	negative	Significant at 5%
Two-wheeler sales	Gross value added (retail trade etc.)	positive	Significant at 5%
Two-wheeler sales	Two wheeler price index	negative	significant at 10%

Source : Estimated

Per capita income has positive impact at 10% level of significance indicating that higher the per capita income greater is the demand for two-wheelers. On the contrary, borrowing rate of interest has significant negative impact at 5% level of significance justifying the established view that the higher the interest rate of borrowing, lower is the demand. Similarly, the gross value added in retail trade sector has also significant positive impact on the demand for two-wheelers, as it is a convenient method of transportation of goods by small traders, transportation by Rapido operators and also for food delivery system like Zomato, Swiggy etc. The price of the two-wheelers is not usually expected to have positive impact of on its demand. Here, positive but insignificant impact of price of two wheelers vehicle on its demand might be outplayed by the significant positive impact of per capita income on demand, indicating a fall in real price of two-wheelers.

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