Working Paper 439

Income and Vehicular Growth in India: A Time Series Econometric Analysis

Vijayalakshmi S
Krishna Raj

ISBN 978-81-7791-295-1

Institute for Social and Economic Change (ISEC) is engaged in interdisciplinary research in analytical and applied areas of the social sciences, encompassing diverse aspects of development. ISEC works with central, state and local governments as well as international agencies by undertaking systematic studies of resource potential, identifying factors influencing growth and examining measures for reducing poverty. The thrust areas of research include state and local economic policies, issues relating to sociological and demographic transition, environmental issues and fiscal, administrative and political decentralization and governance. It pursues fruitful contacts with other institutions and scholars devoted to social science research through collaborative research programmes, seminars, etc.

The Working Paper Series provides an opportunity for ISEC faculty, visiting fellows and PhD scholars to discuss their ideas and research work before publication and to get feedback from their peer group. Papers selected for publication in the series present empirical analyses and generally deal with wider issues of public policy at a sectoral, regional or national level. These working papers undergo review but typically do not present final research results, and constitute works in progress.

Working Paper Series Editor: **A V Manjunatha**

INCOME AND VEHICULAR GROWTH IN INDIA: A TIME SERIES ECONOMETRIC ANALYSIS

Vijayalakshmi S[1] and Prof. Krishna Raj[2]

Abstract

India is one among the fastest growing economies in the world with an average growth rate of eight per cent of Gross Domestic Product in the last decade. The impact of increase in GDP can be observed in many sectors of the economy and transport is not devoid of it. Micro-economic theories firmly established the relationship between income and consumption having direct and positive impact. This can be observed in case of India's per capita income and personal vehicular growth. In this line, the paper tried to analyse this relationship by compiling time-series data of total registered vehicles and personal income from 1960-2015. Since, vehicular population has influenced other important variables like urbanisation and employment, the paper tried to model their effect under Autoregressive - Distributed Lag model (ARDL) and proves their long run co-integration.

Though increase in income and vehicles tend to show positive sign of economic growth, its negative implications cannot be ignored. The paper also brings out the emergence of negative externalities of growth of vehicular population by way of deteriorating air quality of the country, which has affected the GDP. World Bank (2013) estimates show that three percent of GDP is lost due to air pollution in India which is commonly attributed to vehicular emission.

Keywords: Per Capita Income, Vehicular Growth, Co-integration, ARDL, Air pollution, Road length.

Traffic congestion and air pollution are the by-products of personalised vehicular growth in India. The stupendous growth of vehicular population, particularly in the mega cities is directly influenced by the growth of personalised income. There is a strong one-to-one relationship among growth in per capita income, urban population, employment and private mode of transport. These aspects of development largely indicate welfare gain, whereas, presence of negative externalities in the form of traffic congestion and air pollution reflect welfare loss. World Bank (2014) estimates show that approximately 54 percent of world population resides in cities contributing around 60 percent to the world's GDP. The growth in income has direct relationship with vehicle ownership with approximately 1.2 billion vehicles in the world, excluding construction vehicles (IOMVM, 2014). The same pattern of growth in per capita income and vehicular growth is observed in India. It is estimated that around 63 percent of its GDP is being contributed by major metropolitan cities alone in 2011 and this trend is expected to be about 70 percent by 2030 indicating rapid urbanisation. These cities are home to around 31 percent of the total population (Census, 2011) and support 182.4 million vehicles on narrow and highly congested roads. Even though, the economic growth looks very promising with improvement in the standard of living which has created more demand for private mode of transport, but such growth of vehicles is not accompanied by the other supporting factors like growth of road length, scientific traffic management system and improved public transport. This has resulted in crawling traffic and air pollution. Therefore, the economic future of cities depends on how traffic and air pollution are better managed in the years to come.

---

[1] PhD Scholar at Centre for Economic Studies and Policy, Institute for Social and Economic Change, Bengaluru

[2] Professor of Economics at CESP, ISEC, Bengaluru

The growth linkage between GDP and transport sector is very strong in recent decades. During the last decade, the annual average growth rate of road transport sector when compared to GDP stood at 8.8 percent which was greater than the overall GDP growth of 7.6 percent between 2001-2011. This clearly signifies that the road transport sector is one of the fastest growing sectors in the economy. Further, the contribution of the entire transport sector to the total GDP is 4.8 percent. Out of this, road transport is the major contributor with 3.1 percent; railways contributed 0.9 percent and remaining 0.8 per cent by other modes of transport in 2013-14 (TERI, 2014). Among different modes, the shares of rail and road dominate the entire transport system by 87 percent and road transport alone has a modal traffic performance of 62 percent (NTDPC, 2010). India's freight volume increased at a compounded annual growth rate of 9.08 percent and passenger vehicles at 10.76 percent, the road length by 4.01 percent in 2011 (TCI and IIM, 2012). The increasing gap between demand for personalised vehicular ownership and growth of road length had created negative externalities like traffic congestion (incidents of time delay, unnecessary fuel consumption) and air pollution (causing health hazards).

Against this backdrop, the paper makes an attempt to study the long-term relationship between income and vehicular growth with other important variables (employment and urbanisation) for India. Secondly, the paper made an effort to assess the air quality condition of the country affected by vehicular population with the use of secondary data.

The paper is organised in four different sections: Section I tries to bring out the review of theoretical and empirical studies to find out the relationship between income and vehicular growth. Section II tries to prove this by establishing long-run relationship among GDP, per capita income, working age population, urbanisation and vehicular growth through econometric analysis using time-series data; Section III deals with extent of traffic congestion and air pollution by comparing relative vehicular growth rate to road length and per capita vehicles and the last section concludes the analysis.

SECTION I

1.1. Economic Growth and Transport Sector: Theoretical and Empirical Explanation:

Economic development is strongly associated with increasing demand for transportation, more evidently, private vehicles on road, creating not only traffic congestion but also air pollution (Dargay, 2007). The theoretical background mainly establishes the fact that, the major reason for the increase in vehicular population is due to economic development indicated by growth in income, employment and urbanisation. There are many studies which have found empirically a strong relationship between income and growth of vehicles in different parts of world. But, a clear theoretical framework about the relationship remains unexplored. It is indeed true that, a comprehensive theory for the present analysis may not be available in the literature, but major concepts from several theories can strengthen the causal relationship that we are trying to derive.

The paper tries to formulate such framework at the micro level by drawing its route of relationship between income and vehicular growth from traditional microeconomic framework of consumer behaviour. It is well established in the theory that, income has a pivotal role to play in individual's decisions regarding purchases. As far purchase of vehicles are concerned, the decisions are

based on the utility characteristics of the good in relation to income and other socio-economic factors like age, employment and urbanisation trend (Lancaster, 1966).

While speaking about the relationship between income and purchase of vehicles, micro-economic concept of income elasticity may aid for our understanding. It is commonly understood that expenditure on vehicular purchase have positive elasticity of demand (Income elasticity) and most of the time it is considered to be luxury consumption. This is also acknowledged by Dargay *et al* (2007) who states that, vehicle ownership is slow in lowest level of per capita income and about twice as fast as at middle income levels. This kind of pattern indicate as income increases, demand for luxury goods increase more than the other goods, which point at income elasticity greater than one (or positive).

It was also observed by Greene, *et al* (1995) that as per capita income increases, people tend to travel more by private vehicle. That means automobile use often increases with the economic development (Litman, 2002). Dargay *et al* (2007) establishes the fact that the relationship between vehicle ownership and per capita income has been highly non-linear in many countries. Ewing *et al* (2001) also examines that there is direct and positive effect of per capita income on per capita vehicle miles travelled over several decades. Medlock and Soligo (2001) opine, the demand for vehicle stocks as a function of consumer's wealth.

Speaking of other variable, urbanisation, it is clearly indicated in the urban spatial economics that population growth, urbanisation along with economic development have been identified as factors influencing car ownership (Riley, 2002). Theories related to urbanisation, spatial interaction models (Krugman, 1991), theories of industrial location (Marshall, 1891) have tried to advocate that concentration of economic activity in a location brings economies of scale. Such economies of scale attract more industries to the location, making the place more attractive to employment. Such employment leads to increased income level of the location, which again cause the growth of vehicular population. Bayliss (1981) opine that growth in vehicular ownership is continuing hand-in-hand with rapid urbanisation. Button (1993) state that, an increase in vehicular ownership especially due to urbanisation coupled with employment opportunities have put high pressure on road traffic. Hence, it can be theoretically justified that, income, urbanisation and employment opportunities are closely linked with each other having a direct and positive impact on vehicular population.

On this theoretical background, the paper tries to find certain major empirical works. It is undeniable that, a comprehensive and high-performing transport is an important enabler of sustained economic prosperity (Eddington, 2006). Litman (2002) empirically proves that per capita automobile ownership peaked at about $21,000 annual income in US in 1998. This study also reveals that automobile ownership and income have Engel curve pattern. Similar kind of study was conducted by Button (1993) and Medlock *et al* (2002) who provided evidences that there is a S-shaped curve (Sigmoid curve) found between the income growth and vehicular population. This signifies that as income increases, the population of vehicles also increases at a high rate and at later stage, the vehicular ownership increases at a decreasing rate owing for Engle's Law.

At macro level, UK's Transport and Road Research Laboratory (1979) looked at car and commercial vehicles ownership for 85 developing countries using national data for 1970 and found a significant increase in the ownership pattern especially in certain European countries. A study by Dargay

et al (2007) analysed the per capita income and vehicle ownership data of 45 OECD & non-OECD countries and found that, both the variables are having Gompertz function curve which indicate a significant positive relationship between variables. Another work by Garcia *et al* (2008), who based their study in 15 areas of European Union and Eakins (2013), who used the data of Irish household survey between 1995 and 2008, found a strong and positive relationship between per capita income and trip generation.

From Indian perspective, there are few studies by Kumar and Krishna Rao (2006) who used stated and revealed preference survey for Mumbai household and proved that, car ownership rises with household income and determined by other factors like family size, home ownership and car prices. On similar line, Srinivasan *et al* (2007) found that the personal vehicle ownership rises with income, using Chennai household travel survey data. Apart from these, there is extensive Indian studies which mainly focused on determining the determinants of vehicle ownership (Shirgaokar *et al*, 2012; Padmini and Dhingra, 2013; Banerjee, 2010; Gopisetty and Srinivasan, 2013; Dash *et al*, 2013; Chamon *et al*, 2008) but few studies were available on establishing an empirical and econometric relationship between income and vehicular ownership. In this regard, the paper makes an effort to bring out such relationship and fill the research gap.

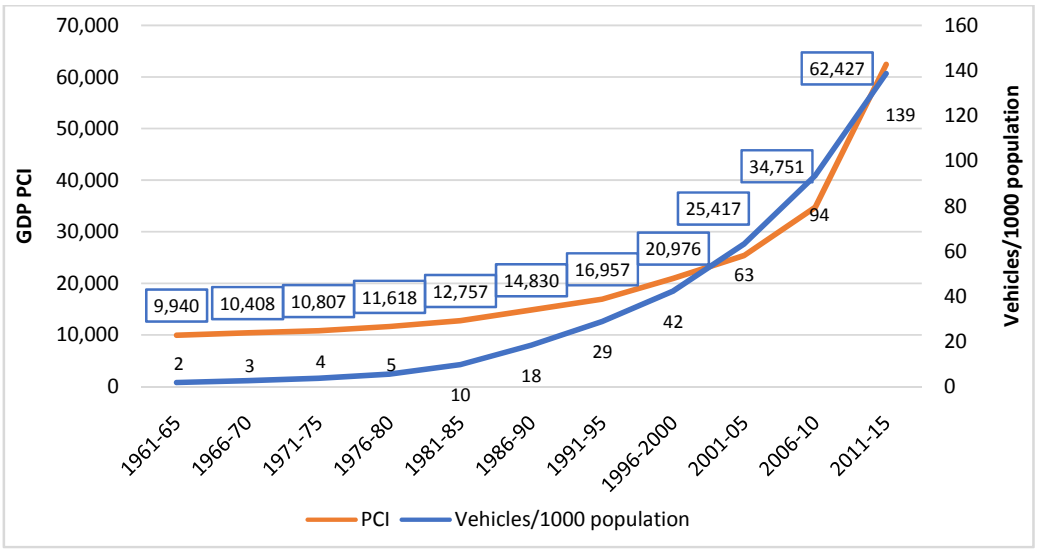
It is important to state certain empirical literature on the models used to study the relationship of these variables. Studies on modelling the relationship between income and vehicular use was pronounce in the literature. Several authors have attempted to understand the relationship between vehicles and income using various non-linear models. Dargay & Gately (1998) used Gompertz function, while Mogridge (1989) tried to adopt logistic growth curves to understand the relationship. Button *et al* (1993) used a quasi-logistic form to bring out the analysis. Studies based on time-series data and methodology was hardly found in the literature and hence, this paper makes an attempt to see the relationship among variable.

From the empirical literature, it can be inferred that, growth in income levels have a strong association with vehicular growth rates. This association needs to be analysed from the context of India which will help in understanding the problems due to traffic congestion and air pollution and finding a possible policy suggestion.

1.2. India's Economic Growth and Transport Sector

Research studies explain that the primary reason for rapid growth of vehicular population is directly attributed for economic development which in turn caused rapid urbanisation and better employment opportunities (Riley, 2002). To validate this explanation for India, the relationship between Per capita vehicles (vehicles per thousand populations) and per capita income of India for the period of 1961-2015 has been observed in Figure 1.

Figure 1: Per capita vehicles and per capita income (constant prices) in India for the Period 1961-2015

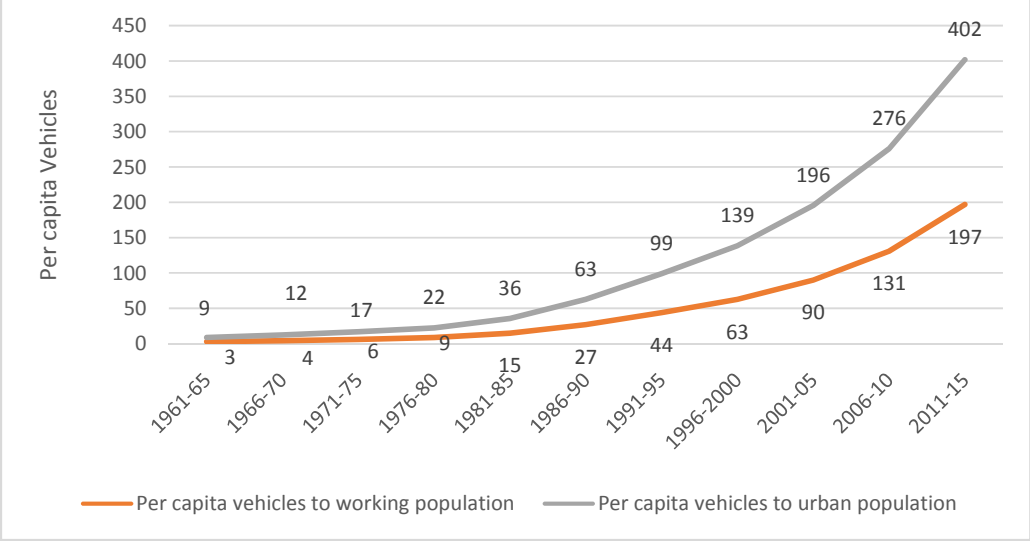


Source: Author's analysis based on MORTH & RBI data

The information in Figure 1 gives a very strong intuition that, the income and vehicular ownership are strongly correlated. The per capita average income which was Rs. 9940 in 1961-65 increased around seven times to Rs. 62,427 in 2011-15 showing an average of 5.69 percent of growth per annum. However, vehicles per thousand population, which was just two per 1000 persons in 1961-65 has increased by 69 times by 2011-15 showing an average of 11 percent growth per annum. A huge increase can be seen in the recent decade, which has been a matter of concern leading to severity of traffic congestion.

The paper also tried to bring out the relationship between the urbanisation and working age population growth. It is interesting to note that the total vehicular population in million plus cities accounted for nearly 30 percent of total vehicular population of the country. Figure 2, reveals the total number of vehicles in relation to the total urban population in the country. The per capita vehicles to urban population was nine vehicles per 1000 in 1960-65 and the same has increased to 402 vehicles per 1000 population in 2011-15, this has resulted in 44 percent increase in total vehicles due to urbanisation. Same kind of result is observed when we use the working age population data. Per capita vehicles for working age population was just three in 1961-65, which has increased to 197 vehicles per 1000 population in 2011-15, showing around 65 percent increase in total vehicles.

Figure 2: Total Vehicles and Urban population in India



Source: Author's analysis based on MORTH &World Bank data

From the analysis of different variables, it unfolds that there is a direct impact on the vehicular population of the country. Such graphical correlation, however, needs to be tested empirically using relevant econometric tools and the results of the same are discussed in Section II.

SECTION II

Time series Econometric Analysis of the relationship

2.1. Data and methodology

As the analysis is mainly on Indian economy at an aggregate level, time series econometric analysis will be used for empirical examination of the relationship among variables considering annual data series from 1961 to 2015. The variables for the analysis have been chosen based on theoretical and empirical background. Studies on modelling the relationship between vehicle ownership and income was theoretically more pronounce. Many studies have used Gompertz function, logistic and ARMA models (Wu *et al*, 2014), which mainly used panel or cross-sectional data. Since our model is using time-series data, it made an effort to adopt Autoregressive Distributed lag model (ARDL) for testing long-run relationship among different variables. For more explicit understanding, the paper tried to frame three models to capture the relationship in the long-run.

Variables included in the models are as follows:

-Dependent variable:

1. Total registered vehicles: The main purpose of the paper is to assess the impact of income, urbanisation and growth in working age population on growth of vehicles.

-Independent variables:

2. Per capita income (PCI) taken in 2011-12 series (Constant prices).
3. Gross Domestic Product (GDP) at factor cost is taken in 2011-12 series (Constant prices).
4. Total working age population: population above 18 years of age was considered to capture to see how working age influences vehicular growth.
5. Total urban population: This variable was taken to capture the urbanisation impact on vehicular ownership in the country.

The analysis will be done in three models to understand the relationship between the dependent and other different independent variables considering income i.e., GDP or PCI as common independent variable in three models.

Model 1: Vehicles=f (GDP, working age population)[3]

Model 2: Vehicles=f (PCI, urban population)

Model 3: Vehicles=f (PCI, working age population)

Since the model we are using is under time-series, before conducting co-integration test, it is important to know whether the variables are stationary or not. For that the variables are taken in log form to linearise the trend and tested for unit root test. The results are as follows:

Table 1: ADF Test Result

Variable	**I(0)**	**I(1)**
Lnvhcl	-1.02	-12.83*
Lngdp	3.90	-6.62*
Lnpci	-4.54	-6.05*
Lnwrkppl	-4.57*	--
lnurb	-3.10**	--

*Significant at 1% level; ** Significant at 5% level; *** Significant at 10% level

From the Table 1, it can be said that the variables are non-stationary at level i.e., I (0) but became stationary at first difference I (1)[4] except working age population and urban population which are stationary at level itself. Since the variables contain combination of I (0) and I (1) variables, we are justified to adopt autoregressive distributed lag (ARDL) model for establishing their long-run cointegration.

The long-run equation of models are as follows:

$$lnvhcl_t=\beta_0+\beta_1 lngdp+\beta_2 lnwrkppl+u_{t1} \quad \text{.....(1)}$$

$$lnvhcl_t=\alpha_0+\alpha_1 lnpci+\alpha_2 lnurb+u_{t2} \quad \text{.....(2)}$$

$$lnvhcl_t= \ _0+ \ _1 lnpci+ \ _2 lnwrkppl+u_{t3} \quad \text{.....(3)}$$

[3] When tested for GDP and urban population, the results have come negative and insignificant.

[4] The result is same with Philip-perron test also.

Traditional cointegration technique of Granger (1981), Engle and Granger (1987) or Johansen and Juselius cointegration cannot be applied here as the variables we are dealing with are in different order and further these methods have certain limitations. Superiority of ARDL lies in its identification of cointegrating vector (variables stands as a single long-run relation equation) even with different order of variables. ARDL model of cointegrating vector is reparametrised into Error Correction Mechanism (ECM).

The error correction model will be as follows for three models:

$$\Delta lnvhcl=a_{10}+a_{11}[lnvhcl_{t-1}-lngdp_{t-1}-lnwrkppl_{t-1}]+b_{11}\Delta lnvhcl_{t-i}+b_{12}\Delta lngdp_{t-i}+b_{13}\Delta lnwrkppl_{t-i}+\varepsilon 1t \quad ..(1a)$$

$$\Delta lnvhcl=a_{20}+a_{21}[lnvhcl_{t-1}-lnpci_{t-1}-lnurb_{t-1}]+b_{21}\Delta lnvhcl_{t-i}+b_{22}\Delta lnpci_{t-i}+b_{23}\Delta lnurb_{t-i}+\varepsilon 2t \quad ..(2a)$$

$$\Delta lnvhcl=a_{30}+a_{31}[lnvhcl_{t-1}-lnpci_{t-1}-lnwrkppl_{t-1}]+b_{31}\Delta lnvhcl_{t-i}+b_{32}\Delta lnpci_{t-i}+b_{33}\Delta lnwrkppl_{t-i}+\varepsilon 3t \quad ..(3a)$$

Coefficients $a_{11,}$ $a_{21,}$ a_{31} indicate the speed of adjustment to equilibrium and corresponding values in bracket is error correction term. This reparametrised result gives short run dynamics and long-run relationship of the variables (Nkaro and Uko 2016). The cointegration is tested through Bound test or Bound F statistics.

2.2. Result Discussion

The short and long-run results of the three models are given in Table 2. From the models, it can be seen that the variables under consideration have positive impact on total vehicles. To state, from model 1, it can be said that, 1% increase in GDP will increase the vehicular population by 1.03% whereas working age population increases by 6%. Around same kind of estimations are obtained by including per capita income in model 2. From model 3, it is said that, urbanisation has certain high impact on growth of vehicles by 12.84% and per capita income has 2.03%. Though the estimates look promising and are in-line with the theoretical and empirical understanding, the model needs to be examined with the diagnostic elements of the models (Appendix 1). From the tests, it is observed the R-square of the model is high and there is no serial correlation (LM test) and heteroskedasticity (BP test), which signifies the model is reliable.

Table 2: Short and long-term estimates of three models.

Long term estimates*

Model 1: lnvhcl=	-103.88+1.03lngdp+6.02lnwrkppl
	(-7.2) (5.24) (5.6)
Model 2: lnvhcl=	-129.99+1.67lnpci+5.39lnwrkppl
	(-11.51) (8.8) (11.73)
Model 3: lnvhcl=	-0.35+2.03lnpci+12.84lnurb
	(-2.42) (2.09) (3.3)

Short run estimates*

Lnvhcl=	-0.59 EC-0.60lnvhcl(-1)+0.62lngdp+2.69lnwrkppl-0.22Δlnvhcl(-1)-59.07C
	(-5.21) (-3.31) (2.58) (2.99) (-1.59) (-3.10)
Lnvhcl=	-0.59EC-0.75lnvhcl(-1)+1.27lnpci(-1)+4.50lnwrkppl(-1)-0.12Δlnvhcl(-1)-
	(-5.18) (-3.6) (2.9) (3.5) (-0.7)
	1.10Δlnpci +0.60Δlnpci(-1)+27.3Δlnwrkppl-1.77Δlnwrkppl(-1)-98.62C
	(0.06) (0.38) (1.60) (-0.10) (-3.48)
Lnvhcl=	-1.04EC-1.04lnvhcl(-1)+2.12lnpci(-1)+13.38lnurb(-1)+0.02Δlnpci+35.22Δlnurb
	(-7.08) (-6.78) (1.95) (2.87) (0.017) (0.77)
	-90.33Δlnurb(-1)+33.76Δlnurb(-2)-258.4C
	(-1.52) (0.95) (-2.74)

*t-values are in brackets

The short-run error correction (EC) term in all the three models is negative and significant, which indicate that there is cointegration among the variables. In model 1 and 2, around 60 percent of the disequilibrium is corrected in the year, whereas in model 3, it takes a year to correct the disequilibrium.

ARDL model cointegration needs verification from Bound-F statistics. The computed F-statistics of three models are lying upper critical bound I (1) values according to Pesaran and Pesaran (1996) & Pesaran *et al*, (2001) which confirms that the variables have long-run relationships.

Table 3: Bound F-statistics[5]

Model	Bound F Statistics
1	6.85
2	6.80
3	11.76

Source: From analysis

From the above analysis, it is empirically proved that, the major contributors of the vehicular growth are income, working age population and urbanisation. Apart from these variables which have been analysed, there are other related factors too which contribute to the huge increase in vehicular population in the country[6]. Some of them are:

- *Availability of finance*: The automobile loan has grown substantially from Rs.517 billion to Rs. 1,284 billion during 2008 to 2014, showing an annual average growth rate of 16.6 percent. Among this, 75 percent of cars and 40 percent of 2 wheelers in the country is bought from loan (Arora *et al, 2013*). The innovative schemes by the financial institutions have been implemented to attract consumers to opt for more personal vehicles.
- The *relaxation on import duty*, allowing second hand purchasing of vehicles, giving tax holidays and other incentives developed a system of private vehicle ownership.

[5] For bound values refer Pesaran and Pesaran (1996) & Pesaran et al, (2001)

[6] these factors cannot be used for analysis due to lack of time series data

- The *inadequate public transport* has fuelled the motor vehicle ownership. In the total vehicle population, the growth rate of buses is less than one percent leading to a shift towards personal vehicles.
- Lack of public transport has *increased other modes of transport* like autos, cabs etc. which are creating more pressure on road network. Innovations in transport system like easy accessibility, technology in accessing cabs have increased the demand for them, which simultaneously has increased the number of cabs and autos on road.
- *Innovation in automobile industry*, especially in personal vehicles has decreased the cost of operating the vehicles which have increased the demand for it.

The issue becomes intense when the forecasted values are observed. According to TERI estimation (2009), the on-road vehicles in India may reach up to 315 million by 2030 and ADB (2006) estimates that there will be around 373 million vehicles by 2035. These figures call for the immediate attention by the policy makers as other contributing factors of the transport sector (like road system, traffic management system) is not improving to meet the demand which may create other negative externalities in the country. The next section examines situation in which the growth of income and vehicles is not supported by infrastructure availability.

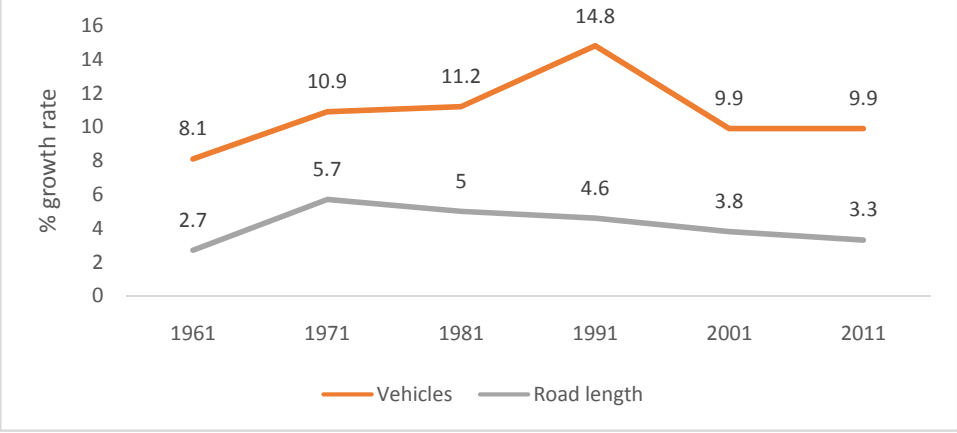
SECTION III

Vehicular Growth and Its Impact

3.1. Vehicular Growth and Road Length

Movement of vehicles on road signifies the economic importance of the place (Taylor, 2000) but, such movement should be supported by better infrastructure. If road capacity, traffic management system or any technology related to transportation, is improving proportional to the growth of vehicles, then the problem of congestion would have never become severe. But, considering the case of India, the road capacity may not be in tune with the vehicular growth.

Figure 4: Growth Rate of Vehicles and Road Length in India



Source: RTO India, MoRTH 1961-2011

The road density[7] in India has increased from 3.28 kms in 2001 to 3.94 kms in 2011 which is increasing at the compound annual growth rate of 3.8 percent (MoRTH, 2011) whereas vehicles are increasing at the rate of 10 percent per annum during 1961-2011 creating huge infrastructure gap. The urban road length situation is still worst. From Table 4, it can be stated that, the urban road length increased 3.35 times from 1981-2011, whereas vehicles increased by 26 times during the same period

Table 4: Decade-wise Urban Road Length (in kms)

Road Length and Vehicles	1971	1981	1991	2001	2011
Urban road length (kms)	72120	123120	180799	252001	411840
Registered vehicles (million)	1.9	5.7	21.4	55	141.9
Road space for vehicles (in kms per vehicle)	0.18	0.1	0.03	0.02	0.01

Source: MoRTH 2013

The intensity of traffic congestion is very evident in urban areas, due to phenomenal growth of vehicles and a meagre increase in the road length. From Table 4, it is evident that, the road space available for the vehicles is decreasing at an increasing rate i.e., from 0.18 kms per vehicle to 0.01 km from 1971 to 2011, which has created huge pressure on road.

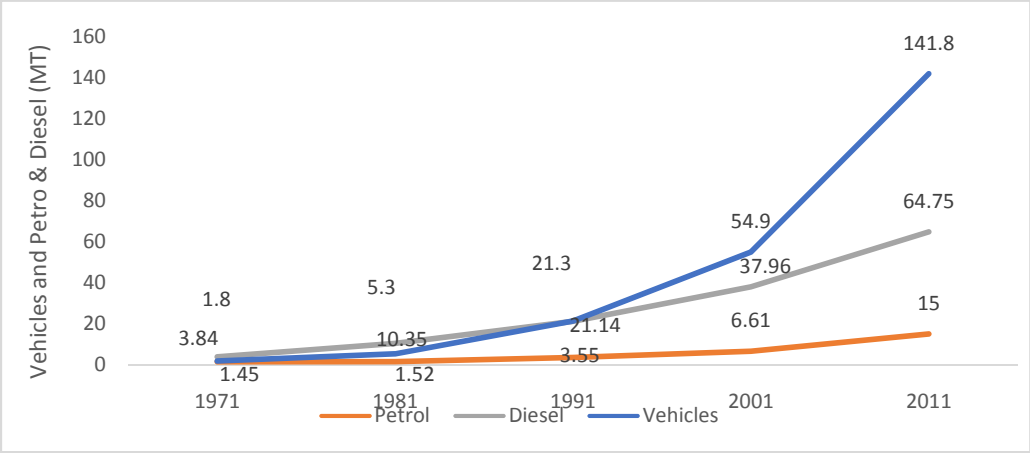
On the other side of the story, there are environmental concerns which are at stake due to such high growth of vehicular population in urban areas. The following section provides a glimpse about fuel consumption and air pollution scenario of the country, which are generally linked to growing income which again leads to increased demand for vehicles.

3.2. Transport and Fuel Consumption

The transport sector depends on different sectors of the economy, one such sector is energy. India stands 4th in the ranking of highest consumer of energy of the world and the main sector which is consuming major share of India's energy can be pointed to transport sector. Being the major sector, it accounts for nearly 18 percent of the total energy consumed in India, second only to industry. Among the different types of vehicles, two-wheelers consume 61.42 percent of the end-use share (retail) of petrol; cars consume 30 percent (PPAC, 2013). The petrol consumption grew at the rate of 8.97 percent whereas diesel at 8.06 percent between 2001-2013. This is largely due to growth of personal vehicles in the country. The details of trend in vehicular growth, petrol and diesel consumption in India is given in Figure 5.

[7] Road density is the average road per 1000 population

Figure 5: Petrol and Diesel Consumption by vehicles in India (in million tonnes)



Source: PPAC & MOSPI 2011

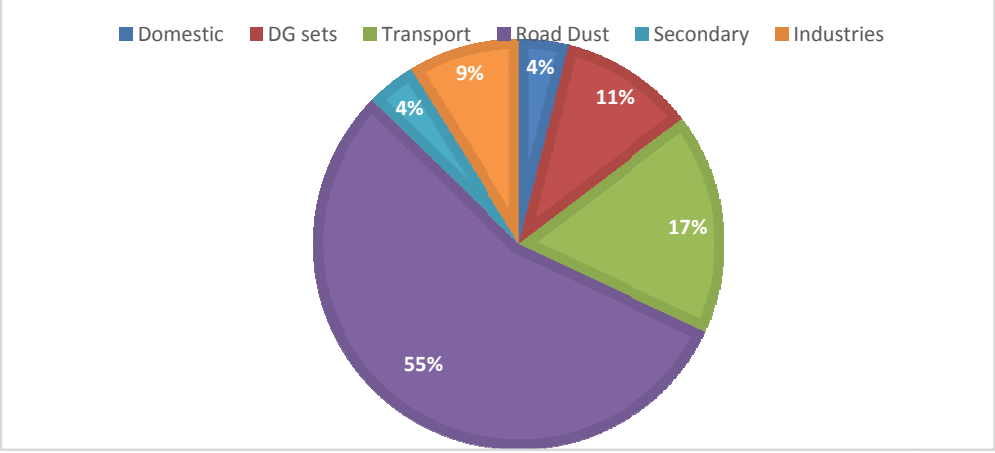
From Figure 5, it can be summerised that the vehicular growth and demand for energy (petrol and diesel) are strongly co-related. For reducing this dependency, TERI (2009) has estimated that, there will be an 18 percent reduction in motor fuel demand, if buses are able to meet 70 percent of the total passenger travel demand by 2030.

3.3. Vehiclular Growth and Air Pollution

One of the major source of air pollution, particularly in the form of particulate matter (PM), is vehicular emissions. According to WHO (2008) estimates 600,000 people die prematurely each year in the world from diseases directly related to air pollution. The Global Burden of Disease (WHO, 2011) report listed ambient air pollution as the 6th important cause of death in South Asia. A study supported by WHO estimated about 154,000 people died in India in 2005 as a result of ambient fine particulate matter ($PM_{2.5}$) (NTDPC, 2014). Traffic-related air pollution leads to cardiovascular morbidity, asthma incidence and other resiratory illness in childern. According to World Bank study (2013), in India, outdoor air pollution accounts for 29 percent, which causes premature deaths of 109,000 adults each year. The study reveals an alarming fact that, the health cost of air pollution is about three percent of GDP in 2013 which is due to vehicular activities.

From the above analysis, it can be said that the transport sector is the major contributor to air pollution in the country. But among different modes in the transport sector, roadway transportation is the major cause of CO_2 emission in India. From the transport sector, the average emission of CO_2 was estimated to be 14 percent during 1971-2013 (World Bank, 2013). Among total emission by transport sector (142 MT of CO_2) road sector alone contributed 87 percent of emission in 2011 (MoEF, 2011). In 2011, Central Pollution Control Board (CPCB), Ministry of Enviornment and Forest jointly conducted a study on modelling particulate pollution in the country. The study reveals the following results:

Figure 6: Sources of Particulate pollution in India in 2011



Source: CPCB, 2011

The study revealed the fact that the transport and road dust contribute nearly 70 percent of particulate pollution in India (2011). Hence, problem of vehicular growth not only has impact on the economic activities of the country, but also has a major impact on the environment.

SECTION IV

Conclusion

The paper made an effort to provide a statistically significant evidence for the relationship between income and vehicular growth. By considering other relevant variables like urbanisation and employment under ARDL approach, the paper proves the long-run relationship which exists among the variables. This relationship, further, proved to create certain negative externalities in the form of heavy pressure on road from vehicles (traffic congestion), deterioration of air quality and so on. Though the primary objective of the paper is to see the long-run cointegration, the paper also made an effort to bring out the environmental concerns like increasing fuel consumption and how road transport sector is a major contributor to air quality deterioration. Though the government has taken necessary steps in connection with fuel quality improvement (Bharath IV) which has led to decrease in CO2 emission by transport sector, contrary to such measure, the air quality is still affected by particulate matter.

An important aspect which is bought out in the paper is, though the economic development indicators like income, standard of living, employment, urbanisation, vehicular growth picturise the positive side of the development, such development is happening at a cost of environment and health issues. The paper clearly bought out the growing demand for fuel and increasing emission of particulate matter has created environmental hazard for health of the people in the country. This kind of situation is more rampant in metropolitan cities of the states. Hence, the paper brings to the notice that, increase in income has positive impact on vehicular ownership, more so in personal vehicles. To curb this behaviour, the country needs more investment diverted towards providing better and cheap public transport facility, making it more attractive.

Reference

Alonso, W (1964). *Location and Land Use*. Boston, MA: Harvard University Press.

Arora, *et al* (2013). *Banks Growth: Auto Loan Growth-Why So High?* Conundrum, 13.

Asian Development Bank (ADB) (2006). *Energy Efficiency and Climate Change Considerations for On-road Transport in Asia*. Manila: Asian Development Bank.

Banerjee, Walker J L, E Deakin and A Kanafani (2010). *Vehicle choice in India: Household Choice among Motorised Vehicle Segment*. In proceedings of 12th World Conference on Transport Research, Lisbon, Portugal.

Bayliss, D (1981). One Billion New City Dweller-How Will they Travel. *Transportation,* 10: 314-43.

Brownstone, *et al* (1997). A Vehicle Se Forecasting Model Based on Revealed and Stated Vehicle Type Choice and Utilisation Data. *Journal of Transport Economic and Policy*.

Button, K (1993). Modelling Vehicle Ownership and Use in Low Income Countries. *Journal of Transport Economics and Policy*, 27 (1): 51-67.

Central Pollution Control Board and Ministry of Environment & Forests (2010). *Status of the Vehicular Pollution Control Programme in India*. CPCB and MoEF, GOI

———— (2011). *Air Quality Monitoring, Emission Inventory and Source Apportionment Study for Indian Cities*. CPCB and MoEF, GOI.

Central Pollution Control Board (2008-2013). *Annual Reports on Air Pollution*. CPCB.

Chamon, P Mauro and Y Okawa (2008). Mass car Ownership in the Emerging Market Giants. *Economic Policy*, 23 (54): 243-96.

Dargey, J *et al* (2007). Vehicle Ownership and Income Growth Worldwide: 1960-2030. *The Energy Journal by International Association for Energy Economics*, 28 (4): 143-70.

Dash, Vasudevan V and S K Sing (2013). Disaggregate Model for Vehicle Ownership Behaviour of Indian Households. *Transportation Research Record*, 2394: 55-62.

Eakins, J (2013). The Determinants of Household Car Ownership: Empirical Evident from the Irish Household Budget Survey. *SEEDS*.

Eddington, Rod (2006). *The Eddington Transport Study: The Case for Action*. UK: House of Commons.

Elinzondo and Krugman (1992). Trade Policy and Third World Metropolis. *Journal of Development Economics,* 49: 137-50.

Engle, R and C W J Granger (1987). Cointegration and Error Correction: Representation, Estimation and Testing. *Econometrica*, 55: 252-76.

Ewing, R and R Carverao (2010). Travel and the Build Environment: A Meta-analysis. *Journal of the American Planning Association,* 76 (3): 265-94.

Gopisetty and Srinivasan (2013). Joint Model for Analysis of Household Trip Frequency and Vehicle Ownership in Chennai City. *International Journal of Advances in Engineering and Applied Mathematics*, 5 (2-3): 129-44.

Government of India (2001 & 2011). *Census of India 2001 & 2011*. GOI.

Gracia, C *et al* (2008). *Correlation between Transport Intensity and GDP in European Region: A New Approach*. Conference Paper, 8th Swiss Transport Research Conference, Monte Verita.

International Organisation for Motor Vehicle Manufacturers (2014). *Data on Vehicle-in Use in the World*. IOMVM. Data accessed from: *http://www.oica.net/category/vehicles-in-use/*.

Kumar and Krishna Rao (2006). A Stated Preference Study for Car Ownership Model in the Context of Developing Countries. *Transportation Planning and Technology*, 29 (5): 409-25.

Lancaster Kevin (1966). A New Approach to Consumer Theory. *Journal of Political Economy*, 72 (2): 132-57.

Litman Todd and Felix Laube (2002). *Automobile Dependency and Economic Development*. Victoria Transport Policy Institute.

Marshall, A (1890). *Principles of Economics*. London: Macmillan.

Medlock, B *et al* (2002). Car Ownership and Economic Development with Forecast to Year 2015. *Journal of Transport Economics and Policy,* 36 (2): 163-88.

Medlock B Kenneth and Ronald Soligo (2001). Economic Development and End-use Energy Demand. *The Energy Journal*, 22 (2): 77-105. Accessed: 05-08-2017.

MoEF - Ministry of Environment and Forests (2010). *India: Green House Gas Emissions*. New Delhi: MoEF, GOI.

MoRTH- Ministry of Road Transport and Highways (2014). *Basic Road Transport Statistics*. New Delhi: MoRTH, GOI.

———— (2014). *Road Transport Year Book 2012-13*. New Delhi: Transport Research Wing, MoRTH, GOI.

National Transport Development Planning Commission (2013). *India Transport Report: Moving India 2032*. NTDPC: GOI.

Padmini and Dhingra (2013). *Development of Behavioural Model of Travel for Metropolitan Areas*. In Proceedings of 12th World Conference on Transport Research, Lisbon, Portugal.

Pesaran and Y Shin (1996). An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. In Strom, S, A Holly and P Diamond (eds), *Centennial Volume of Rangar Frisch*. Cambridge: Cambridge University Press.

Pesaran, R J Smith and Y Shin (2001). Bounds Testing Approaches to the Analysis of Level Relationships. *Journal of Applied Econometrics*, 16: 289-326.

Petroleum Planning and Analysis Cell (2013). Report on *All India Study on Sectoral Demand of Diesel and Petrol*. PPAC, GOI

Riley, K (2002). Motor Vehicles in China: The Impact of Demographic and Economic Changes. *Population and Environment,* 23 (5): 479-94.

Shringaokar, E Deakin, R Cervero and J Walker (2012). The Rapid Rise of Middle Class Vehicle Ownership in Mumbai. University of California Transportation Centre Report (UCTC-DISS-2012-01).

Srinivasan, Lakshmi Bhargavi P V, G Ramadurai, V Muthuram and S Srinivasan (2007). Determinants of Changes in Mobility and Travel Pattern in Developing Country: Case Study of Chennai, India. *Transportation Research Record*, 2038: 42-52.

The Energy and Resource Institute (2009). *Transport System in a Low Carbon Society: Results of the Regional Study of India*. New Delhi: TERI.

The Energy and Resource Institute (2010). *Air Quality Assessment, Emission Inventory & Source Apportionment Study of Bangalore City*. New Delhi: TERI

———— (2014). *Energy Data Yearbook and Directory 2012-13*. New Delhi: TERI

Transport and Road Research Laboratory (1979). *Investigations into Vehicle Ownership in Developing Countries*. Department of the Environment Department of Transport TRRL Leaflet LF758. Transport and Road Research Laboratory, Crowthorne.

Transport Committee (2010-11). *Transport and the Economy*. UK: The House of Commons. Vol 1.

Transport Corporation of India & Indian Institute of Management (2012). *Operational Efficient of National Highways and Freight Transport in India (2011-12).* A Joint Study Report by TCI and IIM Calcutta. 3rd Edt. TCI

Verhoef, T Erik, Lindsey and Robin (2001). Traffic Congestion and Congestion Pricing. In Button, K J and D A Hensher (ed), *Handbook of Transport Systems and Traffic Control*, Vol 3. Amsterdam; London and New York: Elsevier Science, Pergamon. Pp 77–105..

World Bank Report (2013). *Diagnostic Assessment of Select Environmental Challenges in India: An Assessment of Physical and Monetary Losses of Environmental Health and Natural Resources*. Vol I. World Bank

World Health Organisation (2011). Top 100 Cities with the Worst Air Quality in the World. *Urban Emissions*. Accessed from the website http://urbanemissions.blogspot.com/2013. WHO.

Wu, *et al* (2014). Vehicle Ownership Analysis Based on GDP per capita in China: 1963-2050. *Sustainability,* 6: 4877-99.

Zipf, G K (1949). *Human Behaviour and the Principle of Least Effort*. Addison Weasley, Cambridge, Mass.

Appendix 1: Diagnostic Test Result

Model	R-squared	Durbin-Watson	LM test	BP test
1	0.972	2.0	2.68 (0.26)	1.89 (0.75)
2	0.975	2.0	2.56 (0.27)	1.95 (0.74)
3	0.971	1.95	0.19 (0.90)	1.72 (0.62)

Recent Working Papers

375 Quantifying the Effect of Non-Tariff Measures and Food Safety Standards on India's Fish and Fishery Products' Exports
Veena Renjini K K

376 PPP Infrastructure Finance: An Empirical Evidence from India
Nagesha G and K Gayithri

377 Contributory Pension Schemes for the Poor: Issues and Ways Forward
D Rajasekhar, Santosh Kesavan and R Manjula

378 Federalism and the Formation of States in India
Susant Kumar Naik and V Anil Kumar

379 Ill-Health Experience of Women: A Gender Perspective
Annapuranam Karuppannan

380 The Political Historiography of Modern Gujarat
Tannen Neil Lincoln

381 Growth Effects of Economic Globalization: A Cross-Country Analysis
Sovna Mohanty

382 Trade Potential of the Fishery Sector: Evidence from India
Veena Renjini K K

383 Toilet Access among the Urban Poor – Challenges and Concerns in Bengaluru City Slums
S Manasi and N Latha

384 Usage of Land and Labour under Shifting Cultivation in Manipur
Marchang Reimeingam

385 State Intervention: A Gift or Threat to India's Sugarcane Sector?
Abnave Vikas B and M Devendra Babu

386 Structural Change and Labour Productivity Growth in India: Role of Informal Workers
Rosa Abraham

387 Electricity Consumption and Economic Growth in Karnataka
Laxmi Rajkumari and K Gayithri

388 Augmenting Small Farmers' Income through Rural Non-farm Sector: Role of Information and Institutions
Meenakshi Rajeev and Manojit Bhattacharjee

389 Livelihoods, Conservation and Forest Rights Act in a National Park: An Oxymoron?
Subhashree Banerjee and Syed Ajmal Pasha

390 Womanhood Beyond Motherhood: Exploring Experiences of Voluntary Childless Women
Chandni Bhambhani and Anand Inbanathan

391 Economic Globalization and Income Inequality: Cross-country Empirical Evidence
Sovna Mohanty

392 Cultural Dimension of Women's Health across Social Groups in Chennai
Annapuranam K and Anand Inbanathan

393 Earnings and Investment Differentials between Migrants and Natives: A Study of Street Vendors in Bengaluru City
Channamma Kambara and Indrajit Bairagya

394 'Caste' Among Muslims: Ethnographic Account from a Karnataka Village
Sobin George and Shrinidhi Adiga

395 Is Decentralisation Promoting or Hindering the Effective Implementation of MGNREGS? The Evidence from Karnataka
D Rajasekhar, Salim Lakha and R Manjula

396 Efficiency of Indian Fertilizer Firms: A Stochastic Frontier Approach
Soumita Khan

397 Politics in the State of Telangana: Identity, Representation and Democracy
Anil Kumar Vaddiraju

398 India's Plantation Labour Act - A Critique
Malini L Tantri

399 Federalism and the Formation of States in India: Some Evidence from Hyderabad-Karnataka Region and Telangana State
Susant Kumar Naik

400 Locating Armed Forces (Special Powers) Act, 1958 in the Federal Structure: An Analysis of Its Application in Manipur and Tripura
Rajiv Tewari

401 Performance of Power Sector in Karnataka in the Context of Power Sector Reforms
Laxmi Rajkumari and K Gayithri

402 Are Elections to Grama Panchayats Party-less? The Evidence from Karnataka
D Rajasekhar, M Devendra Babu and R Manjula

403 Hannah Arendt and Modernity: Revisiting the Work *The Human Condition*
Anil Kumar Vaddiraju

404 From E-Governance to Digitisation: Some Reflections and Concerns
Anil Kumar Vaddiraju and S Manasi

405 Understanding the Disparity in Financial Inclusion across Indian States: A Comprehensive Index for the Period 1984 – 2016
Shika Saravanabhavan

406 Gender Relations in the Context of Women's Health in Chennai
Annapuranam K and Anand Inbanathan

407 Value of Statistical Life in India: A Hedonic Wage Approach
Agamoni Majumder and S Madheswaran

408 World Bank's Reformed Model of Development in Karnataka
Amitabha Sarkar

409 Environmental Fiscal Instruments: A Few International Experiences
Rajat Verma and K Gayithri

410 An Evaluation of Input-specific Technical Efficiency of Indian Fertilizer Firms
Soumita Khan

411 Mapping Institutions for Assessing Groundwater Scenario in West Bengal, India
Madhavi Marwah

412 Participation of Rural Households in Farm, Non-Farm and Pluri-Activity: Evidence from India
S Subramanian

Price: ₹ 30.00 ISBN 978-81-7791-295-1

INSTITUTE FOR SOCIAL AND ECONOMIC CHANGE
(ISEC is an ICSSR Research Institute, Government of India and the Grant-in-Aid Institute, Government of Karnataka)
Dr V K R V Rao Road, Nagarabhavi P.O., Bangalore - 560 072, India
Phone: 0091-80-23215468, 23215519, 23215592; Fax: 0091-80-23217008
E-mail: manjunath@isec.ac.in; Web: www.isec.ac.in