Cointegration analysis of Income and Vehicular Growth in India: An ARDL Approach

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Abstract

India is one among the fastest growing economies in the world with on an average growth rate of 8 per cent of Gross Domestic Product in the last decade. It is observed that such high growth rate of GDP significantly influenced personal income growth and the vehicular growth in India, particularly personal mode of transport. Hence, there is a need for the study to analyse the pattern of income growth influencing the extent of vehicular growth in India during 1960-2015. This paper tries to analyse this relationship by compiling time-series data of registered vehicles and growth of income in this period and other relevant variables. The autoregressive distributive lag model (ARDL) used for the analysis proved that there is a long run relationship among the variables under consideration. The analysis both theoretically and empirically proves that these variables are strongly correlated which implies that economic growth spurred the personalised vehicular growth or ownership which indicates economic welfare of the city dwellers. However, the welfare does not come without any cost i.e., growth led to emergence of negative externalities like terrific traffic congestion and severe air pollution which crippled the societal welfare and overall development in major Indian cities. World Bank estimates show that three percent of GDP is lost due to air pollution in India which is commonly attributed to the vehicular emission.

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

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Introduction:

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 personalised income growth. There is a strong one to one relationship among growth of 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 (2010) estimates show that approximately 51.4 percent of world population resides in cities contributing around 60 percent of world's GDP. The same pattern of growth in GDP, 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 about 70 percent by 2030 indicating rapid urbanization. These cities are home to around 31 percent of total population (GOI, 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 which 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.

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 transport sector to the total GDP is stood at 4.8 percent this implies that road transport is the major contributor of about 3.1 percent, whereas, the railways contributes merely 0.9 percent and remaining 0.8 per cent by other modes of transport in 2013-14 (TERI, 2014). Among different modes, rail and road shares 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).

In this backdrop, the present paper makes an attempt to study the long-term relationship between income and vehicular growth and also traffic congestion and air pollution at macro level with the use of secondary data. The growth of income is influenced by the working age population (employment) and vehicular traffic is directly linked to rapid urbanisation.

The paper is organised in three 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 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 vehicular ownership per 1000 population.

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 surrounds around 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. Nevertheless, 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 it route of the 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 is having positive elasticity of demand (Income elasticity) and most of the time 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 was usually referred as Engle's curve (Kasztalska, 2017) indicating as income increases, demand for luxury goods increase more than the other goods, which indicate of being 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 the fact that there is direct and positive effect of per-capita income on per-capita VMT over several decades. Medlock and Soligo (2001) opine that the demand for vehicle stocks as a function of consumer's wealth.

Speaking of our other variable, urbanisation, it is clearly indicated in the urban spatial economics, that population growth, urbanization along with economic development have also 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 (Urbanisation) 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, such increase in vehicular ownership especially due to urbanisation coupled with employment opportunities has put high pressure on road traffic. Hence, it can be theoretically justified that, income, urbanisation and employment are closely linked with each other having direct and positive impact on vehicular population.

Empirical evidences

It is held in the literature that, a comprehensive and high performing transport is an important enabler of sustained economic prosperity (Eddington, 2006). Litman (2002) empirically study that per capita automobile ownership peaked at about $21,000 annual income in US in 1998. The study also reveals the fact that automobile ownership and income have Engel curve pattern. Similar kind of study is conducted by Button (1993) and Medlock et.al. (2002) reveals that there is 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, but after reaching to the point of inflexion, the growth of vehicles slows down as compared to income.

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, indicate a significant relationship between both the 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.

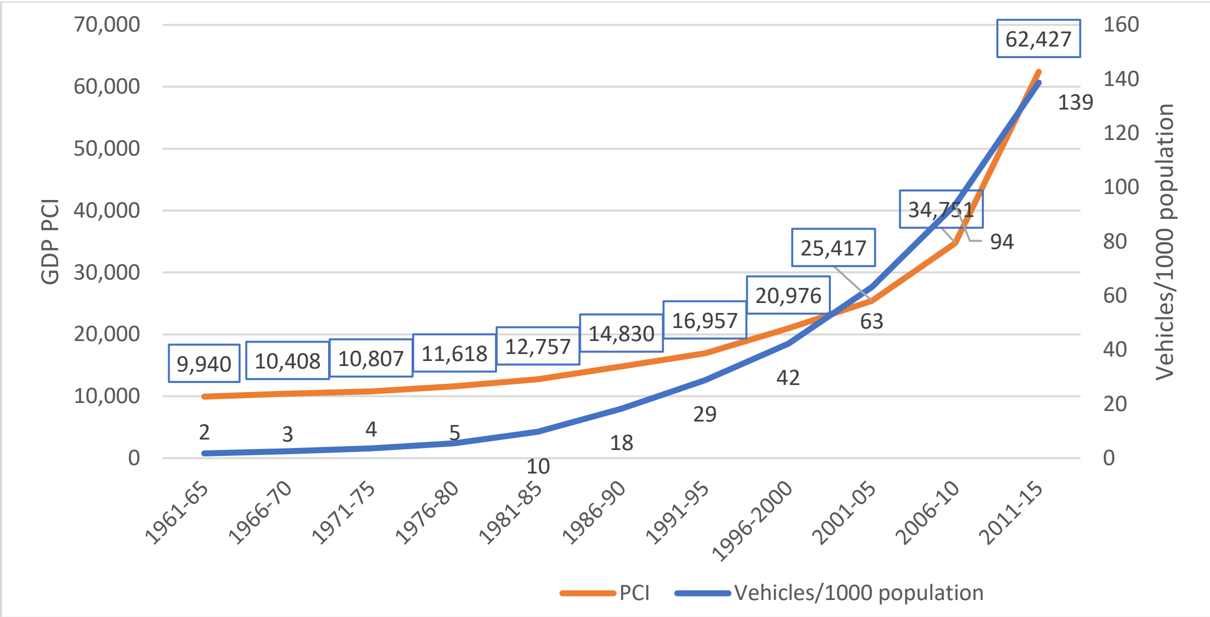
It is important to state certain empirical literature on the models used to study the relationship of these variables. Studies on modelling the relationship between income and vehicular use was pronounce in the literature. Several authors have attempted to understand the relationship between vehicles 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.

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 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 experience shows 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). That means to say that, there is positive impact of income on the vehicular ownership which can be observed from figure 1.

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

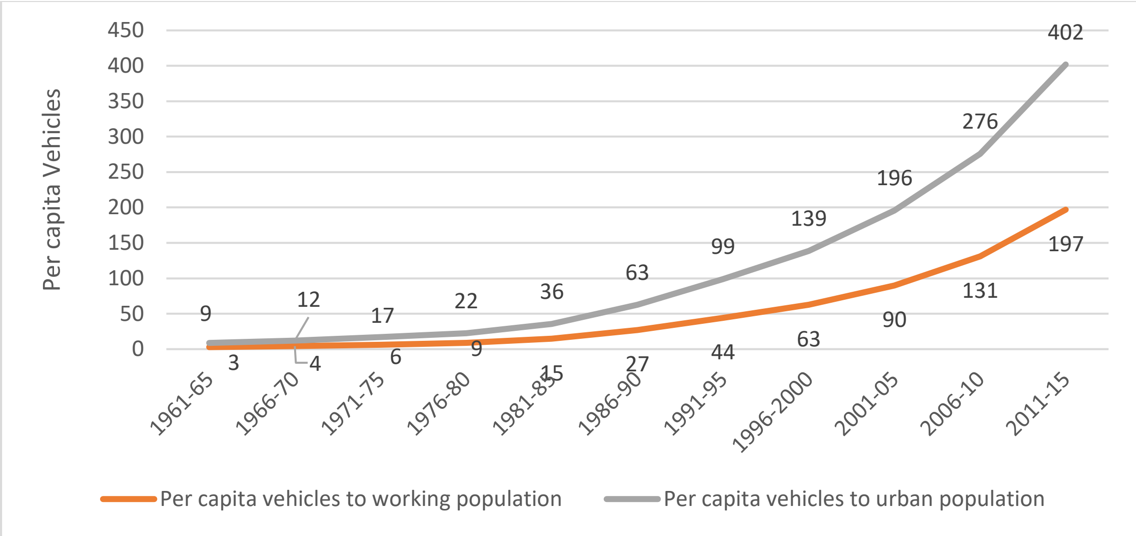


Source: Author's analysis based on MORTH & RBI data

From the above figure, the analysis gives a very strong intuition that, the income and vehicular ownership are correlated. The per capita income which was Rs. 9940 in 1961-65 increased around seven times to Rs. 62,427 in 2011-15 showing around 5.69 percent of growth however, vehicle per thousand population was just two per 1000 persons in 1961-65 has increased by 69 times by 2011-15 showing around 11 percent growth, 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 nearly 30 percent of total vehicular population of the country. In the figure 2, we have considered the total vehicles in relation with total urban population in the country. The per capita vehicles to urban population was nine vehicles per 1000 urban persons in 1960-65 has increased to 402 vehicles per 1000 urban population in 2011-15, which is showing 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 per 1000 working age population was just three in 1960-65, which has increased to 197 vehicles per 1000 working age population in 2011-15, showing around 65 percent increase in total vehicles. Such analysis is detailed in figure 2 below:

Figure 2: Total Vehicles, working age population and Urban population in India



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

From the analysis of different variables, it is indeed true that there is direct impact on the vehicular population of the country, but such graphical correlation needs to be tested empirically using certain econometric analysis, which will be discussed in the following section.

SECTION II

Time series Econometric Analysis of the relationship

2.1 Data and methodology

The variables for the analysis have been chosen based on theoretical and empirical background. Marshall (1890) state that there is positive impact of industrial location on urbanisation by increasing the employment opportunities and income, which has positive impact on vehicle purchase. Studies on modelling the relationship between vehicle ownership and income was theoretically more pronounce. The study uses the data on variables like per capita income (*PCI)*, vehicular population (*vhcl*), urbanisation (*urban*) and employment (*work*). The period of analysis is from 1961-2015 which annual data series are. Many studies have used Gompertz function, logistic and ARMA models (Wu *et al*., 2014), which mainly used panel or cross-sectional data.

2.2 Rationale behind the model and variables (Specification of model)

To analyse the relationship between income and vehicular ownership, the paper has considered four variables: per capita income, vehicular population, urbanisation and employment. Description and sources of each variable is given in table 1:

Table 1: Description and sources of variables under study

Variables	Type of variable	Description	Source

Vehicles (vhcl)	Dependent	Total registered vehicles	MoRTH 2016
Private vehicles (Pvhcl)	Dependent	Total registered private vehicles (Car, Two-wheelers, Jeeps)	MoRTH 2016
Per capita income (PCI)	Independent	GDP per capita at constant prices (2011-12)	RBI
Urbanisation (urban)	Independent	Urban population	World Bank
Employment (work)	Independent	Working age population[2]	World Bank

The main objective of the paper is to see the relationship among the variables and find the impact of income and other variables on the dependent variables (vehicles purchase). For this purpose, the paper considered two models (since there are two dependent variables).

Model 1: Vehicles=f (PCI, working age population)

Model 2: Private Vehicles=f (working population, urban population)

The rationale for the two models is to observe the impact of independent variable on total vehicles and private vehicles separately.

2.3 Econometric Analysis

We specify the following equations in regression form to know the impact of income, urbanisation and growth working population on vehicular ownership:

$$Ln(vhcl_t)=\beta_0+\beta_1 ln(pci)+\beta_2 ln(work)+u_{t1} \qquad \text{.......(1)}$$

$$Ln(pvhcl_t)=\alpha_0+\alpha_1 ln(work)+\alpha_2 ln(urban)+u_{t2} \qquad \text{.......(2)}$$

Where $vhcl_t$, $pvhcl_t$, pci, work and urban represent total registered vehicles, private vehicles, per capita income, working population and urbanisation. Ln represents the natural log form of the series to linearize the trend. Parameters β_1, β_2, α_1, and α_2 are long run elasticities of vehicles and private vehicles with respect to pci, work and work and urbanisation respectively.

A time dummy, namely dummy 1991 is used in the analysis exogenously to control for any structural effect if it exists[3]. The year 1991 is a significant in Indian economic history as the

[2] Since employment data is not available in time series, we have included working age population.

[3] Properly specified dummy do not affect asymptotic null distribution (Luktepohl, 2004)

major economic reforms were introduced which has significant impact on income and purchasing trends of Indian consumers.

A summary descriptive statistics of the variables used in the model is provided in Table 2.

Table 2: Descriptive Statistics

(In Rupees million)

	WORK	VHCL	URBAN	PVHCL	PCI
Mean	5.71E+08	3740.375	2.21E+08	3260.268	32420.87
Median	6.04E+08	1940.000	2.06E+08	1625.000	23675.12
Maximum	6.94E+08	22954.00	4.29E+08	17501.00	88706.00
Minimum	3.44E+08	43.00000	80564904	24.00000	15585.38
Std. Dev.	1.15E+08	5105.651	1.05E+08	4499.480	19696.89
Skewness	-0.467397	1.842585	0.381697	1.704652	1.349745
Kurtosis	1.765000	6.050548	1.926915	5.001420	3.742098

Data Source: RBI, World Bank, MoRTH.

To test for long run relationship most popular methods used are Engle and Granger (1987) test, Johansen-Juselius (1990) tests. These methods condition that, the variables in the model should be stationary at first difference i.e. I (1). Hence, the said model needs to be tested for stationarity to continue the further analysis. For this unit root test is conducted using Augmented Dickey Fuller (ADF) and Philip Perron (PP) tests for all the variables and the results are given in table 2.

Table 3: Unit root test result

Variable	ADF	Result	PP	Result
Lnvhcl	-12.8*	I (1)	-13.9*	I (1)
Lnpvhcl	-13.9*	I (1)	-13.9*	I (1)
Lnpci	-6.05*	I (1)	-6.3*	I (1)
Lnwork	-5.3*	I (1)	-6.6*	I (0)
lnurban	-3.50*	I (0)	-3.10*	I (0)

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

From the table above, we can find that though majority of variables are non-stationary at level i.e., I (0), they become stationary at first difference I (1). But urban population is stationary at level in both ADF and PP tests. This confirms that our model has mixed lag variables and hence we are restricted to use the popular methods of cointegration like Engle and Granger (1987) test or Johansen-Juselius (1990) test.

To overcome the limitations of these tests, Pesaran, Shin and Smith (1996) and Pesaran and Shin (1999) have developed alternative approach called Autoregressive Distributed Lag (ARDL) which was further developed by Pesaran *et al.* (2001). This approach gained popularity over other approaches by providing inclusion of variables at different order. That means the approach can be adopted for models whose variables are in I (0) or I (1) or even fractionally integrated (Pesaran and Pesaran, 1997). Major advantage of ARDL is it correct for both residual correlation and endogenity problem among the variables and hence, ARDL approach to cointegration provides robust and consistent results of long run coefficients (Pesaran and Shin. 1999).

Considering the above discussion and the variables under study, it is justified that, our variables are in mixed order and we are justified to adopt autoregressive distributed lag (ARDL) model for establishing their long run co-integration.

The long-run equations of models are as follows:

$$\Delta \ln(vhcl) = \beta_0 \sum_{i-1}^{q} \beta_{1i} \Delta \ln(vhcl_{t-1}) + \sum_{i-1}^{q} \beta_{2i} \Delta \ln(pci_{t-i}) + \sum_{i-1}^{q} \beta_{3i} \Delta \ln(work_t) + \sum_{i=0}^{q} \beta_4 \ln(vhcl_{t-1}) + \beta_5 \ln(pci_{t-1}) + \beta_6 \ln(work_t) + u_t \quad \ldots\ldots\ldots (1a)$$

$$\Delta \ln(pvhcl) = \propto_0 \sum_{i-1}^{q} \propto_{1i} \Delta \ln(pvhcl_{t-1}) + \sum_{i-1}^{q} \propto_{2i} \Delta \ln(work_t) + \sum_{i-1}^{q} \propto_{3i} \Delta \ln(urban_t) + \sum_{i=0}^{q} \propto_4 \ln(pvhcl_{t-1}) + \propto_5 \ln(work_t) + \propto_6 \ln(urban_t) + u_{t2} \quad \ldots\ldots\ldots (2a)$$

Where Δ is the first difference operator, q is optimal lag length, β_1, β_2, β_3 represents short-run dynamics of the model and α_1, α_2, α_3 are long run elasticities.

ARDL model of co-integrating vector is reparametrized into Error Correction Mechanism (ECM). The error correction model for equation 1(a) and 2(a) is given below:

$$\Delta lnvhcl = a_{10} + a_{11}[lnvhcl_{t-1} - b_{11} lnpci_{t-1} - b_{12} lnwork_{t-1}] + \gamma_{11} \Delta lnvhcl_{t-i} + \gamma_{12} \Delta lnpci_{t-i} + \gamma_{13} \Delta lnwork_{t-i} + \varepsilon_{1t} \quad ..(1b)$$

$$\Delta lnpvhcl = a_{20} + a_{21}[lnpvhcl_{t-1} - b_{21} lnwork_{t-1} - b_{22} lnurban_{t-1}] + \gamma_{21} \Delta lnpvhcl_{t-i} + \gamma_{22} \Delta lnwork_{t-i} + \gamma_{23} \Delta lnurban_{t-i} + \varepsilon_{2t} \quad ..(2b)$$

Coefficients a_{11}, a_{21}, indicated the speed of adjustment to equilibrium and corresponding values in bracket is error correction term. For the cointegration, these coefficients must be significant different from zero and estimates of them must not be too large (it must lie between 0, -2). The γ indicates the short term relationship. The reparametrized result gives short run dynamics and long run relationship of the variables (Nkaro&Uko 2016). In order to find out the long run relationship, we have conducted Bounds test on equation 1(a) and 2(a) using Bound F statistics with two bounds, i.e., lower and upper bound.

H_0 (null Hypothesis) – there is no cointegration among variables.

The rule of thumb is if calculated F-statistic is greater than the upper bound then the null hypothesis is rejected and if it is less than lower bound, the null hypothesis is accepted and if it falls between the lower and upper bound, the test is inconclusive (then we check for error correction term for finding the relationship).

With respect to lag length, we have used Schwarz Bayesian Criterion to select the optimal lag length of variables, which gives the optimal lag length for our model 1 as 1 and for model 2 as 2. Since the data is in annual series, we expect the impact will be captured with a lag of one or two years.

2.4 ***Result and Discussion***

The short and long run results of the two models are given in table 4. 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, one percent increase in per capita income will increase the vehicular population by 1.63% whereas working age population increases by 5.6%.

In the same line of explanation, one percent increase in urbanisation increases private vehicles by 3.08% and same percent increase in working population (employment) increases private vehicles by 1.8%. The present study findings are in line with the findings by Dargey et al (2007) and Ewing (2001).

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 (see 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 4: Short and long-term estimates of the models.

Long term estimates*

Model 1: lnvhcl= 1.63lnpci + 5.67 lnwork -123.8C (7.7) (12.2) (-14.4)
Model 2: lnpvhcl= 1.8 lnwork + 3.08 lnurban – 86 C (3.4) (11.7) (-13.6)

Short run estimates*

$\Delta lnvhcl = -0.81\ ECM + 0.818 lnvhcl(-1) - 0.817 lnpci + 4.64 lnwork + 1.3 \Delta lnpci(-1) - 0.27 d91 - 101.34$ (-5.7) (-5.7) (-0.5) (5.25) (4.7) (-1.6) (-5.4)
$\Delta lnpvhcl = -1.69\ ECM + 0.3\ lnpvhcl(-1) - 9.5 lnurban - 12.2\ lnwork - 0.50 d91$ (-4.01) (1.8) (-0.32) (-2.69) (1.9)

$R^2 = 0.75$, Adj $R^2 = 0.72$

*t-values are in parenthesis

The short- run error correction (EC) terms in all the three models are negative and significant, which indicate that there is co-integration among the variables. In model 1 the speed of adjustment is 81% to correct for disequilibrium and in model 2, it takes a year to correct the disequilibrium.

ARDL model co-integration is verified with the F statistics. The computed F-statistics of two 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 5: Bound F-statistics

Model	Bound F Statistics	Lower bound I (0)	Upper bound I (1)
1	8.69	3.65	4.66
2	9.75	3.65	4.66

Source: From analysis

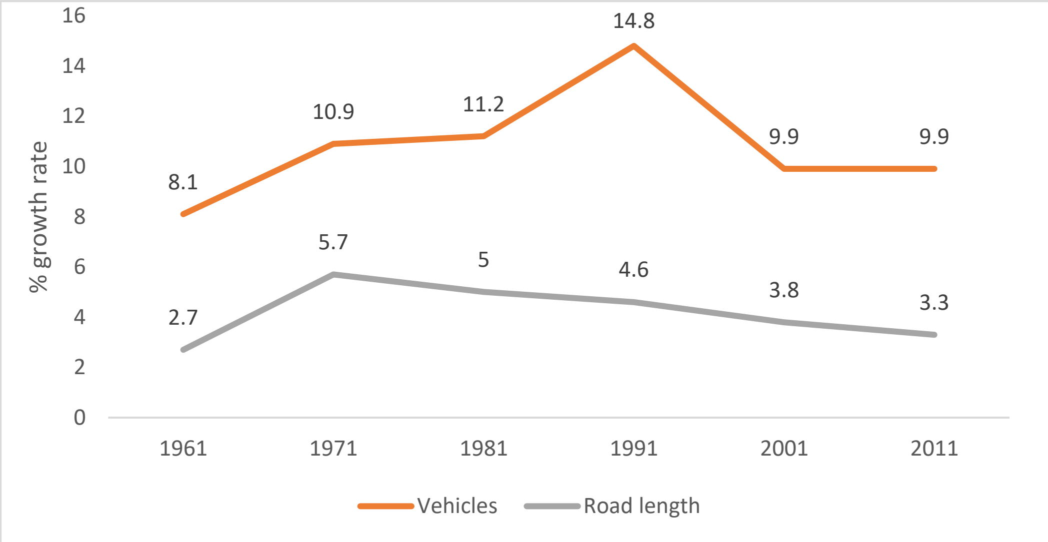
From the above analysis, it is empirically tested that, the major contributors of the vehicular growth are income, working age population and urbanisation. Further the model analysis will be complete if we know the stability test of both models. We tests cumulative sum of recursive residuals (CUSUM) and Cumulative sum of squares of recursive residuals (CUSUMSQ) stability test based on Brown *et al.* (1975). The results are shown in appendix 2 and for both model the plots remain within critical bounds at 5 percent level of significance, which signifies that the model is structurally stable.

SECTION III

3.1 Vehicular growth and Road length

Having proved the impact of income and other variables on vehicles in the country, it is convinced that, vehicular population is increasing at a staggering rate creating heavy pressure on road. Though movement of vehicles on road signifies the economic importance of the place but, for such movement of vehicles, infrastructures are basic requirements (*Verhoef 2001*). 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, is not in tune with the vehicular growth. To give an overall picture, the road density[4] 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*) given in figure 3.

Figure 3: CAGR of Vehicles and Road length in India



Source: RTO India, MoRTH 1961-2011

The figure 5 clearly gives the picture of huge gap between the road length and vehicular growth. On an average, the vehicles are growing at 10 percent per annum, whereas road length is growing at around 4 percent between 1961-2011. However, the urban road length situation is still worst which is revealed in table 4 below. From this table, 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 6: Urban road length in kms from 1971-2011

	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

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

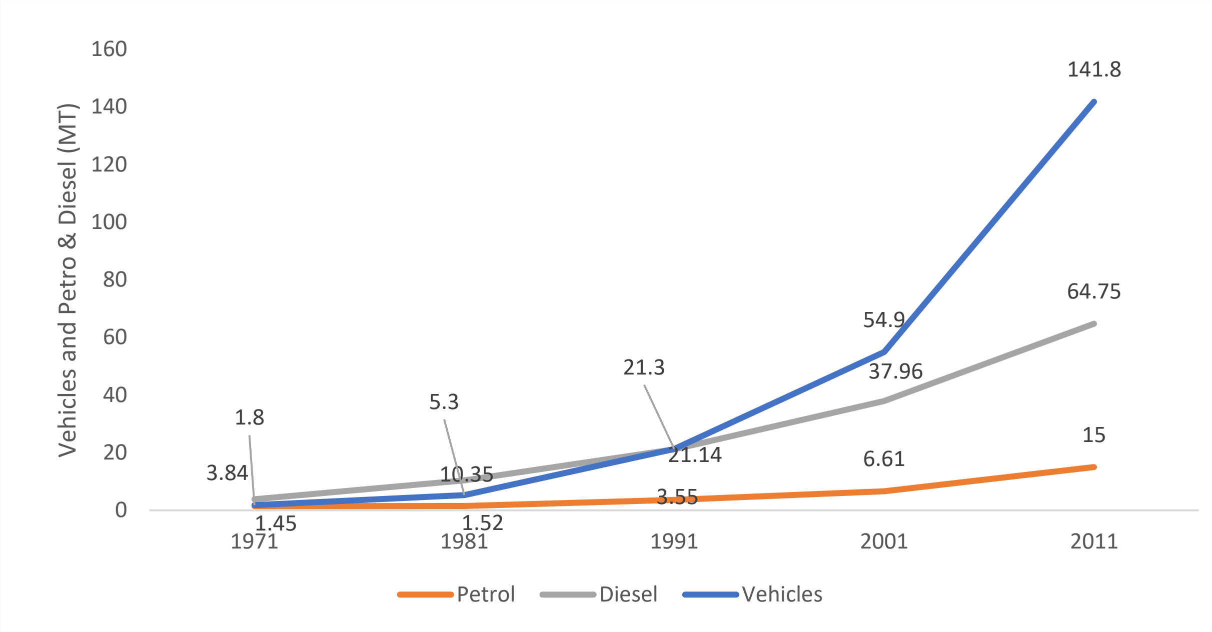
The intensity of traffic congestion is very evident in urban area, due to phenomenal growth of vehicles and a meagre increase in the road length. In table 4, it is evident that, the road space available for the vehicles is decreasing at an increasing rate from 0.18 kms per vehicle to 0.01 km from 1971 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. The following section provides a glimpse about fuel consumption and air pollution scenario of the country, which are generally linking to growing income leading to increasing demand for vehicles.

3.2 *Transport and Fuel Consumption*

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, car consumes 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 trend in vehicular growth, petrol and diesel consumption in India is given in the figure 6 below.

Figure 4: Petrol and Diesel Consumption in MT



Source: PPAC & MOSPI 2011

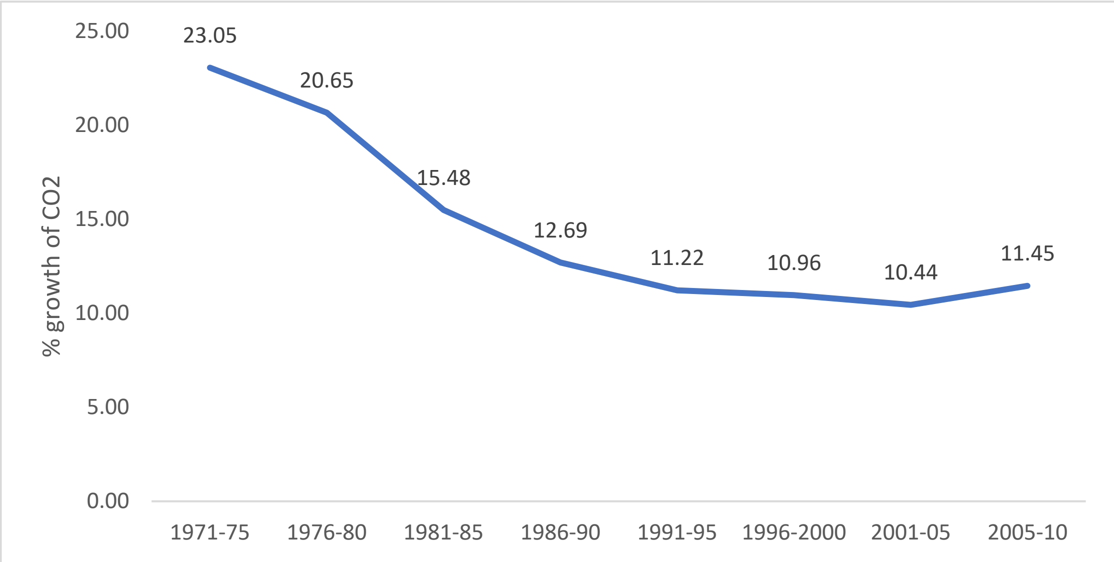
From the Figure 6, it can be summerised that, the vehicular growth and demand for energy (petrol and diesel) are strongly co-related. For reducing this dependency, TERI (2009) has estimated that, there will be an 18 percent reduction in motor fuel demand, if buses are able to meet 70 percent of the total 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,which is considered to be a serious challenge in India. According to WHO (2008) 600,000 people die prematurely each year 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 3 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 of the air pollution in the country, but among the different modes in the transport sector, roadway transportation is major cause of the CO_2 emission in India. The growth rate of CO_2 emission by transport sector is depicted in Figure 7 showing decreasing trend, which is mainly due to significant imporvement in fuel efficiency as India moved from Bharath I standard to Bharath IV and also made lead free and low sulphur element fuel from 2000.

Figure 5: Growth rate of CO_2 emission by transport sector in India

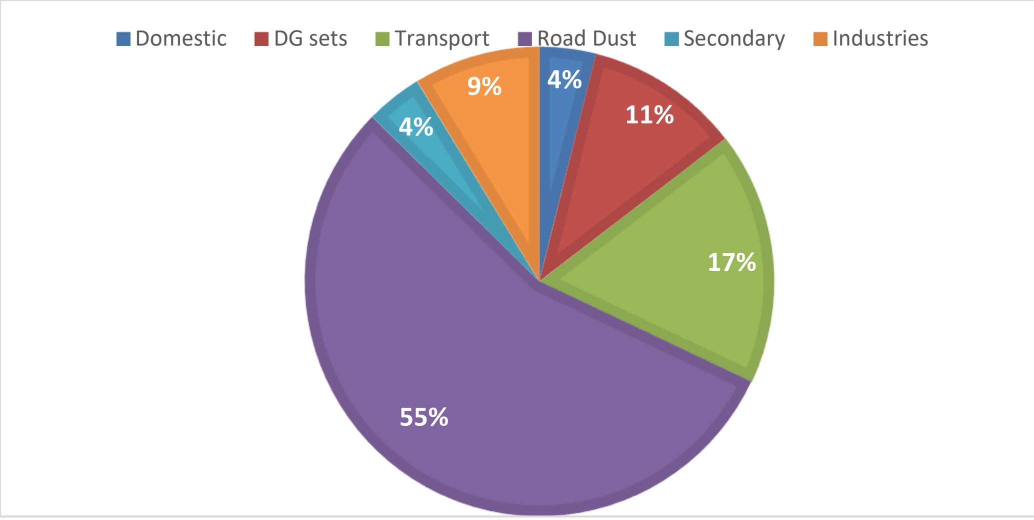


Source: World Bank data on CO_2 emissions

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, CPCB, GOI and MoEF 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 contributes nearly 70 percent of particulate pollution in India (2011). Hence, problem of vehicular growth not only has impacts on the economic activities of the country, but also has a major impact on the environment also.

4. Conclusion

The study mainly focuses on the understanding and bringing out the relationship between income and vehicular growth empirically. For such analysis, the paper adopted ARDL model to understand the single long-run relationship among the variables. The major intention of the paper is to bring out the intensity of traffic congestion in the country, which is directly attributed to tremendous growth of vehicles. This growth was significantly influenced by growth in income, urbanisation and working age population. The test result has come in tune with the theoretical and empirical analysis. The paper also tried to explore other related variables and their impact on vehicular growth and in turn traffic congestion. One of the important aspect which is bought out in the paper was, though the economic development indicators like income, standard of living, employment, urbanisation, vehicular growth picturise the positive side of the development but such development is happening at a cost of environment and health issues. Paper clearly bought out the growing demand for fuel and increasing emission of particulate matter has created unhealthy environment in the country. This kind of situation is more rampant in metropolitan cities of the state. Hence, paper concludes by making a clear statement that development is at the cost of environment and health if not taken certain policy actions.

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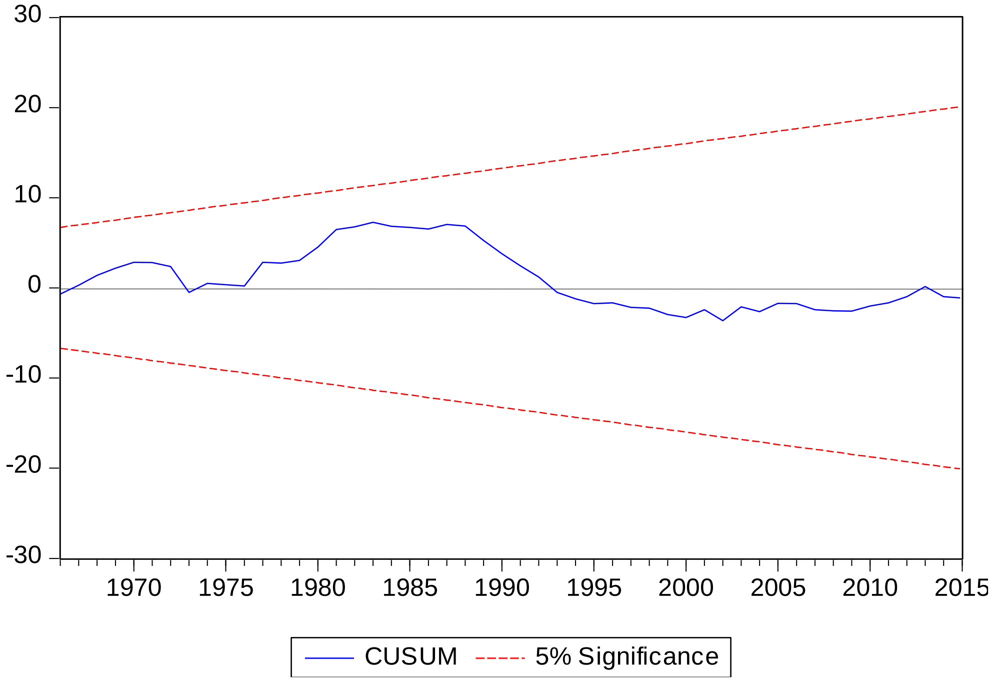
Appendix 1: Diagnostic test result

Model	R-squared	Durbin-Watson	LM test	BP test
1	0.972	2.0	1.2 (0.53)	3.50 (0.62)
2	0.975	2.0	3.8 (0.14)	2.6 (0.08)

Paranthesis is the probability values

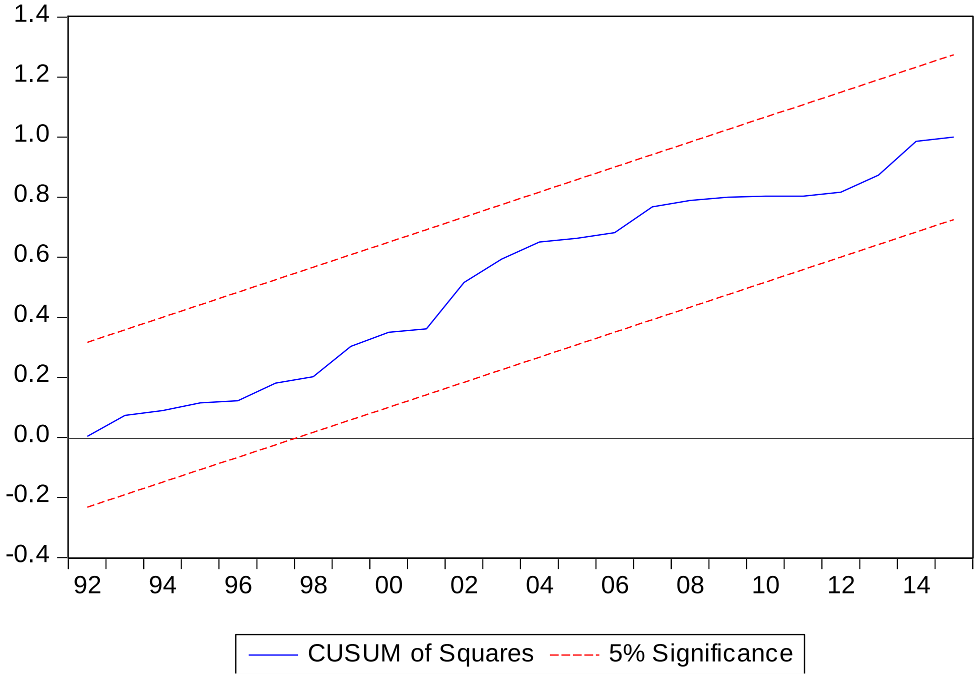
Appendix 2: CUSUM and CUSUMSQ test of stability

Model 1 Cusum Test



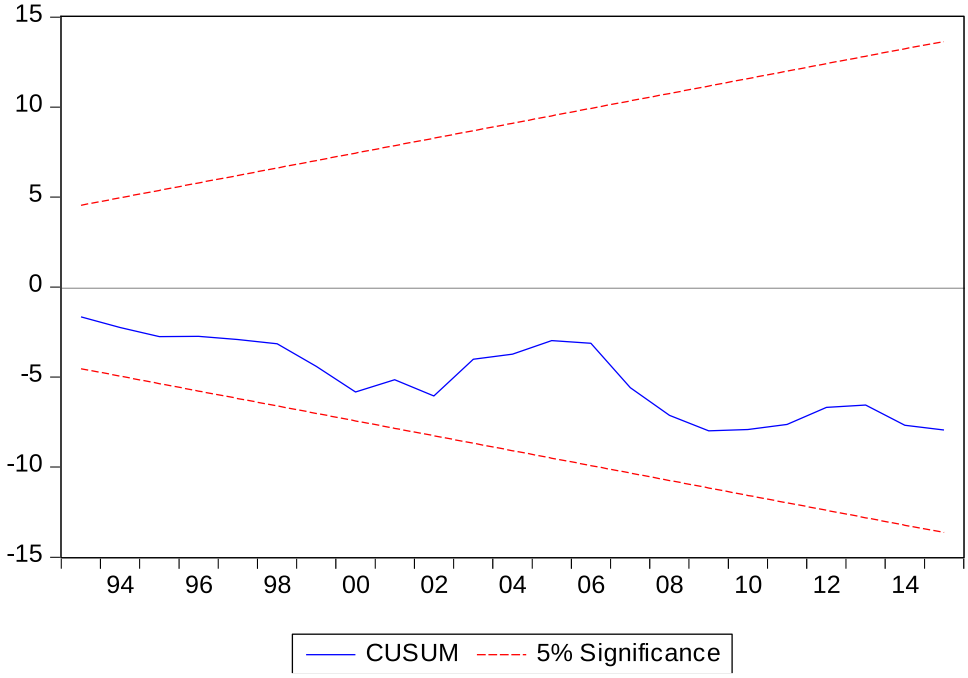
The straight lines represents critical bounds at 5 percent significance level

Model 1 Cusum of squares test



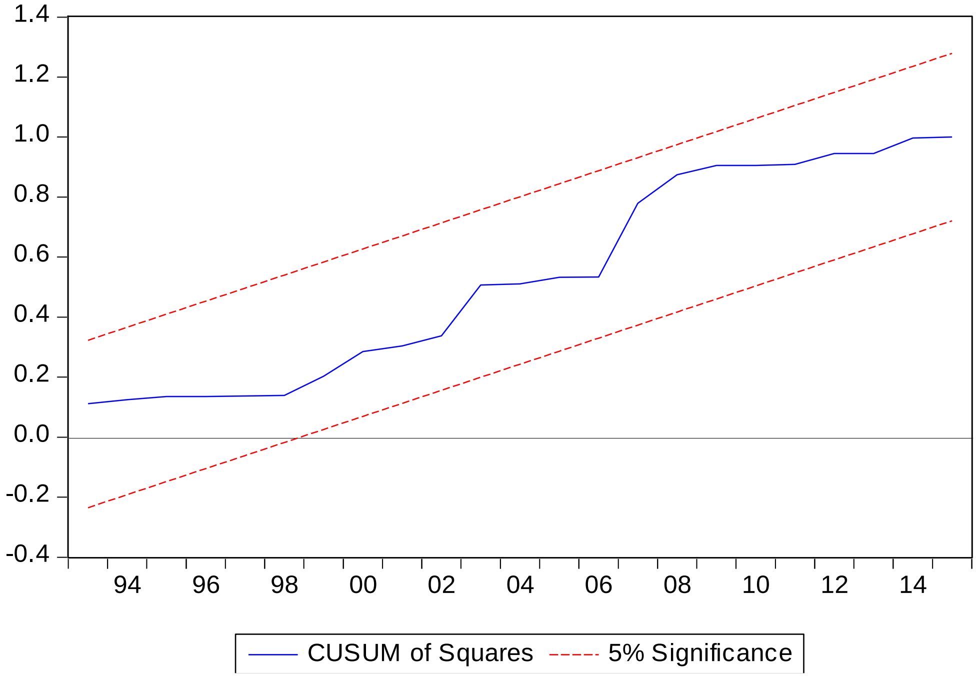
The straight lines represents critical bounds at 5 percent significance level

Model 2 Cusum test



The straight lines represents critical bounds at 5 percent significance level

Model 2: Cusum of square test



The straight lines represents critical bounds at 5 percent significance level