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# GDP, RAILWAY FREIGHT, INFLATION & POPULATION DENSITY: AN ECONOMETRIC QUADRANGULAR STUDY IN INDIAN CONTEXT (1960-2009)

**SANTANU MANDAL*; SAMYADIP CHAKRABORTY****

*Doctoral Research Scholar, Department of Operations,
IBS, Hyderabad, India.
**Doctoral Research Scholar, Department of Operations,
IBS, Hyderabad, India.

## ABSTRACT

*The main purpose of this study is to ascertain the existence of a relationship (if any) between GDP, Inflation, population density and freight carried by Indian railways. The paper explores the nexus between Indian GDP, Railway freight, inflation and population density, with a view of understanding the causality relationship in the backdrop of Indian economic growth over a period of fifty years (1960-2009) using cointegration and Granger causality test. Detection of stationarity in the series was carried out using the Augmented Dickey-Fuller test (ADF) and Phillips-Perron(PP) Unit root test and stationarity outcomes indicated GDP & Inflation data to be stationary and Population density & Railway Freight to be non stationary at 5% level of significance. The paper reveals unidirectional causality from GDP to Population density and also from GDP to railway freight, whereas bidirectional causality is found to exist between railway freight and population-density. Thus, these test findings confirm the existence of a positive relation between GDP and Indian railway freight for the period (1960-2009).*

***KEYWORDS:*** *Economic growth, GDP, Inflation, Population-density, Rail freight.*

## I. INTRODUCTION

Growth in economy of a country can be ascribed as an incremental change in its production of goods and services over a certain time period or in simple terms as rate of change in its GDP. An increase in per capita gross domestic product usually indicates the economic growth for a country. This increase in GDP is usually reflected as an increase in the living standards of people. The government of every country is trying to achieve higher GDP growth rates so as to constantly improve the living standard of its residents. Social science literature provides us with sufficient economic indicators thereby allowing analysis of economic performance

and simultaneously predicting future performance. Any effort on part of the government of a country to improve the living standards of its residents must address the efficient distribution of goods & services, which is one of the important pillars constituting economic activity.

Transportation & freight of our country (a component of our logistics) plays a vital role in supporting this important pillar of our day to day economic activity. In fact, transportation costs account for nearly 40% of production costs of goods. Indian logistics costs around 13% of its GDP implying the fact that it plays an important role in the country's economic growth and development which is manifested in the GDP. In the Indian logistics scenario, railways have contributed greatly since its inception with now carrying almost 2 million tons of cargo freight daily. Indian Railways carry variety of goods ranging from mineral ores, fertilizers, petrochemicals, agricultural produce, iron & steel etc. It makes 70% of its revenues from the freight segment. Nowadays a privatization scheme of allowing companies to run their own container trains is being approved .Thus its evident that railways have contributed significantly in the country's economic activities and hence can well be intuitively claimed to be affecting GDP growth. Till now, most of the research is done to find the relationship between the economic indicators and GDP. But in the Indian context, in depth research is still very few on the effect of cointegration relationship nexus between economic growth and railway freight behavior. This gap provided us the impetus to explore further in this area.

The rest of the paper is constructed as follows. Section II discusses the prior literature and theoretical framework. Section III entails the objectives followed by Section IV portraying the significance/need of the study. Section V discusses the methodology applied and model estimation followed by Section VI discussing the key results and findings. Section VII summarizes the findings and concludes with Section VIII discussing few limitations of this study

## II. REVIEW OF LITERATURE

India is a country where railway is the most important and by far often the cheapest form of long distance goods transport. Several research works have been undertaken worldwide to find a suitable nexus (existing if any) between the country's economic growth (GDP growth) and logistics infrastructure and growth in terms of annual freight carried. Researches involving both railways and roadways have been undertaken, however in the context of large countries where the railways serve as the main stream of central long distance freight-carriage, railway-freight carried data has been portrayed as a vital focusing point in the potential nexus. Besides passenger transport, freight transport forms an integral part of today's modern society and key to sustained economic growth (Wie Liu et al., 2004; Hilmola, 2006; Pradhan, 2010; and several other associated researchers have focused on the importance of logistics and railway freight. Ideal examples of contributing works include those by Wie Liu et al. (2004) in the Chinese context, Hilmola (2006) in the context of European railway networks, Sharma and Vohra (2008) carrying out a comparative critical evaluation of the rail and road transport infrastructure and economic impact in the Asian context (comparing and rating China Vs India), recently published related work by Pradhan (2010) in the Indian context, etc among others. So, as far as logistics infrastructure and impact on Indian economic growth are concerned, naturally the vital position of Indian railway becomes inevitable and the objective of seeking a close nexus involving railway-freight and GDP growth becomes justified.

Certain research works, involving railway's annual freight carried and its relationship with the country's GDP growth, are important and need to be mentioned. An ideal example is the cointegration and causality analysis based study by Pradhan (2010). It indicated a close relationship linking India's economic growth (GDP indicates) and railway transportation infrastructure provided by Indian Railways in terms of railway annual freight carried. Pradhan (2010) reported unidirectional causality for the growth of transportation freight infrastructure and economic growth as indicated through GDP figures and have used Granger causality test, Philip Perron (PP) unit root analysis and Engle and Granger's principle of cointegration analysis to compute the required outcome over a 38 year time horizon (1970-2007). Thus Pradhan (2010) gives a vital baseline to further discern along the lines of other closely linked associated factors affecting railway goods carriage and economic development. In a corresponding research study over a time horizon of 53 years (1952-2004), Wie Liu et al. (2004), has indicated the importance of logistics in the perspective of the Chinese economy and analyzed freight traffic turnover volume with the country's economic growth indicator (GDP). They have carried out reliable cointegration relationship analysis between GDP increment and logistics volume increment. Their findings indicate that logistics development plays an important role to GDP growth and it is important to keep the balance between both of them. Thus the corresponding findings in the Chinese and Indian perspective further bolster the relationship causality.

The freight movement development and the direct or indirect impact of freight transportation on influencing the regional or national economy have been discussed and empirically analyzed in several research studies focusing on transport related freight growth and economic enhancement. Studies by Ramanathan (2001); Banister and Berechman (2001), Ramanathan and Parikh (1999), Eisner, (1991), etc have indicated freight carriage and transportation infrastructure to be essential elements of the modern society and key to sustained economic growth. In majority of the studies GDP has been used as an effective proxy for economic growth. Analysis of long term co-integrating properties and causality analysis using Johansen-Juselius (1990) approach or the Engle and Granger (1987) approach and non-stationarity analysis using Augmented Dickey-Fuller test (ADF) or the Philip Peron unit root techniques have been predominantly used. Several other research papers that have focused on the railway freight carriage and economic growth or its effectiveness in building the freight transport and growth nexus are those studies by Kulshreshtha et al. (2001), Jiang (2001), etc among others. Kulshreshtha et al. (2001) have done a detailed analysis based on Model of Freight Transport Demand using the evidence from Indian Railways data.

Literary and empirical evidences more and more support and indicate the important role logistics and freight capacity and carriage plays in national economy. The studies clearly indicate that the rapidly developing economies as well as the developed ones greatly support the development of logistics as a crucial factor influencing nation gross domestic products upward trend. To put evidence to that another similar research findings can be quoted here. In assessing the railway infrastructure, Hilmola (2006) conducted partial productivity analysis on European railway freight transportation and emphasized that improvement in productivity of railway freight carriage and related factors have huge scope of potential improvement. Research findings and analysis reveals that it underlines decent probability of economic growth through GDP and so Hilmola (2006) convincingly advocates that improvement in railway and roadway infrastructures and corresponding enhancement of freight and goods carriage capacity will facilitate consequent GDP growth.

Pradhan (2010) study however concludes that transport and freight carried by the Indian railways is a key infrastructure in the present study having a direct influence on economic growth. However some studies have also portrayed a loophole and lacking side. Although the increased transport facility and freight carriage infrastructure has given evidence of leading to more economic growth in India, studies by Sharma and Vohra (2008) have done a critical evaluation of freight and railroad transport infrastructure in India and clearly accepted the inadequacy of infrastructure development in India with respect to other developing economies, both in quantity and quality. Both Sharma and Vohra (2008) and Pradhan (2010) have however distinctly highlighted the need of a suitable transport policy to boost the economic growth and to maintain sustainable economic development in the country.

There are few findings for the study on the relation between logistics and the macro-economy. Findings by Wie Liu et al. (2004) describe that the nexus between logistics and GDP growth of a country is indirect and complicated. They showed that the development of logistics industry resulting in the improvement of national economy, but a strong dynamicity factor remains linked with the nature of logistic and GDP scale increments in terms of policy–making in line with harmonious development between logistics and economy. The factors that obviously come in picture as part of the macroeconomic scenario affecting such policy-making are inflation, population level or rather the population density etc. Government policies are mainly aimed at generation of mass benefit and most macroeconomic policies may it be involving GDP growth projection or railway freight projection keeps in mind these highly important factors (inflation and population-density) affecting normal economy.

Inflation is a key factor that plays a significant decisive role in making the key decision regarding the choice of transportation and many other vital decision options in terms of profitability and goods carried. The dependence of inflation in the economy, the choice of transportation or the impact on freight transport or the combined effect of the fluctuation in both the decision elements i.e. freight data and inflation on GDP growth. However the impact of the population density and its significance in the Indian context as far as its influence on the freight carried is concerned is not very decisive and opens lacunae of research. However international research studies on the impact of population on GDP though quite few, still exists. Corresponding studies thus create a wonderful baseline for the next stage of probing providing the vertices of the research quadrilateral as GDP, Rail-freight, Consumer Price Inflation and Population-density.

Relationship and impact of inflation on GDP growth or the economic growth of a country have been portrayed and linked in several research studies worldwide. In a recent paper, in the Nigerian economy context, Chimobi (2010) in his study concerning the impact of inflation on the economic growth in Nigeria have used GDP as a proxy for economic growth and his findings over the time period of 1970-2005, indicate no co-integrating relationship between inflation and economic growth or GDP data. In another corresponding study in the Mexican context, Risso and Carrera (2009) have estimated the long-run relationships and threshold effects between inflation and economic growth in their research in the context of Mexican economy over a fairly long time span of 37 years (1970-2007). Significantly negative long-run relationship has been recorded between inflation and economic growth for the Mexican economy. They reported about the weakly exogenous nature of inflation and also mentioned about the elastic nature of real GDP with respect to inflation. Results show that increase in 1% of inflation decreases real GDP by 1.5%. During the time period under discussion, Mexico experienced approximately double digit inflation (higher than 10%).

Their results, which show consistent outcome with most of the contemporary research, suggest that high levels of inflation produce a negative effect on economic growth. Significant theoretical reasons justify that savings and inflation which are preferably determined simultaneously, are instrumental in contributing towards the economic development process of emerging economies. The relevant findings by Chaturvedi et al. (2009), show that savings rate and growth have bi-directional simultaneous relationship, whereas inflation and growth shared a unidirectional relationship.

Other conflicting research findings inline to this study involving GDP-inflation influencing nexus are those by Erbaykal and Okuyan (2008) in the context of Turkey covering the time-span of 1987-2006 and indicating no statistically significant long-term relationship; findings by Tan (2008) in the ASEAN context and indicating the existence of a trade-off between inflation and economic growth in few of the ASEAN members like Singapore, South Korea and Thailand , whereas missing in case of others; empirical findings by Ahmed and Mortaza (2005) in the context of Bangladesh using GDP and CPI over a period of 1980 to 2005 using co-integration and error correction models and demonstrates statistically significant long-run negative relationship.; etc among others.

Barlow (1994) in his research have indicated certain inconsistencies as far as the outcome of his two variable and three variable correlation model method of confirming the influence of population density on economic growth (GDP used as proxy). Absence of correlation between two variables can usually be considered a strong indication that neither variable is influencing the other however the outcome of the three variable model using the lagged fertility as the third variable as per Barlow (1994) again gives a different result showing negative relationship. The output of the three variable models can be further intuitively confirmed on the basis of rational argument that higher population density invariably gives a stress and reverse growth impact on economy. In a previous research finding by Coale (1986) in his cross- sectional study of the data set of low-income countries proposed that zero correlation existed between the growth rate of per capita income from 1960 to 1982 and the growth rate of population in the same years. However in one of the relatively recent studies by Kumar (2000) had inferred that the increase in population is causing severe damage to the growth opportunity from the exploration of natural resources and population policies are required to be framed in accordance with the future development strategies. So a highly confusing anomaly and diverse findings exist as far as impact of population-density on GDP or country's economic growth is concerned. So this opens up a rich avenue of detailed close handed analysis.

## III. OBJECTIVE

The objective of the study is to investigate the impact of three key variables(inflation,population density & railway freight) that has been found to have considerable influence(as suggested by literature) on the economic growth of a country(measured in terms of GDP).The study has been done in Indian context for the period 1960-2009.

## IV. SIGNIFICANCE OF THE STUDY

Most of the earlier works have tried to find out the relationship between GDP and several other economic indicators including inflation and population density in the Indian context but they have not considered the impact of railway freight on GDP which is positively enunciated

in the literature. Therefore this study attempts to address the relationship between GDP, inflation, population density along with railway freight .Also this study is very different from earlier ones in the sense that it considers a longer horizon (1960-2009)i,e, a span of fifty years which has seen many strategic changes in the economic policies, technological developments and the rapidly changing tastes ,preferences and living habits of the highly heterogeneous mass of Indian people. .

## V. METHODOLOGY

To test whether a given series is stationary or not in this study,the Augmented Dickey – Fuller Test complemented by Phillips-Perron Unit root Tests have been applied on the given set of variables.The Kwiatkowski-Phillips-Schmidt-Shin(KPSS) Test for detecting stationarity is also been conducted.To test for long term relationship between any two variables given in the study,Johansen Cointegration Test has been employed.Though Johansen Test can give implications for finding such long term relationship but the necessary condition in applying this test is that the two series under consideration have to be non-stationary else it cant be applied to find such relationship.Thereafter,the Granger causality test has been applied to find any bilateral causality among the given set of variables.

### A. DATA SOURCE

:The data for the period (1960-2009) have been collected and compiled from the following sites :--

- http ://www.tradingeconomies.com
- http://censusindia.gov.in
- http://indiabudget.nic.in

### B. VARIABLES

**DEPENDENT VARIABLE**

**GROSS DOMESTIC PRODUCT (@FACTOR COST)**: In the proposed study GDP at factor cost is being considered as the dependent variable based on literary evidences. Empirically, it is defined as the aggregate market value of all finished goods and services produced in a country in a given year, equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports. For any country, GDP is one of the several important economic indicators.

**INDEPENDENT VARIABLES**

To assess the variation in Indian GDP ,as already indicated, the explanatory variables under consideration are :

**INFLATION (%):** Basically,when the prices of goods and services in an economy rises over the general level conidered over a fixed period of time ,the price is said to be inflated or inflation is said to have occurred in the concerned economy.Thus,it affects the negatively the purcahsing power of money.The predominant measure of price inflation is the inflation rate(calculated based on consumer price index).

**POPULATION DENSITY(PEOPLE/SQ.KM)** : As evident ,it is the average no of people residing per sq. km in the Indian subcontinent. Over the 50 years due to technological innovation and improved medical facilities ,population density across the country have increased beyond imagination.Also this is boosted by the economic growth giving rise to a host of job opportunities around the country and across sectors.

**RAILWAY FREIGHT (MILLION TON-KM)**:This is the amount of goods carried by the Indian Railway annually per km. Since inception, Indian railway has given considerable support for the growth of a host of industries by providing raw materials as well as finished goods movement across the country and thereby contributing to the growth of the overall economy.

**MODEL PROPOSED**

$GDP = \alpha + \beta_1 \text{ Railfreight} + \beta_2 \text{ Inflation} + \beta_3 \text{ Popden} + u_t$

The above regression has been carried out and the relevant details are present in the next section in results.

## VI. RESULTS

The said study incorporates time series data which changes over the period.These changes in the concerned time series data causes the mean and the variance of the said data to vary over time ;a phenomenon called non-stationarity which can affect normal test procedures.To test for non-stationarity in the given data series, Augmented Dickey –Fuller(ADF) Test is first employed and then the results were confirmed through support of Phillips-Perron(PP) Unit Root Tests.In the case of KPSS test, the picture has been different but since the ADF results were supported by PP test so based on these ADF results only the relevant findings and conclusion has been made.

**NULL HYPOTHESIS ($H_0$)**: The series has a unit root i.e. the series is non-stationary.

**ALTERNATIVE HYPOTHESIS ($H_1$):** The series do not have a unit root i.e. the series is stationary.

**ADF TEST FOR GDP**: The Augmented Dickey Fuller test is carried out for detecting stationarity in GDP (of India) and as the below table shows, the given GDP series from 1960-2009 is stationary at 5 percent and non-stationary at 1 percent levels. Since 5% is the chosen conventional level of significance usually considered in practice, so its concluded that the discussed GDP series (1960-2009) is stationary.

Null Hypothesis: GDP has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 9 (Automatic based on SIC, MAXLAG=10)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | 4.004755 | 1.0000 |
| Test critical values: | 1% level | -4.205004 | |
| | 5% level | -3.526609 | |
| | 10% level | -3.194611 | |

*MacKinnon (1996) one-sided p-values.

**ADF TEST FOR INFLATION** : The Augmented Dickey Fuller test is carried out for detecting stationarity in inflation for the period (1960-2009)for India and as the below table shows, the given series under consideration is stationary at all the chosen 1 %,5% and 10 percent levels .

Null Hypothesis: INFLATION has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 1 (Automatic based on SIC, MAXLAG=10)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -5.402768 | 0.0003 |
| Test critical values: | 1% level | -4.161144 | |
| | 5% level | -3.506374 | |
| | 10% level | -3.183002 | |

*MacKinnon (1996) one-sided p-values.

**ADF TEST FOR POPULATION DENSITY(POPDEN) :** The Augmented Dickey Fuller test is carried out for detecting stationarity in population density figures for India for the period (1960-2009) and as published by the below table; the series under discussion is non-stationary.

Null Hypothesis: POPDEN has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 9 (Automatic based on SIC, MAXLAG=10)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -2.284196 | 0.4325 |
| Test critical values: | 1% level | -4.205004 | |
| | 5% level | -3.526609 | |
| | 10% level | -3.194611 | |

*MACKINNON (1996) ONE-SIDED P-VALUES.

**ADF TEST FOR RAILWAY FREIGHT: :** The Augmented Dickey Fuller test is carried out for detecting stationarity in railway freight carried annually in India for the period (1960-2009) and it was found that the concerned series is non stationary at both 1%,5% and 10% levels.

Null Hypothesis: RAILFREIGHT has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -2.933327 | 0.1614 |
| Test critical values: | 1% level | -4.156734 | |
| | 5% level | -3.504330 | |
| | 10% level | -3.181826 | |

*MacKinnon (1996) one-sided p-values.

Thus in the above study of tests of stationarity in the given economic time series data, it was found that the following two series are stationary viz.(a)GDP (b)Inflation whereas the other two series I.e., Population density and Railway freight were found to be non stationary. Also, since in general, 5% is the preferred level for such tests, hence the above finding is clearly supported across all the variables under consideration. The above results were supported and confirmed by Phillips –Perron(PP) Unit root tests as shown below:

**PP TEST FOR GDP:** As indicated the test statistic value is significantly higher than the critical values in absolute terms at 1%, 5% and 10 % levels implying **stationary** nature of the data.

Null Hypothesis: GDP has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 3 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | 9.078485 | 1.0000 |
| Test critical values: | 1% level | -4.156734 | |
| | 5% level | -3.504330 | |
| | 10% level | -3.181826 | |

*MacKinnon (1996) one-sided p-values.

**PP TEST FOR INFLATION :**The values of the test statistic clearly shows its computed value is slightly higher than 1 percent critical value and significantly higher than 5% & 10% critical values in absolute terms thereby implying the presence of stationary nature in the given data.

Null Hypothesis: INFLATION has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 6 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -4.675034 | 0.0024 |
| Test critical values: | 1% level | -4.156734 | |
| | 5% level | -3.504330 | |
| | 10% level | -3.181826 | |

*MacKinnon (1996) one-sided p-values.

**PP TEST FOR POPULATION DENSITY:** The computed value of the test statistic is marginally lower than the concerned critical values in absolute terms at the given levels which thereby indicates the non-stationary nature of the series under consideration.

Null Hypothesis: POPDEN has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 2 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -0.479689 | 0.9813 |
| Test critical values: | 1% level | -4.156734 | |
| | 5% level | -3.504330 | |
| | 10% level | -3.181826 | |

*MacKinnon (1996) one-sided p-values.

**PP TEST FOR RAILWAY FREIGHT :** As indicated by the adjoining table ,the computed value of test statistic is lower than the critical values in absolute terms at all the three levels under consideration and hence it can be concluded that the discussed series is non – stationary.

Null Hypothesis: RAILFREIGHT has a unit root

Exogenous: Constant, Linear Trend

Bandwidth: 1 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -3.042767 | 0.1315 |
| Test critical values: | 1% level | -4.156734 | |
| | 5% level | -3.504330 | |
| | 10% level | -3.181826 | |

*MacKinnon (1996) one-sided p-values.

The objective of finding a long term equilibrium relation between two time series (cointegration) necessitates the two economic time series under consideration to be non-stationary. As observed in this study, the two series (population density & railway freight )are non stationary. Hence these two can be subjected to Johansen Cointegration test for finding any such relationship between the same. But based on the same reasoning, the other two series viz. GDP and Inflation cannot be subjected to this test because of the stationary nature of the data.

**JOHANSEN COINTEGRATION TEST (POPULATION DENSITY, RAILWAY FREIGHT):** There exists a long run equilibrium relationship between the population density of India and the railway freight carried during the period under consideration.

Trend assumption: Linear deterministic trend

Series: POPDEN RAILFREIGHT

Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 5 Percent Critical Value | 1 Percent Critical Value |
|---|---|---|---|---|
| None ** | 0.819073 | 88.30432 | 15.41 | 20.04 |
| At most 1 * | 0.121914 | 6.240494 | 3.76 | 6.65 |

*(**) denotes rejection of the hypothesis at the 5%(1%) level

Trace test indicates 2 cointegrating equation(s) at the 5% level

Trace test indicates 1 cointegrating equation(s) at the 1% level

1 Cointegrating Equation(s): Log likelihood -650.5516

Normalized cointegrating coefficients (std.err. in parentheses)

| POPDEN | RAILFREIGHT |
|---|---|
| 1.000000 | -0.000912 |
| | (2.6E-05) |

Thus the long run relationship between the population density and railway freight carried in India during the period (1960-2009) can be written as:

Popden= -0.000912 Railfreight.

The nature (stationary & non-stationary)of the given data series of the variables under consideration does not come into picture as far as the Granger Causality Test of finding any bilateral causality among them is concerned.

**GRANGER CAUSALITY TEST**

Standard economic literature suggests the presence of causal relationship among the economic indicators.With a view to understand the same, the Granger Causality Test is performed and the results are summarized below the table:

| | GDP | Inflation | Popden | Rail freight |
|---|---|---|---|---|
| **GDP** | | |  |  |
| **Inflation** | | | | |
| **Popden** | | | |  |
| **Railfreight** | | | | |

In the above table, the causal relationships are shown by arrows indicating the causality direction between the variables.

## VII. CONCLUSION

The current study therefore investigates the relationship nexus between Indian GDP and inflation, population density and railway freight. From the regression results it has been found that railway freight has a significant and positive impact on Indian GDP whereas inflation and population density failed to have substantial impact on Indian GDP under the said period of study (1960-2009).Also from Johansen test of conintegration, a long term relationship has been found to exist between population density and railway freight in India for the aforesaid period. Further, Granger Causality Test has shown that GDP can throw some light in predicting future behavior of Indian population density and railfreight. The same test has simultaneously published the existence of a bilateral causality between railway freight and population density of India for the period 1960-2009.Thus the existence of a positive relation between GDP and Indian railway freight for the period (1960-2009) as found is consistent with the earlier studies of Pradhan (2010), Ramanathan(2001), Hilmola (2007) and Wei Liu et. Al (2006).

## VIII. LIMITATIONS

The present study has found a long term relationship between the considered variables (population density & railway freight).Other earlier econometric studies have used Vector Error Correction (VEC) Model which has not been used in this study. This leaves scope for further research. Secondly, the Granger causality test can be extended from bilateral to multivariable causality through the technique of vector autoregression (VAR). Third, the railway freight considered for the said period makes no clear distinction between the kinds of freight carried and lacks the due consideration for their relative importance in affecting the economic growth.

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**APPENDIX-A**

**[1]REGRESSION RESULTS**

GDP = C(1) + C(2)* RAILFREIGHT + C(3)* INFLATION +C(4)*

POPDEN

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -629089.6 | 720577.2 | -0.873036 | 0.3872 |
| RailFreight | 10.44608 | 2.046553 | 5.104231 | 0.0000 |
| Inflation | -27453.81 | 20813.68 | -1.319027 | 0.1937 |
| Popden | -4132.824 | 3993.758 | -1.034821 | 0.3062 |
| R-squared | 0.678345 | Mean dependent var | | 920435.9 |
| Adjusted R-squared | 0.657368 | S.D. dependent var | | 1304508. |
| S.E. of regression | 763591.1 | Akaike info criterion | | 30.00607 |
| Sum squared resid | 2.68E+13 | Schwarz criterion | | 30.15903 |
| Log likelihood | -746.1518 | Durbin-Watson stat | | 0.420503 |

| **Variables** | **Beta coef.** | **t-stats** | **p-value** | **tolerance** | **VIF** |
|---|---|---|---|---|---|
| **constant** | -629089.6 | -0.87304 | 0.3872 | | |
| **Railfreight** | 10.446 | 5.104231 | 0 | 0.182 | 5.501 |
| **Inflation** | -27453.8 | -1.31903 | 0.1937 | 0.99 | 1.011 |
| **Popden** | -4132.81 | -1.03482 | 0.3062 | 0.181 | 5.526 |

**ANOVA TABLE**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 5.656E13 | 3 | 1.885E13 | 32.337 | .000[a] |
| | Residual | 2.682E13 | 46 | 5.831E11 | | |
| | Total | 8.339E13 | 49 | | | |

a. Predictors: (Constant), Popden, Inflation, Railfreight

b. Dependent Variable: GDP

**[2] CORRELATION MATRIX**

| | **GDP** | **RAILFREIGHT** | **INFLATION** | **POPDEN** |
|---|---|---|---|---|
| **GDP** | 1 | 0.810529 | -0.069228 | 0.691974 |
| **RAILFREIGHT** | 0.810529 | 1 | 0.059791 | 0.90431 |
| **INFLATION** | 0.069228 | 0.059791 | 1 | 0.089497 |
| **POPDEN** | 0.691974 | 0.90431 | 0.089497 | 1 |

**[3]HETEROSCEDASTICITY TEST**

**WHITE HETEROSKEDASTICITY TEST**

| | | | |
|---|---|---|---|
| F-statistic | 132.9727 | Probability | 0.000000 |
| Obs*R-squared | 48.38286 | Probability | 0.000000 |

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 12/09/10 Time: 10:03

Sample: 1960 2009

Included observations: 50

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 7.94E+11 | 1.10E+12 | 0.724846 | 0.4728 |
| RAILFREIGHT | -2203369. | 8443085. | -0.260967 | 0.7955 |
| RAILFREIGHT^2 | 42.40149 | 7.408699 | 5.723203 | 0.0000 |
| RAILFREIGHT*INFLATION | -530448.9 | 140891.6 | -3.764944 | 0.0005 |
| RAILFREIGHT*POPDEN | -58753.64 | 28325.47 | -2.074233 | 0.0445 |
| INFLATION | 6.61E+10 | 4.10E+10 | 1.609024 | 0.1155 |
| INFLATION^2 | 1.02E+09 | 3.90E+08 | 2.615582 | 0.0125 |
| INFLATION*POPDEN | 43686385 | 2.55E+08 | 0.171520 | 0.8647 |
| POPDEN | -8.58E+09 | 1.31E+10 | -0.656578 | 0.5152 |
| POPDEN^2 | 50758509 | 33766159 | 1.503236 | 0.1406 |

| | | | |
|---|---|---|---|
| R-squared | 0.967657 | Mean dependent var | 5.36E+11 |
| Adjusted R-squared | 0.960380 | S.D. dependent var | 8.14E+11 |
| S.E. of regression | 1.62E+11 | Akaike info criterion | 54.63665 |
| Sum squared resid | 1.05E+24 | Schwarz criterion | 55.01905 |
| Log likelihood | -1355.916 | F-statistic | 132.9727 |
| Durbin-Watson stat | 1.554925 | Prob(F-statistic) | 0.000000 |

**APPENDIX-B**

**[1] KPSS TEST OF STATIONARITY**

**NULL HYPOTHESIS ($H_0$)** : The series is stationary.

Null Hypothesis: GDP is stationary

Exogenous: Constant, Linear Trend

Bandwidth: 5 (Newey-West using Bartlett kernel)

| | | LM-Stat. |
|---|---|---|
| Kwiatkowski-Phillips-Schmidt-Shin test statistic | | 0.234085 |
| Asymptotic critical values*: | 1% level | 0.216000 |
| | 5% level | 0.146000 |
| | 10% level | 0.119000 |

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Exogenous: Constant, Linear Trend

Bandwidth: 3 (Newey-West using Bartlett kernel)

| | | LM-Stat. |
|---|---|---|
| Kwiatkowski-Phillips-Schmidt-Shin test statistic | | 0.085873 |
| Asymptotic critical values*: | 1% level | 0.216000 |
| | 5% level | 0.146000 |
| | 10% level | 0.119000 |

Null Hypothesis: POPDEN is stationary

Exogenous: Constant, Linear Trend

Bandwidth: 5 (Newey-West using Bartlett kernel)

| | | LM-Stat. |
|---|---|---|
| Kwiatkowski-Phillips-Schmidt-Shin test statistic | | 0.192835 |
| Asymptotic critical values*: | 1% level | 0.216000 |
| | 5% level | 0.146000 |
| | 10% level | 0.119000 |

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

| | |
|---|---|
| Residual variance (no correction) | 248.5903 |
| HAC corrected variance (Bartlett kernel) | 1126.077 |

Null Hypothesis: RAILFREIGHT is stationary

Exogenous: Constant, Linear Trend

Bandwidth: 3 (Newey-West using Bartlett kernel)

| | | LM-Stat. |
|---|---|---|
| Kwiatkowski-Phillips-Schmidt-Shin test statistic | | 0.060781 |
| Asymptotic critical values*: | 1% level | 0.216000 |
| | 5% level | 0.146000 |
| | 10% level | 0.119000 |

**[2] GRANGER CAUSALITY TEST**

Pairwise Granger Causality Tests
Sample: 1960 2009
Lags: 4

| Null Hypothesis: | Obs | F-Statistic | Probability |
|---|---|---|---|
| INFLATION does not Granger Cause GDP | 46 | 0.08353 | 0.98698 |
| GDP does not Granger Cause INFLATION | | 1.70575 | 0.16948 |
| POPDEN does not Granger Cause GDP | 46 | 1.89237 | 0.13235 |
| GDP does not Granger Cause POPDEN | | 7.24092 | 0.00021 |
| RAILFREIGHT does not Granger Cause GDP | 46 | 1.29773 | 0.28876 |
| GDP does not Granger Cause RAILFREIGHT | | 2.62997 | 0.04974 |
| POPDEN does not Granger Cause INFLATION | 46 | 0.46523 | 0.76078 |
| INFLATION does not Granger Cause POPDEN | | 0.13540 | 0.96825 |
| RAILFREIGHT does not Granger Cause INFLATION | 46 | 0.56324 | 0.69079 |
| INFLATION does not Granger Cause RAILFREIGHT | | 0.44759 | 0.77343 |
| RAILFREIGHT does not Granger Cause POPDEN | 46 | 12.9981 | 1.0E-06 |
| POPDEN does not Granger Cause RAILFREIGHT | | 220.839 | 0.00000 |