Economic Growth in India : A Critical Analysis with Special Emphasis on Energy Consumption and Environment Degradation

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Abstract

The purpose of this paper is to examine whether the decline in environmental quality in India is due to high energy consumption? If so, what effect does excessive economic growth rates have on energy consumption in the country? The higher energy consumption is a resultant of rapid economic growth creating scope for large demand which is caused by industrialization and growth in international trade related to industrial goods The study has been conducted to find whenever an emerging economy produces higher growth rates does it really cause more energy consumption leading to environmental degradation using threshold regression analysis.. The other significant area of research is that as India poses higher economic growth rates, the higher would be the energy consumption levels leading to environmental imbalances.

1. Introduction

It is the mad rush for rapid economic growth in emerging economies like India that is having a negative impact on the ecological management. It is evident that rapidly growing economies are causing severe pollution problems in the form of emissions of various forms of gases. The higher emissions in these countries are a resultant of higher energy consumption. Higher rate of growth of population, rapid industrialization, increase in number of vehicles as a result of a very high economic growth are acting as major driving forces towards high energy consumption.

The economic growth exhibited in the countries like India is exuberant. The higher growth levels have placed these economies in the different League of Nations altogether. China and India together contributed world's 30% of GDP in US $ in 2002-03 (World Bank, 2004). At 2006, China is growing at over a growth rate of 10%, while India is growing at 9% growth rate.

There are many voices which speak for higher growth rates especially for economies like India and China. This is because a country like India has made inadequate progress since 57 years of its independence. Poverty levels though decreased, still hovers over 25% of the population. The problem with previous years was a low growth of GDP which resulted in a much low per capita income growth. The GDP of India between 1950 and 1980 was around 3% and

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annual growth of per capita income was just 1.5%. For a country like India which is world's second largest populous nation, this growth rate was found to be inadequate to make any significant impact on overall progress of the nation. Some initiation was taken up during the 1980s by the Government of India to set things right. Though they were half hearted, it improved the per capita income growth to 3.0% as poverty levels fell from over 45% to 35% by the end of 1990. Thus, India realized that only strong economic growth rate could increase the per capita income levels of the people which in turn help in bringing down the poverty levels and improve the socioeconomic conditions of the poor. This further encouraged the Government to make some serious corrections in its economic policies. Thus, the foundation for a strong economic growth was laid in the form of economic reforms in 1991 which is popularly known as Structural Adjustment Program (SAP). This program was a result of a "closed economic policy" which India followed over the decades which resulted in a severe macroeconomic crisis by early 1990s. The reforms focused on strengthening the economic growth which should translate into reduction of poverty levels, improving poor social economic conditions and better standard of living for the people of India. The reforms started yielding results by mid-1990s as India posted a growth rate of over 7% for three consecutive years followed by a low growth rate which was a result of world wide recession. On the other hand, the governments kept changing, but the reforms program continued. More reforms brought a much higher growth rate and this was evident during the early 2000s as the growth rate for the first seven years of 2000 was over 7.5% per annum.

Thus, many argue that the higher growth rate is the only panacea for the ills poor socio economic conditions prevailing in the developing countries.

On the other hand another set of experts speak against this rapid rate of growth which India and China are exhibiting. They opine that there are environmental costs and damages associated with rapid economic growth which results in expanding of economic activities. This ever increasing consumption demand would have global effects such as high emissions leading to global warming, greenhouse effects and destruction of forests.

Added to the above, the environmental degradation can also add to the problems of imposing higher costs on the poor by increasing the expenditure of health related issues. It is widely believed that the world's poorest 20% of the population take this burden which is a result of high environment degradation. This is also said to be responsible for world's 80% of the diseases worldwide due to pollution in the forms of water, air and land due to industrialization (United Nations Report, 1998).

Consider this example in the case of India - the cement companies' acquisitions in India. As on 2006, the cement industry was in a boom with over 50 new cement companies of around 1000 tonnes per day capacity are coming up. This means for each ton of cement produced in India, one ton of carbon di-oxide is released into the atmosphere! Going by the 2006 production levels 160 million tonnes per year in India, one can imagine the state of affairs of this rapid economic growth on sustainable development in the country.

This problem is associated with rapid industrialization. This stage is a resultant of high economic growth led by change in the structure of economic activities, higher industrial exports, lower industrial imports, higher production and industrial activity and high rate of growth in population. There are many forces which are driving the relationship between environment degradation and economic growth.

India is said to be in the first phase of rapid industrialization where it is experiencing the structural shift from agriculture to industrial growth. The share of agriculture for India has considerably declined from over 80% in 1950s to around 25% by 2007 and industrial share in GDP went up from around 20% to over 45% during the same period of time. During the same period of time the levels of energy consumption have also drastically increased for the economy, exhibiting a relationship between economic growth and energy consumption. Thus, subjectively we hypothesize that:

Hypothesis 1: *Rapid economic Growth rate with structural shift towards industrialization in India are leading to environment degradation.*

India has also witnessed a massive increase in its manufacturing exports and decline in its manufacturing imports. There was a constant increase in manufacturing exports for India from 1980s onwards. This increase was on surge during the 1990s. Similarly, there was a contrasting trend observed in the manufacturing imports. The imports of this segment declined at a slow pace during the 1980s. But in the 1990s the decline was at faster pace. The increase in manufacturing exports lead to extra energy consumption which goes into the production functioning of these goods, while the effects of imports of manufacturing goods is not clearly evident. This is because, if the imports are pure manufacturing goods then it is bound to act as substitute for the local made manufacturing goods, leading to decline in energy consumption. But if the imports are manufacturing capital goods, then it complements the existing manufacturing and industrial products, leading to increase in energy consumption levels. Thus, it is also hypothesized that:

Hypothesis 2: *Increase in manufacturing exports and decline in manufacturing imports leads to higher consumption of energy levels causing environment dilapidation.*

2. Literature Review

The above made arguments and the relationship between the environment degradation and rapid economic growth highlight the number of research studies done on these domain areas in the past.

There are a considerable number of studies that examine the link between energy consumption and economic growth. Following Kraft and Kraft (1978), Some of the earlier studies that examined the causality link between energy and income with diverse results are by Dilip M. Nachane, Ramesh M. Nadkarni and Ajit V. Karnik, 1988; Hwang and Gum, 1992 and Bentzen & Engsted, 1993. But they all suffer from omitted variables bias. It was Stern, (1993) who was the first to advocate and use a multivariate setting, a powerful time series technique to understand the relationship.

Followed by Stern, many authors have done similar studies on a large scale sample (regression analysis) for a 10 years time period by employing the following model:

$$\mathbf{ES} = a_i + t_y + b_1\,\mathbf{GDP}_{it} + b_2\,\mathbf{CV}_{it} + e_{it} \quad \text{......... (1)}$$

Where, ES stands for Environmental Stress, GDP stood for Gross Domestic Product and CV for Control Variables. While, *a* stands for country specific effect, t = 1.....t years, i = 1.....N countries and e = error term.

While, some other studies have taken into consideration the following form:

$$\mathbf{ES} = a_i + t_y + b_1\,\mathbf{GDP}_{it} + b_2\,(\mathbf{GDP})^2_{it} + b_3\,\mathbf{CV}_{it} + e_{it} \quad \text{......... (2)}$$

Everything being similar, a new variable GDP square is taken into account. This variable specifies the acceleration of GDP of the country and includes all the structural changes taking place in the country. Some of the researchers have also considered the following model:

$$\mathbf{ES} = a_i + t_y + b_1\,\mathbf{GDP}_{it} + b_2\,(\mathbf{GDP})^2_{it} + b_3\,(\mathbf{GDP})^3_{it} + b_4\,\mathbf{CV}_{it} + e_{it} \quad \text{......... (3)}$$

Other things being similar, GDP cube is also considered. There is no specific meaning for this variable and that is the reason why this cubed term is not always included in most of the models.

To begin with, the studies conducted by Shafik and Bandyopadhyay (1992), were the first to work on the relationship between the environment degradation and economic growth.

In 1994, Selden and Song in their study have taken into consideration the role of trade and production of industrial goods as related to consumption in another country when it is exported. They adopt the following model:

$$\mathbf{ES} = a_i + t_y + b_1\,\mathbf{GDP}_{it} + b_2\,\mathbf{AGDP}_{i(t-3)} + b_3\,(\mathbf{GDP})^2_{it} + b_4\,(\mathbf{GDP})^3_{it} + b_5\,\mathbf{TV}_{it} + b_6\,\mathbf{CV}_{it} + e_{it} \quad \text{......... (4)}$$

Other things being similar as discussed above, the study also includes AGDP, average per capita income growth lagged to the last three years and TV

(Trade Variables) are also taken into consideration.

If we turn the focus on some of the emerging economies like China and India which are exhibiting a rapid economic growth rate, to sacrifice their rapid rate of growth for betterment of environment quality. This in turn puts the spotlight to examine whether the rapid economic growth itself is the real cause of these problems in both these economies?

This paper tries to search answers to these questions by investigating the relationship between energy consumption and growth variables, especially economic growth, Industrialization and manufacturing trade. The study carries further by specifically testing the relationship between energy consumption and economic rate of growth at higher levels to find whenever these economies grow at a much higher levels of growth, does it really affect energy consumption or not.

3. Research variables & Econometric Models

In this section, first an attempt is made to identify the dependent variables to be adopted in the models. Then explore the possible exploratory variables that affect the dependent variables. Going by the objectives of the study, the paper tries to develop model to explain the relationship between energy consumption being driven by different growth variables. Based on these variables, the paper then provides empirical evidence through an econometric estimate of a model applied to India.

3.1 Energy Consumption and Growth Variables

a. Dependent Variables:

Energy Consumption:

There are severe environmental threats in most of the developing economies like India because of the growing needs in the form of high energy consumption. It is hypothesized in the earlier argument that as energy consumption increases it leads to more emission of some dangerous toxic gases. Thus, the paper takes into account energy consumption in kilo tons oil equivalent per country.

Energy Consumption = Energy Used in Kilo tonnes oil equivalent per country

b. Independent Variables:

b.1 Growth of Market Size:

The energy use in the fast emergining economies like India is largely due to the rapid growth rate of its economy. These higher growth rates are putting increasing pressure on energy consumption in the form of increasing needs. Increase in energy consumption may eventually be raged by rising GDP, increasing the attractiveness of environmental protection as a consumable. Thus, the GDP growth rates are positively associated with the energy use in the emerging countries like India. Thus, growth of GDP, i.e. annual percentage change in GDP in the current year to previous year is taken into consideration.

Growth of market size = DGDP/GDP per country

b.ii Industrialization:

It is a known fact that the production and industrial activities involve energy as an essential input. It is one of the key sources of industrialization. As emerging economies keep growing at higher rates leading to rise in income and progression of economy into the industrial stage, the energy need increases significantly due to the emergence of transportation networks, introduction of various factories and other infrastructure requirements that needs sustained sources of energy. This economic transition stage results in much higher energy consumption and subsequently the energy needs increase drastically for these economies.

There were a lot of data problems as the data on commercial energy use, manufacturing as a function of total industrial production was not available. Hence, the paper considered the share of industrial output in the total GDP for the economy.

Industrialization = Share of Industrial Output in GDP per country

b.iii Population

Population growth is another key indicator that is taken into consideration. As the population grows the needs also increase. The size of population coupled with rise in GDP growth and higher per capita income creates demand for various products and this leads to increase in energy consumption. India has large population residing in rural areas depending more on agriculture. This set of population though are not concerned with the industry, consumes energy in the form of fuel. Thus, in these rural communities though the energy consumption is low but is usually met in the form of fuel and biomass. In order to find the impact of population on energy consumption in India, the paper considers the rate of growth of population.

Population = Rate of Growth of Population per country

b.iv Registered Vehicles

Transportation is a major contributor to energy use. This becomes even more important variable when it is about India which is geographically one of the largest countries in the world. Locations with high levels of travel, long-distance travel, level of public transportation and the number of total vehicles in the country typically tend to have a very high-energy consumption.

India, at present, is among highly populated nations with raising incomes thus creating the demand for motor vehicles. Added to this, the vast public transport systems also play a key role. In the case of India, the data for number of registered vehicles was not available. But the Ministry of Roads and Highways and Government of India provides the time series data on registered vehicles per 1000 people and this variable was taken as proxy for total number of registered vehicle in each year.

Registered Vehicles = Registered vehicles per 1000 inhabitants for India

b.v Manufacturing Exports

The paper also takes into account the country's advancement in international trade as an advent of its rapid economic growth and its impact on energy consumption levels. The participation in international trade was further broken into various categories only to find that the exports of manufacturing products were on rise. This means that the manufacturing products produced are also exported to different parts of the world, leading to much higher energy consumption in the economy. It was found in Suri and Chapman, (1998) that the manufacturing exports are on rise for all the developing economies in the world. It was also evident in their research that the rate of growth in this segment was even higher for the developing economies.

The other interesting aspect to this argument is that the demand for these products from these economies is increasing at a faster rate and the clients being the developed economies. This is because of the availability of these products at a much cheaper rate because of the low cost resources in developing economies.

The paper takes into account the effect of manufacturing exports as the share in total exports for India because of the lack of data availability on pure manufacturing exports as function of GDP.

Manufacturing Exports = Share of manufacturing exports in total exports for India

b.vi Manufacturing Imports

The role of imports of manufactured goods has a double edge impact on energy consumption. Thus, it is important to know whether the imports of manufacturing goods are on increase or otherwise.

The increase in imports of manufacturing goods leads to decline in energy consumption if those goods are used to replace the manufactured goods which are produced domestically which consume high energy levels. Thus, imports of these manufacturing goods, by replacing domestic production, would reduce the energy requirements of the country.

However, there is also a contrasting argument which states that the increase in manufacturing imports like the capital intensive goods or machinery can lead to increase in energy consumption levels. This is because imported capital intensive goods would be used for the production, adding to the existing production levels in the country.

Thus, the net effect of increase in manufacturing imports can be either positive or negative for the developing economies. In a research study by Chapman, (1998) it was found that for almost all the developing economies, the manufacturing imports are in declining trend and even for economies where there is a rise in this segment of imports, the rate of growth is very negligible. In the case of India also, the share of manufacturing imports in its total exports have been declining since from 1970s (World Development Indicators, 2006).

There was data availability problem hence the share of manufacturing imports in total imports was taken into consideration.

Manufacturing Imports = Share of manufacturing Imports in total Imports for India

3.2 Data Sources

The time period selected for the study is from 1970 to 2005. This was done precisely because of two reasons. One, large sample data availability and two, during this 30 year period, the economy witnessed a structural shift from agriculture sector to industrialization. The data used in the study are mostly of secondary in nature, collected from authentic sources. The sources comprise of website, which include Government of India and website of World Bank's Development Indicators: 1970-2005.

The data for variables like energy consumption, GDP growth rates, share of industry in GDP, rate of growth of population, manufacturing exports and imports as a share in total exports and imports respectively for India are also adapted from the World Bank data series.

The data for India's number of registered vehicles per 1000 inhabitants was taken from the Government of India's official statistical website (CSO) on social-economic data series released in 2002 and for the last three years, the data was computed from the values taken from Government of India's Ministry of Roads and Transportation.

With this elaborated description on research variables, their selection and data sources, the paper now turns to apply some econometric models which are aimed at explaining the effect of growth variables on energy consumption levels.

3.3 Empirical Models

In order to prove or disprove the hypothesis, the following regression model is used:

$$Y = \alpha + \beta X + \varepsilon \qquad \text{................ (5)}$$

Where,

Y = dependent variable
X = Independent variable
e = Error term

Energy Consumption Equation:

$$Y_t = \alpha + \beta_1 g_t + \beta_2 X_t + \varepsilon_t \text{ .... (6)}$$

Where,

Y_t = Energy Consumption
g_t = GDP Growth variable
X_t = Control variables
e_t = Error term

Thus, the equation for India would take the following form:

$$EC_t = \alpha + \beta_1 GDP_t + \beta_2 IND_t + \beta_3 POP_t + \beta_4 RV_t + \beta_5 MEX_t + \beta_6 MIMP_t + \varepsilon_t \text{ .... (7)}$$

Where,

EC_t = Energy Consumption in the year 't', measured in kilo tonnes oil equivalent in the year t.

GDP_t = the GDP growth variable in the year 't' is measured by rate of growth. This is expected to have positive sign.

IND_t = measures the share of industry in GDP in the year 't'. It is expected to have a positive sign.

POP_t = measures the rate of growth of population in year 't' is expected to have a positive sign.

RV_t = measures the rate of growth of registered vehicles in year 't' is expected to have a positive sign.

MEX_t = the manufacturing exports share in total exports in year 't' and the expected sign would be positive.

$MIMP_t$ = Manufacturing imports share in total imports in year 't' and it is expected sign would be either positive or negative.

e_t = error term.

The final form of equation with expected signs:

$$EC_t = \alpha + \beta_1 GDP_t + \beta_2 IND_t + \beta_3 POP_t + \beta_4 RV_t + \beta_5 MEX_t + \beta_6 MIMP_t + \varepsilon_t$$

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3.4 Regression Analysis

In the next stage we introduce regression analysis by including three different levels of GDP growth rates to see their impact on the energy consumption levels. This would show whether the higher GDP growth rates of both India and China share a positive relationship or otherwise with the energy consumption levels in their respective countries.

The three different levels of GDP growth rates are identified as below:

(i) Above 6.5% (ii) Above 7%
and, (iii) Above 7.5%

This is presented in the interactive form, where the dummy takes the value 1 with the GDP growth rate of the country crosses the three specified levels and takes 0 otherwise.

Scenario 1 :

Interactive form = GDP Growth rate X 1 (if GDP exceeds 6.5%, 7% & 7.5%)

Scenario 2 :

Interactive form = GDP growth rate X 0 (if GDP does not exceed the above mentioned levels)

Thus, the above models are estimated by using the Ordinary Least Squares (OLS) method.

3.5 Auto-Correlation Problem

In order to ensure that the model specified is correct and is free from any other defects, the paper then employs Durbin Watson test in the very first place to check if the model suffers from the problem of auto-correlation. Durbin Watson statistic is a test for only first order serial correlation.

The formula for Durbin Watson test is:

$$DW = \frac{\sum_{t=2}^{T} (e_t - e_{t-1})^2}{\sum_{t=2}^{T} e_t^2}$$

The interpretation of this test is that if there is perfect positive auto-correlation (r=+1) then d=0. If there is perfect negative auto-correlation (r=-1) then d=4. If there is no auto- correlation, then d=2. That is, the standard way to look at this is if the Durbin Watson statistic reports a value which is around 2, then this is an indication that the model is free from auto-correlation problem. However, if the value is nearer to 0 or 4 then we can presume that there exists a problem with auto-correlation. Usually it is noted that a positive Durbin Watson statistic value of less than 1.50 is an indication that there exists the auto-correlation problem. Therefore one needs to keep a watch on the Durbin Watson value in the final output estimation.

Despite its reliability, there exist few problems in using Durbin Watson test. This test will no longer be valid if there is a lagged variable in the right hand side of the equation. Also, this test is used only to examine the first order auto- correlation. However, in the present paper neither of the models have any lagged value in the right hand side of the equation. But, in order to overcome the second limitation, the paper uses alternative method called Breusch-Godfrey LM test. This is the most preferred test in most of the studies.

The Breusch-Godfrey LM test carries out the examination of general and higher order auto-correlation problem. The null hypothesis for the test states that there is no auto-correlation in the residuals up to the specified order. The most widely used model of auto-correlation is the first order autoregressive model. This model is specified as follows:

$$u_t = pu_{t-1} + \mathring{a}_t \quad \text{.......................................(9)}$$

The value **p** represents the first order auto-correlation coefficient. The model incorporates the residual from the past observation into the regression model for the current observation. Suppose if there is a higher order of auto-correlation, then the model takes the following form:

$$u_t = p_1u_{t-1} + p_2u_{t-2} + p_3u_{t-3} + \ldots\ldots\ldots + p_nu_{t-n} + \mathring{a}_t \quad \text{................(10)}$$

The values of p1, p2, p3..... represent the first, second, third....n order of auto- correlation coefficients.

3.6 Multi co-linearity Problem

Correlation Matrix

In the process of ensuring that the model is correct, the paper also tries to test whether both the equations suffer from any kind of multi co-linearity problem. It is assumed that the independent variables are not related to one another and they are independent of each other. Multi co-linearity problem exists when this basic assumption is violated when found that two or more independent variables are highly correlated to one another. One basic method to find this is to generate correlation matrix. But, the problem is that what level of correlation constitutes multi co-linearity is still under debate in the statistical stream. The most conservative set of experts opine that if the two variables have a correlation coefficient greater than 0.50, then it is said to be a problem of multi co-linearity. They also recommend dropping one of the independent variable in such cases. The other set of experts belonging to liberal camp urge to make an assumption that the independent variables are not correlated and the relationship between the variables will remain unchanged. However some of the other experts like Jensen, (2003) argue that if the correlation coefficient value found greater than 0.90 between the two variables then one of them should be dropped.

Variance Inflation Factor (VIF)

Along with simple correlation matrix, the paper also applies Variance Inflation Factor (VIF) method. The formula used to calculate VIF is:

$$\beta_1 = 1 / (1 - R_1^2)$$

If the VIF value is greater than 4.0, then it can be said that there is a multi co-linearity problem. Some authors use the more lenient cut-off of VIF value greater than 5 and or 10 when multi co-linearity is a problem. The paper takes 10 as the cut off value to detect and accept the multi co-linearity problem.

Tolerance Values

Tolerance procedure is to choose each right hand side variable (that is, explanatory variable) as the dependent variable (ignoring the actual dependent variable) and regress it against a constant and the remaining explanatory variables.

There will be as many tolerance coefficients as there are independent variables. The higher the inter-correlation of the independent variables, the more the tolerance will approach zero. As a rule of thumb, if tolerance is less than the value 0.20, a problem with multi co-linearity is indicated. The formula for calculating Tolerance values is:

$$\textbf{Tolerance} = 1 / \text{VIF} = 1 - R^2$$

When tolerance is close to the value 0 there is high multi co-linearity of that variable with other independents and the beta coefficients will be unstable. This means, more the multi co-linearity, the lower the tolerance levels and the more the standard error of the regression coefficients.

4. Empirical Results and Estimates

The paper now turns towards the empirical results and estimates for the equation on energy consumption for India.

i. Energy Consumption and Growth Relationship

This section presents the results of regression estimates in measuring the influence of growth variables on energy consumption for India. The table 1 is the standard model which captures the regression estimates for energy consumption and growth equation for India. The descriptive statistics for India is mentioned in Annexure 1 at the end.

ii. Regression Analysis:

In the second step, for the equation on energy consumption and growth, there are three different models capturing the impact of higher GDP growth on energy consumption at three different growth rate levels for India. Each model is unique in nature and differs from the other two. These models are captured in tables 1A, 1B and 1C. The table 1A presents the inclusion of GDP growth rate at above 6.5% level and also includes all other variables in the model. The table 1B captures the second model with GDP growth rate variable which is above 7% level to see the influence on energy consumption, while the table 1C includes the model in which GDP growth rate of above 7.5% is taken into consideration.

This apart, the study also tests for presence of auto-correlation problem by employing in the first phase the Durbin Watson test and then Breusch-Godfrey's LM test for both equations on India in the standard models. Also the paper makes an attempt to detect the presence of multi co-linearit problem for the models of the equations by computing Variance Inflation Factor (VIF) values and Tolerance limit values.

Energy Consumption and Growth Equation for India: Standard Model

The results show standard model of the relationship between Energy consumption and growth. As expected all the growth variables exert a positive correlation with energy consumption.

Table 1: Standard Model for Energy Consumption & Growth for India

Dependent Variable: Energy Consumption Method: Least Squares Sample: 1970 - 2005 Included observations: 36				
Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**Probability**
C	-1.060612	0.373091	-2.842767	0.0081*
GDP Growth	0.011958	0.008228	1.453250	0.1569+
Industrial Growth	0.083715	0.013985	5.986116	0.0000*
Registered Vehicles	0.054047	0.002815	19.19851	0.0000*
Population	0.200504	0.110945	1.807236	0.0811***
Manufacturing Exports	0.013611	0.005046	2.697244	0.0115**
Manufacturing Imports	-0.002964	0.003696	-0.801814	0.4292
R-squared	0.991594	Mean dependent var		3.488056
Adjusted R-squared	0.989854	S.D. dependent var		1.289936
S.E. of regression	0.129930	F-statistic		570.1260
Sum squared resid	0.489569	Prob(F-statistic)		0.000000
Log likelihood	26.27768	Durbin-Watson stat		1.645117
Testing for presence of Auto- Correlation: Breusch-Godfrey Auto-Correlation LM Test				
F-statistic	0.648520	Probability		0.427429
Obs*R-squared	0.814936	Probability		0.366665

Note: * Significant at 1% confidence level ** Significant at 5% confidence level
*** Significant at 10% confidence level + Significant at 15% confidence level

The interesting point to be noted is the significance of Manufacturing exports, industrial growth and registered vehicles variables on energy consumption, which is stronger than that of the GDP growth.

The 1% increase in manufacturing exports leads to corresponding increase in energy consumption levels by 1.36% and is statistically significant at 5% confidence level. This proves the point that the manufacturing exports are indeed contributing to a great level of pollution by consuming more energy. This is well explained by the fact that manufacturing exports for India have been growing since the early 1980s. A similar contrasting trend can be observed in the case of manufacturing imports. The manufacturing imports exhibit a downward trend since 1980s as a result the manufacturing imports have negative correlation with the energy consumption and are not statistically significant either.

The share of industry sector in GDP exerts a positive relationship with energy consumption. In fact, the increase in 1% growth in share of industry of GDP is leading to a growth of 8.37% for energy consumption and is statistically significant at 1% confidence level. Ever since India attained independence in 1947, its dependence was more on agriculture sector. But over the years the dependence of agriculture sector has reduced and the share of industry has been on rise along with the service sector. The share of industry in GDP was under 10% during the 1950s and it has increased rapidly to around 30% by 2007.

The number of registered vehicles estimated by the number of vehicles available per 1000 inhabitants in the country is making a positive impact on energy consumption levels and is statistically significant at 1% confidence level. The impact of this variable per 1% increase on energy consumption is 5.40%, which is next to industry share variable. During the 1970, according to the government of India data, the number of vehicles available per 1000 inhabitants was only 3 and this has gradually increased to 66 by 2006. The increase in the number was rapid from the 1980s onwards.

The highest impact on energy consumption variable is made by the rate of growth of population in India. The population in India is considered to be world's second largest and is expected to take over China by 2020. Though efforts are made by the government agencies, volunteer organization and other funding groups to ensure the reduction in growth rate of population; its growth rate is still amongst the highest in the world by any standards. The population in India is growing at a rate of over 1.25% per annum. A 1% increase in population in India is leading to a 20% growth in energy consumption levels. This is statistically significant at 10% confidence level.

When it comes to the general rate of growth of GDP, an increase of 1% in this variable is leading to an increase in 1.12% growth in energy consumption levels. This is statistically significant at 15% confidence level. One reason which can be attributed for this can be the fluctuating trend which the GDP growth rate has exhibited during the decade of 1970 to 1980. The period of 1980 to 1990 saw a very low rate of growth in GDP for India. The rate of growth though increased slightly during the 1990 to 2000 period, the increase was marginal compared to the previous decade. But the real change was about to come in the early 2000s where the GDP surged by over 7.5% mark consistently for the next seven years.

High GDP growth rate which is a resultant of rapid industrialization, increasing demand for goods and vehicles, coupled with a very high rate of growth in manufacturing exports and population are having a drastic impact on the energy consumption levels in the country.

The R square value of 0.99 means 99% of variation in the energy consumption for India which is explained by the growth variables during 1970 to 2005 period and the adjusted R square value stands at 98%, which indicates that the overall goodness of the fit is highly significant.

The Breusch-Godfrey Auto-Correlation LM Test stated below the results show that the model does not suffer with auto- correlation problem.

The other possible problem of existence of multi co-linearit is tested using correlation matrix which was discussed earlier is presented in Annexure 2. In order to further ensure the absence of multi co-linearity problem, the results of Variance Inflation Factor (VIF) and Tolerance values is presented in table 2

Table 2: VIF & Tolerance Values for Energy Consumption and Growth equation

Sl. No.	Variables	VIF Values	Tolerance Values
01	GDP	1.98	50.50
02	Industry Share	1.49	67.12
03	Registered Vehicles	1.32	75.76
04	Population growth	1.24	80.65
05	Manufacturing Exports	1.19	84.03
06	Manufacturing Imports	1.16	86.21

The Variance Inflation Factor (VIF) and Tolerance values reflect the presence or absence of multi co-linearity. A high VIF and a low tolerance values represents higher severe multi co-linearity effects in the model. The table 2 shows that the values for VIF and tolerance values for all the variables are under their prescribed limit and it proves the fact that the model is free from the problem of multi co-linearity.

Energy Consumption and Growth Equation for India: Regression Models

The tables 1A, 1B, and 1C present the estimation of the three equations in which the dummy variable GDPD is introduced in the interactive form (Dummy multiplied by GDP) to check that at which higher GDP growth rate levels the effect on energy consumption is recognized even stronger.

Table 1A: Regression Analysis for India at GDP growth > 6.5%

Dependent Variable: Energy Consumption
Method: Least Squares
Sample: 1970 - 2005
Included observations: 36

Variables	Coefficient	Std. Error	t-Statistic	Probability
C	-1.153812	0.373161	-3.091997	0.0044*
GDP Growth > 6.5% (GDPD)	0.011104	0.006482	1.712981	0.0974***
Industrial Growth	0.084196	0.013686	6.152087	0.0000*
Registered Vehicles	0.054201	0.002781	19.48839	0.0000*
Population	0.239157	0.115534	2.070012	0.0475**
Manufacturing Exports	0.014117	0.004979	2.835280	0.0083*
Manufacturing Imports	-0.002946	0.003648	-0.807704	0.4258
R-squared	**0.991810**	Mean dependent var		3.488056
Adjusted R-squared	**0.990116**	S.D. dependent var		1.289936
S.E. of regression	0.128246	F-statistic		585.3237
Sum squared resid	0.476962	Prob(F-statistic)		0.000000
Log likelihood	26.74728	Durbin-Watson stat		1.66045
Testing for presence of Auto- Correlation: Breusch-Godfrey Auto-Correlation LM Test				
F-statistic	0.644936	Probability		0.428694
Obs*R-squared	0.810534	Probability		0.367962

Note: * Significant at 1% confidence level ** Significant at 5% confidence level
*** Significant at 10% confidence level

This model shown above has GDP dummy variable identified as 1 whenever the GDP growth rate for India from 1970 to 2005 exceeds 6.5% level and 0 otherwise.

It is to be noted that whenever the GDP growth rate of India has crossed 6.5% level, it has exerted a positive relationship with energy consumption. If the GDP growth rate above 6.5% is increased by 1% it leads to an increase in energy consumption level by 1.11%. This is statistically significant at 10% confidence level. This only suggests that there are positive effects on energy consumption whenever the GDP growth rate for India crosses above 6.5%.

Among the other variables, viz., industry share in GDP and registered vehicles associate a positive relationship with energy consumption level and both are statistically significant at 1% confidence level. The population growth variable is also having a positive association with energy consumption and is statistically significant at 5% confidence level.

The manufacturing trade variables, manufacturing exports and imports have a contrasting relationship with energy consumption. The former has a positive statistically significant relationship at 1% confidence level while the later exert a negative relationship and has no statistical significance.

The R square value of 0.99 means 99% of variation in the energy consumption for India which is explained by the growth variables during 1970 to 2005 period and the adjusted R square value also stand at 99%. The Breusch-Godfrey Auto- Correlation LM Test stated below the equation results show that the model does not suffer with auto-correlation problem, which indicates that the overall goodness of the fit is highly significant.

Table 1B: Threshold Regression Analysis for India at GDP growth > 7%

Dependent Variable: Energy Consumption
Method: Least Squares
Sample: 1970 - 2005
Included observations: 36

Variables	Coefficient	Std. Error	t-Statistic	Probability
C	*1.201002*	*0.369856*	*-3.247217*	*0.0029**
GDP Growth > 7% (GDPD)	*0.013129*	*0.006548*	*2.004945*	*0.0544***
Industrial Growth	*0.083467*	*0.013473*	*6.194975*	*0.0000**
Registered Vehicles	*0.054512*	*0.002745*	*19.85975*	*0.0000**
Population	*0.266538*	*0.116904*	*2.279975*	*0.0301***
Manufacturing Exports	*0.014082*	*0.004896*	*2.876399*	*0.0075**
Manufacturing Imports	*-0.002843*	*0.003587*	*-0.792652*	*0.4344*
R-squared	**0.992079**	Mean dependent var		3.488056
Adjusted R-squared	**0.990441**	S.D. dependent var		1.289936
S.E. of regression	0.126120	F-statistic	605.3841	
Sum squared resid	0.461282	Prob(F-statistic)		0.000000
Log likelihood	27.34896	Durbin-Watson stat		1.603362
Testing for presence of Auto- Correlation: Breusch-Godfrey Auto-Correlation LM Test				
	F-statistic	0.938341	Probability	0.340998
	Obs*R-squared	1.167319	Probability	0.279953

Note:
* Significant at 1% confidence level
** Significant at 5% confidence level

This model shown above has GDP dummy variable identified as 1 whenever the GDP growth rate for India from 1970 to 2005 exceeds 7% level and 0 otherwise.

It is to be noted that whenever the GDP growth rate of India has crossed 7% level, it has exerted a positive relationship with energy consumption. If the GDP growth rate above 7% is increased by 1%, it leads to an increase in energy consumption level by 1.13%. This is statistically significant at 10% confidence level. This only suggests that the positive effects on energy consumption whenever the GDP growth rate for India crosses above 7%.

One interesting point which is worth noting here is that the when GDP growth rate is increased above 7% level compared to previous 6.5%, the increase in energy consumption levels has gone up by 0.02%. This suggests that whenever the growth rate of GDP is increasing, the energy consumption levels are also exerting a marginal increase.

Among the other variables, viz., industry share in GDP and registered vehicles associate a positive relationship with energy consumption level and both are statistically significant at 1% confidence level. The population growth variable is also having a positive association with energy consumption and is statistically significant at 5% confidence level.

The manufacturing trade variables, manufacturing exports and imports have a contrasting relationship with energy consumption. The former has a positive statistically significant relationship at 1% confidence level while the later exert a negative relationship and has no statistical significance.

The R square value of 0.99 means 99% of variation in the energy consumption for India which is explained by the growth variables during 1970 to 2005 period and the adjusted R square value also stands at 99%. The Breusch-Godfrey Auto- Correlation LM Test shows that the model does not suffer with auto-correlation problem, which indicates that the overall goodness of the fit is highly significant.

Table 1C: Regression Analysis for India at GDP growth > 7.5%

Dependent Variable: Energy Consumption
Method: Least Squares
Sample: 1970 - 2005
Included observations: 36

Variables	Coefficient	Std. Error	t-Statistic	Probability
C	*-1.112079*	*0.353169*	*-3.148860*	*0.0038**
GDP Growth > 7.5% (GDPD)	*0.017395*	*0.007167*	*2.427264*	*0.0217***
Industrial Growth	*0.080005*	*0.013329*	*6.002140*	*0.0000**
Registered Vehicles	*0.054073*	*0.002658*	*20.34127*	*0.0000**
Population	*0.283406*	*0.113389*	*2.499419*	*0.0183***
Manufacturing Exports	*0.015104*	*0.004788*	*3.154470*	*0.0037**
Manufacturing Imports	*-0.004662*	*0.003567*	*-1.306995*	*0.2015*
R-squared	**0.992504**	Mean dependent var		3.488056
Adjusted R-squared	**0.990953**	S.D. dependent var		1.289936
S.E. of regression	0.122691	F-statistic		639.9757
Sum squared resid	0.436536	Prob(F-statistic)		0.000000
Log likelihood	28.34146	Durbin-Watson stat		1.663070
Testing for presence of Auto- Correlation: Breusch-Godfrey Auto- Correlation LM Test				
F-statistic	0.580004	Probability	0.452678	
Obs*R-squared	0.730586	Probability	0.392693	

Note:
* Significant at 1% confidence level
** Significant at 5% confidence level

In this model the GDP dummy variable is identified as 1 whenever the GDP growth rate for India from 1970 to 2005 exceeds 7.5% level and 0 otherwise.

When the GDP growth rate of India has crossed 7.5% level, it has also exerted a positive relationship with energy consumption. If the GDP growth rate above 7.5% is increased by 1%, it leads to an increase in energy consumption level by 1.17%. This time it is statistically significant at 5% confidence level. This once again proves that there is a strong positive effect on energy consumption whenever the GDP growth rate for India crosses above 7.5%.

The two interesting point highlighted here are that when the GDP growth rate is increased above 7.5% level compared to previous 7% and 6.5%, the increase in energy consumption levels has gone up by 0.06%. This suggests that more the increase in GDP growth rate, higher the energy consumption levels. The other point which attracts the attention is the statistical significance of this variable. As GDP growth rate kept increasing its statistical significance improved from 10% to 1% confidence level suggesting that the findings are robust.

The other variables in the model exert a similar relationship with energy consumption as analyzed in the previous models. The R square value for this model is also 99% and the adjusted R square value also stand at 99%. The Breusch-Godfrey Auto-Correlation LM Test shows that the model does not suffer from auto-correlation problem, which indicates that the overall goodness of the fit is highly significant.

5. Concluding Remarks

While the existing empirical works till date have focused on the effects of economic growth and trade on environmental degradation. This work will contribute a new approach to the study of environment quality and growth by examining for India to show that the higher levels of growth are leading to imbalances in environment. Other aspect examined is the role played by the rapid economic growth led by industrialization on the levels of energy consumption. This study can further be extended in a different approach to see at what higher levels of economic growth do the energy consumption is getting affected.

The high levels of energy consumption are driven by rapid economic growth, industrialization, international trade in industrial goods, along with rate of growth of registered vehicles. This suggests that too much of economic growth is too bad for environmental quality. However, the cut in energy consumption levels is not possible because of its negative effect on growth. But surely, the fast emerging economies like India can look forward to cut down the rate at which they are growing, which can lead to restoration in environment imbalances in the years to come.

There is also a huge scope to carry forward this research study further by looking at the aspects of long run relationship and direction of causality between energy consumption, economic growth and industrialization in any economy. This would ensure more robust results and much more meaningful analysis which could be helpful for the policy makers of the countries to frame an inclusive environment quality-led growth policy in the years to come.

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