Is India attaining a sustainable energy-led growth?

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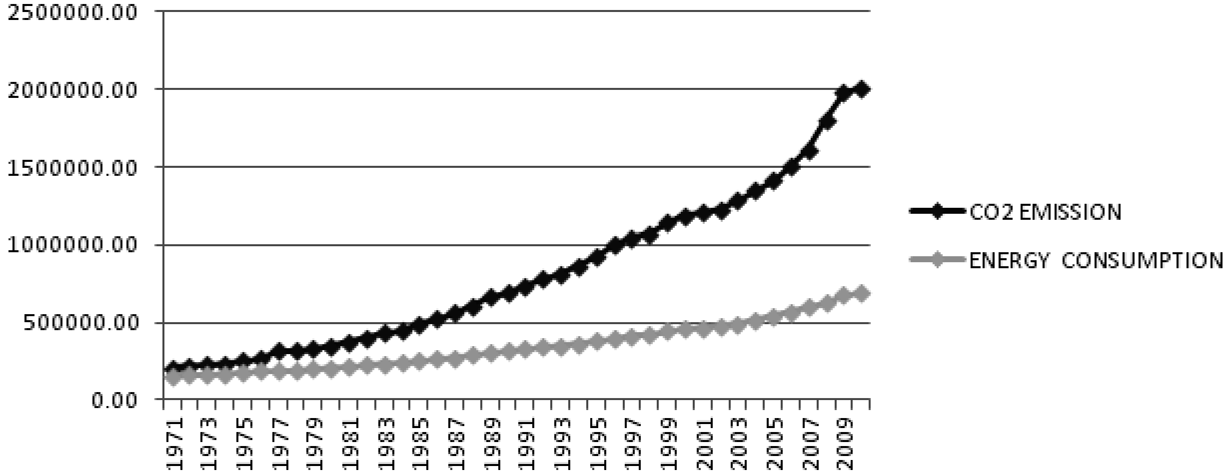
Introduction

Growth story of India is not a fairly new topic for researchers. For last three decades, India is experiencing an elevated growth. This phenomenal growth has been stimulated by widespread technological progression. And this progression is attributed to extensive energy consumption in terms of electricity (Ghosh 2002: 125-126). During 1971-2010, energy consumption of India has gone up to 4.43 times. This growth in energy consumption has boosted the economic growth in India. Cheng (1999) had established the existence of strong unidirectional causal relationship between energy consumption and economic growth in India for the time period 1952-1995. Though Asafu-Adjaye (2000) had established causal relationship in reverse direction and Paul and Bhattacharya (2004) had established a bidirectional causal relationship, these views can be kept apart in due course of this discussion. Keeping the scope of this discussion in mind, causal relationship from energy consumption to economic growth established by Cheng (1999) is considered.

Whenever energy consumption is considered, majorly depletable fossil fuel energy consumption is considered. During 1971-2010, consumption of fossil fuel has gone up from 37.05% in 1971 to 72.67% in 2010, as percentage of total energy consumption. But alongside this growth in fossil fuel consumption, emission level in environment has also gone up. During 1971-2010, Carbon Dioxide (CO_2) emission has gone up from 205869.05 kilo tons in 1971 to 1979424.60 kilo tons in 2010, i.e. nearly an increase of 9.61 times. It is very interesting to observe that the increase in CO_2 emission is more than double of the increase in energy consumption (Figure 1). Hence the increased consumption of fossil fuel, which is enabling the growth of India, is also deteriorating the environment in which the growth is taking place. While discussing about impact of foreign direct investment (FDI) on environment, Acharyya (2009) points out that in a developing country like India, environment is provided with less importance with a view to exerting a pull on fresh investments. This environmental damage caused by economic growth is in the similar lines of Environment Kuznet Curve (EKC). Panayotou (1993) established inverted U-curve relationship between environmental damage and economic growth for developing countries. On a similar note, Dinda (2004) has expressed his doubt about the second half of EKC. He has shown a conflict among the researchers about the level of income at which the environmental degradation starts to decline. Hence the pace at which economy is growing, is affecting the environment in which it is growing. In such kind of circumstances, a growth trajectory can't be considered as a sustainable growth trajectory. But the statement is still needed to be validated.

Figure 1. CO_2 Emission and Energy Consumption pattern in India (1971-2010)



While talking about environmental damages, several kinds of pollutions are considered. Those are air pollution, water pollution, land pollution, light pollution, noise pollution, thermal pollution, visual pollution, radioactive pollution etc. But considering the scope of this paper, only air pollution has been taken care of. Out of all emissions under this category, CO_2 emission has been considered. Selection of the scope of the paper is solely based on the severity of selected indicators in environmental degradation. CO_2 emission caused by increased amount of energy consumption is the matter of concern here. Sustainability of Indian economic growth is needed to be analyzed, given the energy consumption level and CO_2 emission.

Analysis of Indian Growth History

India's growth trajectory has been phenomenal since 80's. From a decadal average of 4.03% in 1961-70 and 3.08% in 1971-80, the gross domestic product (GDP) has gone up to 5.57% in 1980-2000 and 7.47% in 2001-10. Quality of this growth can also be seen in terms of the improvement in industrial value added, which has gone up to 27.32% of GDP in 2001-10 from 19.93% in 1961-70. It clearly shows an evidence of India's growth in productivity over the years. It has been possible by the augmentation is technological front. This augmentation signifies one of the major components of neoclassical growth model, i.e. the productivity growth. This needs to be measured in the Indian context. Denoting *y* as per capita output, and *k* as per capita capital formation, Solow growth model along with Hicks-neutral productivity term (*B*) provides us with,

$$\frac{dy}{y} = \frac{dB}{B} + \alpha \frac{dk}{k} \qquad \text{... (1)}$$

After regressing with the per capita values for India during 1971-2010, dB/B comes out to be 0.464 at 5% significance level. It symbolizes technological growth at a pace of 46.40% for the mentioned period. On the other hand, growth in industrial value added during the mentioned period is amounted to be 46.58%. It is evident that extensive technological progression has resulted in industrial development, which in turn supplemented economic growth. Hence, for further analysis, growth in industrial value added can be considered as a proxy for technological progression.

Table 1. Top 10 countries in terms of Energy Consumption 1971-2010 (kilo tons of oil equivalent)

Country Name	1971	1980	1990	2000	2010
United States	1587469.89	1804678.44	1914996.33	2273331.69	2216323.99
Japan	267528.47	344522.71	439325.22	518963.66	496849.12
India	156464.80	205154.56	316743.22	457214.21	692689.01
Germany	305049.25	357175.66	351145.23	336584.18	327374.66
France	158571.01	191770.25	223889.52	251867.39	262288.16
Canada	141352.61	192608.78	208542.48	251439.67	251838.45
United Kingdom	208676.42	198431.52	205919.95	222936.25	202506.32
Italy	105397.27	130837.86	146556.17	171522.10	170238.88
Poland	86124.43	126619.99	103104.58	89115.96	101454.48
Spain	42606.18	67693.70	90084.86	121969.50	127739.45

However, technological progression cannot take place in isolation. It happens either endogenously or exogenously. Glass and Saggi (1998) discussed about technology transfer via FDI route for the countries, like Mexico, Brazil, India, and China. During 1975-2010, net inflow in terms of FDI has increased from –$10,326,250 to $24,159,180,000. This statistics reflects the extent of technology transfer during that period. Exogenous nature of technology transfer has been discussed by Krugman (1979) and Dollar (1986). This exogenously transferred technology from the developed countries is internalized by the developing countries (Pack and Saggi, 1997). It then takes the form of endogenous technological development. Utilization of this technology requires adequate infrastructural development. Role of energy consumption plays a major role in this regard. Rapid growth in energy consumption supplemented this technological progression. During 1971-2010, energy consumption in India has grown from 156464.80 to 692689.01 kilo tons of oil equivalent. By looking across the world, it can be visualized that energy consumption level of India is at per level with the energy consumption level of the developed countries of the world (Table 1). The demand for energy catalyzed by technological progression was supplemented by five-year plans. Starting from the second five-year plan, heavy industrial sector started to develop. In order to boost up domestic industrial production, capital goods started to be imported and

coal production was increased. As percentage of total energy consumption, fossil fuel consumption has been increased from 37.05% in 1971 to 72.67% in 2010. For infrastructural development purpose, total investment on the power sector has been substantial throughout the span of five-year plans. In eleventh five-year plan, the total outlay in power sector has been the highest so far (Table 2). If power sector of India is looked at, it can be seen that it is majorly driven by coal production. 54% of entire established electricity production facility is coal dependent. In addition to that, more than 70% of the electricity produced is from coal dependent power plants. During 1971-2010, unprocessed coal consumption by diverse industrial sectors has gone up to more than 8 times (
Table *3*).

Table 2. Realized Investment on Power sector as a percentage of five year plan outlay

Five year plans	Duration	Percentage of total outlay
Fourth	1969-1974	21.2
Fifth	1974-1979	25.2
Sixth	1980-1985	28.1
Seventh	1985-1990	28.2
Eighth	1992-1997	26.6
Ninth	1997-2002	26.7
Tenth	2002-2007	22.4
Eleventh	2007-2012	32.4

This indicates the elevated demand of coal in industrial production. Nearly 90% of all the coalmines are managed by government, which signifies an institutional monopoly. However, Captive mining policy was initiated in 1993 with a view to resulting in competition and precision. Under this policy, government has assigned more than 200 coal blocks for expansion by private / public organizations exterior to the state-run coal corporations. Out of 200, merely 30 mines have begun extraction that amounted to be just 36.30 million tons in 2010-11 in opposition to a goal of 104 million tons (World Energy Council, 2012). In order to cover the demand-supply gap, coal import was increased. Starting from 0.22 million metric tons in 1978-79, it has gone up to 67.75 million metric tons in 2009-10. Redesigning the Ramsey type growth model, adopted by Babiker (2001), it can be found that net balance of payment (BOP) deficit is directly proportional to net fossil fuel import. Current account deficit has gone up to $51,781 million in 2010 from $147.51 million in 1975. Not only coal import, but also the crude oil import plays a major role in this context. During 2009, 159 million metric tons of crude oil import was priced at Rs. 3754 billion. In the subsequent year, 163 million metric tons of crude oil import was priced at Rs. 4559 billion (World Energy Council, 2012). This signifies a 2.52% raise in capacity, but 21.44% raise in terms of price. Rising demand of fossil fuel can in turn exert more pressure on BOP deficit.

Table 3. Consumption of Unprocessed Coal by Various Sectors (million metric tons)

Year	Electricity	Steel & Washery	Cement	Railways	Paper	Cotton	Others	Total
1970-71	13.21	13.53	3.52	15.58	0.27	1.45	23.67	71.23
1973-74	16.64	13.78	3.65	13.92	1.00	1.78	26.89	77.66
1978-79	24.80	20.26	4.88	12.13	1.72	2.34	34.02	100.15
1979-80	30.03	19.85	3.87	11.36	1.54	1.99	36.89	105.53
1984-85	57.66	25.00	7.29	9.46	2.83	2.57	36.64	141.45
1989-90	108.32	30.61	9.53	5.80	2.90	2.70	43.56	203.42
1990-91	113.71	30.91	10.43	5.42	2.81	2.58	47.68	213.36
1991-92	126.84	34.03	10.80	5.06	2.67	1.96	50.97	232.33
1996-97	199.62	39.76	10.08	0.14	3.51	1.31	44.20	298.62
2001-02	265.19	30.04	14.85	-	2.78	0.94	35.96	349.74
2002-03	267.90	30.60	16.36	-	2.79	0.72	43.37	361.75
2003-04	279.96	29.67	16.63	-	2.51	0.52	50.11	379.41
2004-05	305.35	34.43	18.10	-	2.61	0.46	46.46	407.41
2005-06	316.49	32.42	18.08	-	2.77	0.29	63.21	433.26
2006-07	331.58	34.90	19.67	-	2.62	0.30	73.25	462.32
2007-08	360.74	39.02	21.35	-	2.64	0.37	78.55	502.66
2008-09	407.49	40.99	21.79	-	2.95	-	64.58	537.79
2009-10	411.06	41.11	21.34	-	3.50	0.27	110.20	587.40

Issues regarding Sustainability of Growth

With a rising GDP growth, employment opportunities also rise simultaneously. This results in migration of rural population to urban population and a rapid urbanization. Through structural decomposition analysis on Chinese economic data for 1992-2002, Peters, Weber, Guan and Hubacek (2007) has shown that urbanization is a major cause for increased CO_2 emission. On a similar note, Gupta (2005) attributed rapid urbanization as a reason for CO_2 emission and climate change. However, these studies mainly focused on middle and high income level countries. A panel data analysis of 99 countries for 1975-2005 was conducted by Phetkeo and Kaneko (2010). They have found out that for India, urbanization leads to lower energy utilization. They have attributed the high population density in urban areas for this phenomenon. They have also pointed out that a reallocation of fuel resources from biomass to fossil fuels has increased the emission level. While conducting a comparative energy transition survey in India and China, Pachauri and Jiang (2008) found out that a reallocation of fuel resources from biomass to fossil fuels leads to lower energy utilization, which is consistent with the results of Phetkeo and Kaneko (2010). During 1971-2010, it is also found out that negative elasticity exists between rate of urbanization and per capita energy consumption and that is amounted to be -0.808 between 5% and 10% significance level. Technological progression at the same time is dependent on the level of migration and energy consumption. However, both of them lead to high amount of CO_2 emission. Hence, any direct relationship cannot be established between per capita growth in output and the level of emission. Extension of Solow growth model along with Hicks-neutral productivity term can be done with a view to establishing a relationship between per capita growth in output and CO_2 emission.

Traditional Solow growth model is given by: $\frac{dy}{y} = \frac{dB}{B} + \alpha \frac{dk}{k}$ ***… (2)***

The Hicks-neutral productivity term can be broken: $\frac{dB}{B} = e\frac{dE}{E} + u\frac{dU}{U}$ ***… (3)***

In light of the previous discussion, the technological progression has been attributed to per capita energy consumption (*E*) and degree of urbanization (*U*). Elasticities of the two aforementioned factors are given by *e* and *u* respectively.

In the similar lines with Pachauri and Jiang (2008) and Phetkeo and Kaneko (2010), relationship between per capita energy consumption (E) and degree of urbanization (U) can be formulated as:

$$\frac{dU}{U} = -x\frac{dE}{E} \quad \text{… (4)}$$

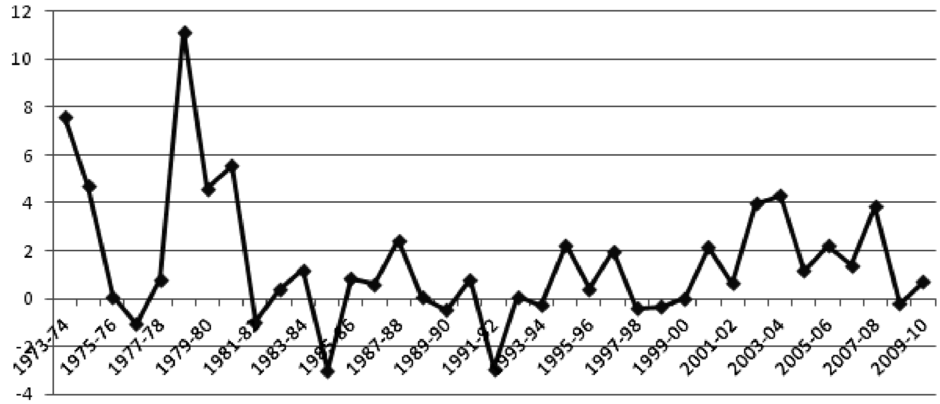
Relationship between per capita energy consumption (E) and CO_2 emission (C) can be written as:

$$\frac{dC}{C} = c\frac{dE}{E} \quad \text{… (5)}$$

Now putting all the values in equation 2, it can be written that: $\frac{dy}{y} = \frac{(e-ux)}{c}\frac{dC}{C} + \alpha\frac{dk}{k}$ ***… (6)***

First component in the right hand side of equation 6 is critical in this context. Elasticity of CO_2 emission with respect to per capita output gives out an indication of environmental damage over a period. In order to calculate the individual values of elasticity, 1971-2010 statistics is considered along with the individual equations. Putting values in equation 4 provides with x = 0.122. Similarly, equation 5 provides with c = 0.277 and equation 2 provides with α = 0.421. Value of α is slightly higher than that of derived by Robertson (2010). Equation 3 provides with the values u = 3.057 and e = -0.160. Negative elasticity of per capita energy consumption is consistent with the propositions of Birol and Keppler (2000). According to them, technological advancement leads to greater energy efficiency, thereby reducing the energy consumption per unit of output. Finally, the elasticity of CO_2 emission comes out to be -1.924. This consequence is significant while keeping EKC hypothesis in mind. Negative elasticity of CO_2 emission depicts a long run scenario regarding the sustainability of growth trajectory in India. Trend of this elasticity tried to be established throughout the study period. It has been shown in Figure 2.

Figure 2. Elasticity of CO_2 Emission during 1971-2010



A vigilant look at Figure 2 reveals that the elasticity of CO_2 emission is showing a declining trend. It symbolizes that with the graduation time, economic growth will reduce the emission level. A few back of envelope calculations show that the derived long run elasticity of CO_2 emission will be achieved during 2062-63. A study on Indian states by Greenstone and Hanna (2011) revealed that the air pollution level is in a declining phase. The result derived by them show that the regulatory framework in India has enabled this ecological improvement. But the significant delay in achieving the objective can be attributed to the institutional voids. In a study on ecological modernization of China, Mol (2006) has also mentioned about the institutional voids, which catalyzes environmental degradation.

Institutional Contributions in Environmental Protection

Though institutional voids are there, accomplishing the movement of Indian economic growth trajectory towards EKC was supplemented largely by regulatory frameworks. Protection of environment is not a very new matter of interest for policymakers. Air (Prevention and Control of Pollution) act came into existence on 29th March, 1981. Five years back, in 1976, appended in Indian constitution was amended by article 48A, which focused on environment and wildlife protection (Prasad 2006: 1278). This in turn resulted in the institutional body in the form of Ministry of Environment and Forests, in 1985 (Khagram 2004: 270). The same fact has been identified by Hadden (1987) as well.

Till 1984, these institutional bodies were not performing at their full capacity. But the Bhopal gas disaster in 1984 almost revolutionized the scenario. According to Meagher (1990), it led to a reassessment of the environmental fortification mechanism in India. Cha (2005) has documented a series of communal welfare litigations in Supreme Court and an augmentation towards the enhancement of elementary privilege of Indian citizens. It was a stepping stone in the direction of all-round environmental protection movement in India. All the way through the late 80s and 90s, India sustained to take up a progression of courses of action premeditated to thwart the consequences of mounting environmental degradation. These courses of action were at the vanguard of India's ecological protection endeavors.

It is not only the income level which enables India to move en route for turnaround point on EKC, but also the institutional measures. Rather it could be said that institutional measures play more vital role in controlling the environmental degradation in comparison with income level (Greenstone and Hanna 2011: 26). This is a feature which is not captured in terms of the scope of EKC hypothesis. Several researchers put forward their sincere efforts to establish this relationship. While demonstrating the mediating nature of institutionalization in the association between environmental value and economic growth, Dasgupta and Mäler (1995: 2412) have stated that "The connection between environmental protection and civil and political rights is a close one". While establishing an association between deforestation and economic growth in Latin America, Africa and Asia, Bhattarai and Hammig (2001) bring into play a dimension of institutional characteristics for giving an explanation of the responsibility of diverse policy establishments. They have used it as an explanatory variable in the environmental degradation and economic growth relationship. But none of these studies were able to establish a significant correlation between institutionalization effect and environmental degradation. Inability of EKC to capture the time effect has also been pointed out by Dinda (2004). This leaves an ample amount of scope to revise the EKC hypothesis due to its inconclusive nature.

But leaving the limitations of EKC apart, it can be said that institutional robustness has played a very significant role in protecting Indian environmental assets. Not moving beyond the scope of the paper, it can be concluded that the policy measures implemented, voluntarily or by compulsion, have assisted in achieving the objective of sustainability of Indian economic growth, at least from air pollution alleviation perspective.

Conclusions

It has been visualized here that on the basis on 1971-2010 statistics, in the long run India is about to achieve sustainable growth trajectory, considering CO_2 emission as the major component of environmental degradation. Economic growth, coupled with institutional robustness is allowing the CO_2 emission to come down. Perhaps within next 50 years of time the EKC turnaround point will also be achieved. But in a broader sense, energy-led growth brings forth many other issues, which were not discussed in this paper. Captive mining policy is leading towards escalating number of cases regarding land acquisition. In various states of central and eastern India, law and order mechanism is creating bottleneck in mining business and parallel economy running in those states are restricting the adequate infrastructural development. Rapid industrialization is resulting in huge deforestation, leaving behind soil and water pollution as consequences.

While going for a detailed sustainability of growth analysis, these are some of the factors which are needed to be considered. Quantified incorporation of these factors in the EKC model can provide a more detailed framework for economic growth analysis, considering the elevated energy consumption. Of course, neoclassical growth theory can also provide a supplementary support in this analysis. But more robust models can be preferred over that, as the new growth theory models has already emerged.

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