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Environmental Performance and its Determinant Factors: A Comparative Study of India and China

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Abstract

India and China are two biggest developing and transitional economies of Asia. These countries have experienced rapid economic growth over the years but are among the biggest consumers of energy as well as heaviest emitters of C02. The present study is undertaken to examine the trends in Environmental Performance and selected variables affecting it (Trade Openness, Technological Innovation and Economic Growth), to compare the impact of these variables on Environmental Performance in India and China and to test the existence of EKC hypothesis in the two countries. The study makes use of secondary data for the period 1990-2016. For the purpose of the study, CO2 emissions (metric tons per capita) are taken as a proxy for Environmental performance, sum of exports and imports as a percentage of GDP for Trade Openness, number of patents registered by residents and non- residents (sum) for Technological Innovation, and GDP per capita (constant 2010 US$) for Economic growth. The study depicts an increasing trend in all the variables for both countries, with China growing at a much higher pace. The results of the analysis using OLS Multiple Regression illustrate a positive relationship between GDP per capita and CO2 emissions, a negative relationship between Technological Innovation and CO2 emissions in both India and China. Trade Openness is found to be positively related with C02 missions in case of China. However, the relationship between Trade Openness and CO2 emissions is not found to be significant in case of India. Further, the results of the study prove the existence of EKC Hypothesis for China but it is not factual for India. The findings of the study have important policy implications for India and China.

JEL Classification: O11, O57, Q55, Q56

Keywords: Economic Growth, Environment, Technological Innovation, Trade Openness, Population

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1. Introduction

In recent years, measuring the welfare of a country has become one of the highly debated issues in the economic research. Economic welfare has always been the need of the economy. However, it has to be supported with social as well as the environmental welfare. A country's performance is often ranked by analyzing the level of development in terms of GDP, but this approach has faced strong criticism. World Bank has written "The basic objective of development is to create an enabling environment for people to enjoy long, healthy and creative lives. But it is often forgotten in the immediate concern with the accumulation of commodities and financial wealth".

Every nation strives for Economic growth. In recent years, environmental condition and climate change has become one of the most important policy issues. This aspect has been ignored earlier by western developed countries in 1970s and 1980s. Increased interest in environmental issues is being seen at both micro level and macro level. At the microeconomic level, stakeholders are highly concerned with firm's environmental performance in order to take their investment decisions. On the other hand, at macroeconomic level, environmental performance of country can be seen as the ability of a country to produce environmental public goods.

India and China are the two big and fast changing economies of Asia. Both the countries started the journey in the same time in almost same circumstances. At present, these countries are large enough and account for one- third of the world's population. However, they are in different stages in terms of economic development, technology, trade, use of energy, culture and well as beliefs. Both the countries play a very important role in the politics and economy all over the world. As per 2017, China's GDP per capita has been $8,118.3 while for India, it has been $1,723.3 i.e. a 4.71 times higher figure for China as compared to India.The economy of China had been based on manufacturing and India is considered to be a mix of both manufacturing and services based economy. Over the period 1989-2018, China has attained 9.61% Economic Growth and for India the growth rate has been 6.15%(Economics, 2018). Much progress had been made by both the countries, mainly China in terms of economy as well as reducing poverty.

Economic development comes with the cost of environmental deterioration in a country. This is because Economic Development involves use of primary energy which in turn plays a huge role in impacting the environmental performance of a country. China and India consume large amount of energy and also emit CO2 on a large scale. In 2017, the two countries together contributed to 34.6% of CO2 emissions which was even more than one third of the world total (International Energy Outlook).

Coal is also a major contributor in impacting the environmental performance. It results in maximum amount of CO2 emissions which in turn have a major share in Green house gases.

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With the high demand by Power sector in India and China, there was a rapid increase in the coal consumption. In 2017, India contributed to 11.4 % while China contributed to 50.7% of the world's coal consumption.

Today China had climbed up much faster than India in terms of economy and prosperity. Moreover in terms of environmental performance, it is ahead of India. India is ranked 177 as compared to 122 for China on the Environmental Performance Index as per 2018. Though, both the countries suffer from poor air quality. It is important to learn from other countries and for India to formulate its policies and move ahead on its development path, it can take lessons from China's evidence. Since both India and China are rapidly growing, innovating, trading and accounting nearly 37% of the world population, it is useful to compare the impact of such macroeconomic variables on environmental performance. So, this study examines the trends in environmental performance and its determining factors; analyses the impact of Economic growth, Technical innovation, and Trade openness on the Environmental Performance in India and China; tests the existence of EKC hypothesis in India and China.

1.1 Literature Review

Various studies have been conducted which analyzed the Environmental quality in India and China. **Bosworth and Collins (2008)** in "Accounting for Growth: Comparing China and India" studied the sources of economic growth in these countries and did a comparative analysis about their experience over last 25 years. **Lema and Lema (2012)** in a study entitled "Technology Transfer? The Rise of China and India in Green Technology Sectors" examined the technology transfers taking place between India and China on the basis of three main green technology sectors i.e. solar energy ,wind energy and vehicles based on electric modes.

Hossein-Ali Fakher, Zahra Abedi (2017) in "Relationship between Environmental Quality and Economic Growth in Developing Countries" used ARDL methods in panel data for 1983 to 2013 time span. Trade openness, Environmental performance and FDI were found to have significant positive impact on Economic growth .**J.M.D.D.J. de Alwis (2014)** in "Environmental Consequence of Trade Openness for Environmental Goods" examined the impact of EGS trade on environmental quality considering three indicators (SO2, NO2 and CO2) using cross country data for 62 countries. It showed the EGS trade liberalization led to fall in pollution but had no relation with the level of income in the countries but favor countries rich in capital to reduce pollution.

Jung Yun Choi and Doo Bong Han (2018) in "The Links between Environmental Innovation and Environmental Performance: Evidence for High- and Middle-Income Countries" analyzed how technology and innovations related to environment using data corresponding to high and middle income countries for the period 1996–2011. It was found that reduction in SO2 and

CO2 as a result of environmental innovations is seen to exist for high income countries but not for middle income.

Isabel et al. (2014) in "Environmental Performance in Countries Worldwide: Determinant Factors and Multivariate Analysis" used the HJ- bipilot to analyze the environmental performance of countries on the basis of variables that can influence it taking sample of 149 countries. Results showed that socioeconomic factors (such as economic wealth and education), and also institutional factors (style of public administration, control of corruption) determine the country's environmental performance. However, the political factors had no effect on environmental performance.

Tonmoy Chowdhury, Sadia Islam (2018) in "Environmental performance index and GDP growth rate: Evidence from BRICS countries" examined EPI and GDP trends. The study for 2008-2016 indicated an inverse relationship between GDP growth rate and EPI index. Expect for Russia, correlation between EPI and GDP growth was not found to be strong.

Apra Sinha (2018)in a study entitled "Is India Tunneling through Environmental Kuznets Curve? An Empirical Analysis" examined the relationship between CO2 emissions and GDP per capita for the period 1960 to 2011.Existence of EKC relationship has been found through the study. Various studies like **Sohag et al. (2015)** in "Dynamics of energy use, technological innovation, economic growth and trade openness in Malaysia" showed positive impact of technological innovation on environmental quality**. Ameer and Munir (2016)** in "Effect of economic growth, trade openness, urbanization, and technology on environment of Asian emerging economies" studied the data for 11 countries and results implied that SO2 emissions are increased with technology and trade openness, while reduced with urbanization.

1.2 Rationale and Objectives

On the basis of existing literature, it has been found that a lot of studies have been conducted that analyzed the environmental performance of India and China using diverse methods. However, no such comprehensive study has been undertaken that has covered several aspects together.

The basic objectives of the current study can be stated as following:

1. To compare the trends in Environmental Performance, Technological Innovation, Trade Openness, and Economic growth for India and China.
2. To analyze the impact of Technological Innovation, Trade Openness, and Economic growth on Environmental performance in India and China.
3. To test the EKC hypothesis for India and China.

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1.3 Research Methodology

The present study is an exploratory research and is based entirely on secondary data. In the study, "Environmental Performance, Trade openness, Technological innovation, and Economic growth" are taken as the variables. The data has been taken from "World Development Indicators (WDI) of the World Bank - published in 2017" in order to study the trends and compare the impact of the variables on the CO2 emission of China and India. The period covers from 1990 to 2016. For Trade Openness (sum of Export and Import as % of GDP); for Economic growth (GDP per capita (constant 2010 US$)) is utilized; for CO2 emissions, (CO2 emissions (metric tons per capita)); for Technological innovation (TI)(sum of the number of patents registered by residents and non- residents) are taken as a proxy of the variable..

The rapidly increasing rate of growth has been a major contributor in increasing the possibility of global warming and climate change. Every nation puts efforts to reduce the carbon footprint. Constant research is undertaken to introduce green technologies that minimize the adverse impact on environment. However, a negative impact has been found in some studies. Fall in CO2 and SO2 emissions was found with innovations in high income countries and not in low income countries (Choi and Han,2018).

There are however different views on how environmental performance is related with economic growth. "Growth is considered to be a precondition for environmental improvement" (Bhagwati, 1993).According to Beckerman (1992) "the strong correlation between incomes and extent to which environmental protection measures are adopted demonstrates that, in the longer run, the surest way to improve your environment is to become rich". An inverted U shaped relationship between per capita income and environmental degradation (EKC hypothesis) has been suggested by some studies.

Trade Openness taken (sum of exports and imports as a percentage of GDP) does not necessarily improve or worsen the Environmental Performance of countries. The impact varies from country to country depending upon the income levels and composition of commodities traded (Shahbaz et al., 2017).

So, firstly the trends for these macroeconomic variables (CO2 emissions, Trade openness, Technological innovation, and GDP per capita) are studied using graphical representation. In order to fulfill the second objective of the research, technique of OLS Multiple Regression is used. CO2 emissions (CO2) are taken as the dependent variable and Trade openness (TO), Technological innovation (TI), and GDP per capita (GDP) as the explanatory variables.

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Functional form of the model can be stated as following:

$$CO2 = \int (TO, TI, GDP) \quad (1)$$

Linear Econometric form of the model is as given below:

$$CO2_t = \square_{\square\square}\square\square\square_{\square}\square\square_t + \square_{\square}\square\square_t + \square_{\square\square}GDP_t + \square_t \quad (2)$$

In the above equation, $\square_{\square\square\square}$is the intercept term $\square_{\square\square\square}\square_{\square\square\square}\square_{\square}\square$and $\square_{\square\square}$are the coefficients of the explanatory variables. $\square\square\square$refers to the error term and subscript t depicts the time period.

Further, as far as the third objective of the study in concerned, EKC relationship is examined for India and China using the regression analysis.CO2 emissions being considered as the proxy for environmental deterioration and GDP per capita for Economic growth, the following regression equation is formed:

$$CO2_t = \square_{\square\square\square}\square\square\square_{\square}GDP + \square_{\square}GDP^{\wedge 2} + e_t \quad (3)$$

Here, CO2 emissions are taken as the dependent variable and GDP per capita as the independent variable.Co2 emissions is regressed on GDP and GDP square. Squared values of GDP are taken to examine the long term impact of Economic growth on environment.

2. Data Analysis

On the basis of the objectives of the research, Data Analysis is divided into three parts. Firstly, the trends in Environmental Performance, Technological Innovation, Trade Openness and Economic growth are studied for India and China. In the next part, impact of these variables is tested on C02 emissions and then existence of EKC relationship is checked for both the countries.

2.1 Trends in Environmental Performance, Trade Openness, Technological Innovation, and Economic growth for India and China

In this section, trends in the stated variables and countries are analyzed for the period 1990-2016 using line graph representation.

2.1.1 Environmental Performance

Carbon dioxide emissions are the major factor contributing to the Environmental Performance of the country. With the industrialization, Co2 emissions have been increasing at a large scale contributing to environmental deterioration.

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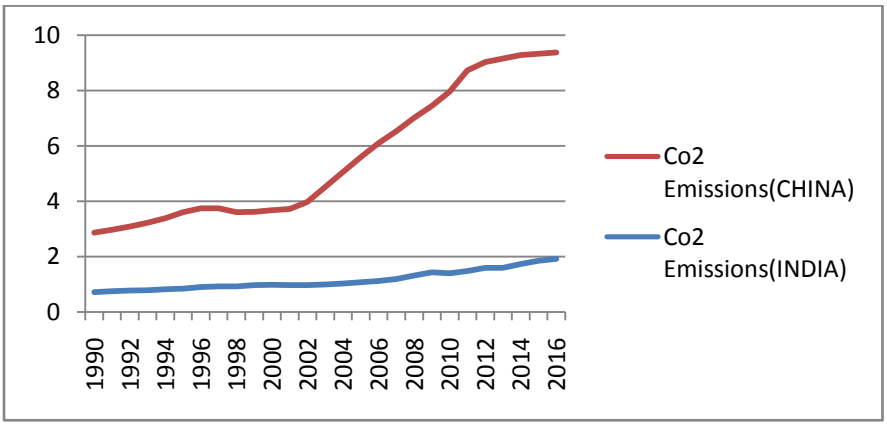
Fig1: India, China CO2 emissions (metric tons per capita)



Source: Author's own representation on the basis of World Bank data

In case of China, over the period 1990-2016, CO2 emissions (metric tons per capita) has increased from 2.15 (metric tons per capita) in 1990 to 7.45 (metric tons per capita) in 2016. This implies a 3.4 times increase in CO2 emissions from 1990 to 2016. An increasing trend is seen for China except for the years 1997-1999 and then further 2014-2016. Relatively flatter portion of the line graph after 2013 in case of China reduction in the carbon dioxide emissions. This recent fall in the CO2 emissions have been a result of fall in industrial activity and surge in hydropower. This resulted in reduced coal use and falling electricity demand.

In case of India, CO2 emissions have seen an increasing trend over the period but it has however always been less than in China. A 2.7 times increase in CO2 emissions has been seen from 1990-2016. India's CO2 emissions are highly derived from the energy sector. Industrialization, rapid economic growth and lifestyle changes have contributed to the increase in CO2 emissions.

2.1.2 Trade Openness

Trade openness is taken as the sum of imports and exports as a percentage of GDP. Trade openness is linked with economic benefits, technology and skill transfer and increased productivity.

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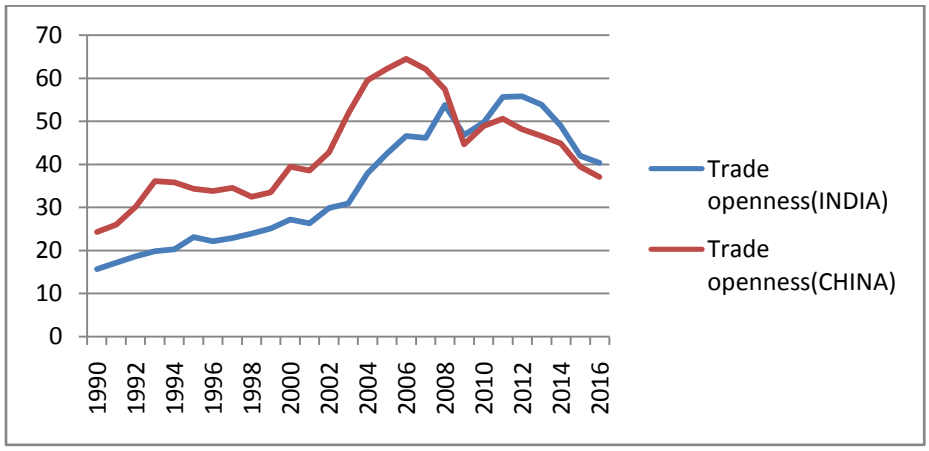
Fig2: India, China Trade openness (sum of Export and Import as % of GDP)



Source: Author's own representation on the basis of World Bank data

With the industrialization and ever since the trade liberalization in 1991, rapid increase in the trade has been seen for both the countries. However it has been more robust in case of China. Trade openness ratio for China was 38.50% in 2000, which is the year before it joined the WTO. It became 143rd member of WTO in 2001 and then the foreign trade of China increased rapidly. A very high ratio was seen in 2007 i.e. at 62.20%.However, a strong drop was seen with the global financial crisis and it fell down to 44.8% in 2009.Since then, it has not been able to reach the previous levels. Rising domestic demand and shifts in export competitiveness has been a contributor in such decline.

India's trade openness has increased from 15.67% in 1990 to 40.34% in 2016. In 2003, India's openness ratio was about 30.92%, which was two times of what it was a decade before (i.e., 15.67% in 1990), but only 59.6% of what the value was for China. However, Trade openness ratio for India has been rising since 2000. The reason behind this could be attributed to aggressive trade liberalization after 2000. India's openness ratio increased to 53.76% in 2008, or 93.57% of the ratio for China. With the Global Financial crisis, decline was seen in case of India as well. The maximum was attained at 55.79% in 2012, even higher than the figure for China which was 48.10%.

2.1.3 Technological Innovation

Technological innovation comprise of the activities that contribute to the research and development, designing of new products, services or techniques. Moreover, it involves improvement of existing products and generates new technological knowledge.

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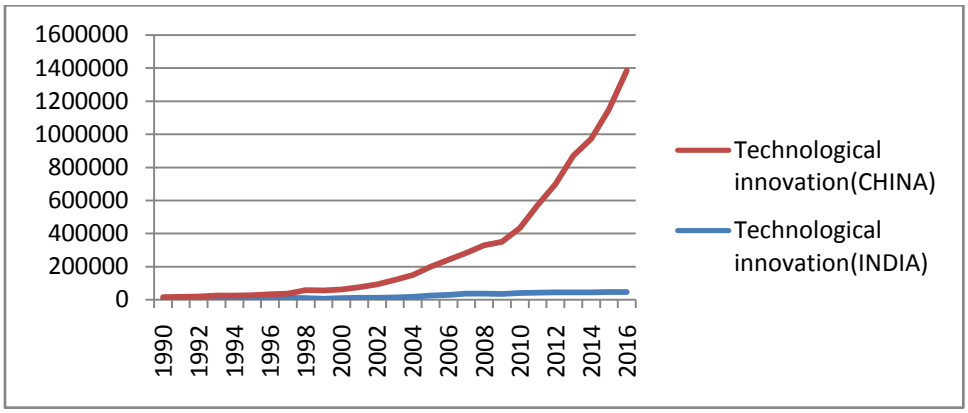
Number of patents registered are linked with the research and development activity and Innovation and thus considered as an indicator of Technological Innovation.

Fig 3: India, China Number of patents registered by residents and non- residents (sum)



Source: Author's own representation on the basis of World Bank data

The pace of technological innovation has been rapid in case of China as compared to India. Following the period of almost same level of technological innovation, China started moving ahead in 1990 and now both the countries are poles apart if we compare the level of technological innovation. In case of India, over the period 1990-2016, technological innovation (number of patents registered by residents and non residents) has grown from 3820 in 1990 to 45057 in 2016. However, it still remained only 3.36% of the value for China. There has been approximately 12 times increase in the patents from 1990 to 2016 in case of India whereas, in case of China the figure depicts 132 times increase over the period. The patents increased from 10137 in 1990 to 1338503 in 2016.This increase shows massive spending on education, research, and infrastructure. Moreover, globalization along with the increase in Foreign Direct Investments has contributed to this fast changing scenario for China.

2.1.4 Economic Growth

One of the widely used methods of measuring material standards of living is GDP per capita. It is an important indicator of Economic growth and is calculated by dividing Gross Domestic Product in a year by the population.

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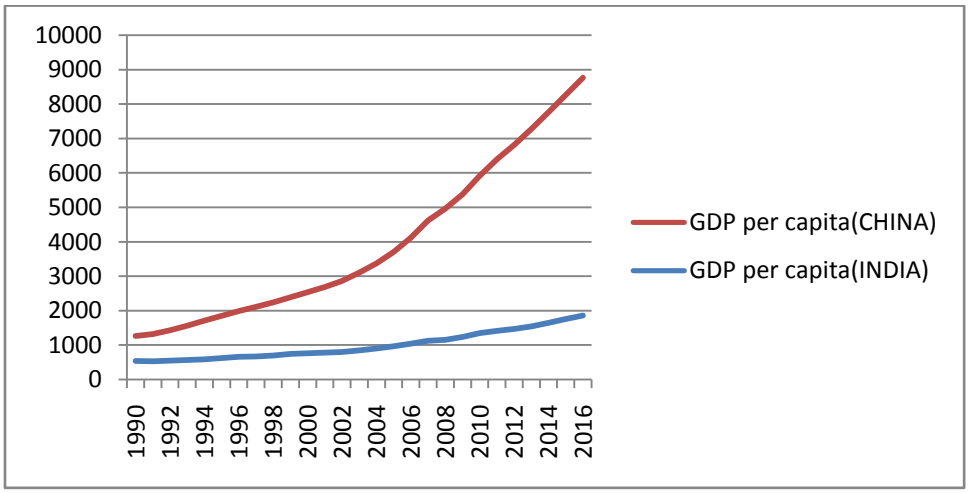
Fig 4: India, China GDP per capita (constant 2010 US$)



Source: Author's own representation on the basis of World Bank data

In the past 25 years, China and India have achieved extraordinary economic performance. Their share of global gross domestic product has also been increasing rapidly. With the GDP per capita(constant 2010 US$)of 730.77 in 1990, there has been an increase to 6894.46 by the year 2016 in China i.e. almost 9.5 times increase. The GDP per capita in the last decade of 20th century more than doubled and increased 2.4 times between 2001- 2010. The highest GDP per capita growth rate was seen in year 2007 i.e. by 13.63% with high liquidity but it fell by the year end due to weakening of global demand and tight monetary policy to curb inflation. Since then, growth rate in GDP per capita has not reached such high levels. However there has been increasing trend over the entire period 1990-2016 for both India and China. The increasing trend can be attributed to the countries increasing their dimensions into global knowledge and turning towards a global economy. India's GDP per capita saw an increase from 536.16 in 1990 to 1964.59 in 2016 which accounts for nearly 3.6 times increase. After the financial crisis in 1991, India adopted trade liberalization and opened up for Foreign Direct Investments. This led to gradual increase in the growth rates. Much of the recent growth is contributed by expansion of services through Information technology, services of the business, commerce and banking. One of the reasons behind China lying much ahead of India is much higher investment rate and policies to control population while taking benefits from sharp increases in productivity.

2.2 Impact of Trade Openness, Technological Innovation and Economic growth on Environmental performance in India and China

For the case of India, following regression equation has been formed on the basis of OLS Multiple Regression:

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$$CO2 = 0.28 - 0.0019TO - 8.1E\text{-}07TI + 0.000947GDP + e_t \quad (4)$$

Multiple Regression value of 0.99 indicates high degree of correlation between dependent and independent variables. 98.95% of the variation in Co2 emissions is explained by the Trade openness, technological innovation and GDP as indicated by the R square value of 0.9895.

Technological Innovation and GDP per capita are found to have significant impact on CO2 emissions in India. Technological innovation is negatively related and GDP per capita is positively related with CO2 emissions.

Further, the analysis is conducted for China and following regression equation is formed:

$$CO2 = 0.71 + 0.002TO - 2.2E\text{-}06TI + 0.0014GDP + e_t \quad (5)$$

Multiple R value of 0.988 indicates high degree of correlation between dependent and independent variables. R square value of 0.9766 depicts that 97.66 % of the variation in CO2 emissions is explained by the Trade openness, technological innovation, GDP. Considering the p values at 5% level of significance, Technological innovation and GDP are found to have significant impact on the Co2 emissions. In case of China, GDP and trade openness are found to be positively related with Co2 emissions. Technological innovation is found to be negatively related with C02 emissions.

In comparing the results for India and China, it is found that Economic Growth is related positively with CO2 emissions in both the countries. Economic growth in these countries is taking place at the cost of destroying the environment. It can be said that countries are not adopting much measures to prevent the harmful impact on environment. However, if we consider Technological innovation individually, it can be seen that with more and more patents being registered, CO2 emissions are falling and thus improving the environmental performance of both the countries. The reason maybe that countries are involving into Research and Development involving Environmental Friendly techniques of Production. Also fall in C02 emissions with increasing patents can be attributed to Green technology and environment related patents. So, India and China should follow the present innovation trend and thus it would have a possibility of improving the environmental quality in the long run.

The positive relationship between trade openness and CO2 emissions in China may be because of use of fossil fuel and coals i.e. non renewable energy in the export goods. Also, import items comprise a large portion of fossil fuel and coal. India can however go for trade openness and innovate more in green production.

It can be said that use of energy is playing a major and important role in the development of India and China.In the last few years, though significant development has been seen in

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renewable energy sector such as solar energy, wind energy. However, it is not enough and more emphasis needs to be given in order to develop while preserving the environment.

2.3 EKC Relationship for India and China

The tradeoff between Economic Growth and Environmental sustainability has become one of the most debatable topics. While Economic growth is considered to be associated with higher energy consumption and thus poor air quality, there are different views linked to it. Environmental Kuznets Curve (EKC) Hypothesis says that "economic development initially leads to deterioration in the environment". However, after a level of economic growth is attained, there tends to be a decline in the levels of environmental degradation. Basically, it postulates that economic growth is required for better environmental performance.

According to EKC hypothesis, an inverted U shaped relationship exists between Economic growth and Environmental Degradation. The explanation for the existence of inverted U shape can be categorized into two types of effects. First one is the Composition Effect which says that economies move from subsistence levels to more intensive patterns of agriculture, to industrialization and then to service sector. Composition effect leads to environmental damage at a faster rate than income (Ekins 1997). Second effect is Displacement effect according to which as the income increases, demand for environmental quality also increases. So, the third objective of the study attempts to find out if EKC relationship exists for India and China for the period 1990 to 2016.

The results of regression on the basis of equation (3) indicate high degree of correlation between the Environmental degradation and Economic growth for both India and China. In case of India, R square value of 0.988 indicates 98.8% of variation in CO2 emissions is explained by the GDP.α1 value is found to be 0.000634 and α2 value is 1.01E-07 for India. This implies GDP to be positively related with CO2 emissions in both the periods, thus non existence of EKC relationship for India.

In case of China, R square value of 0.991 indicates 99.1% of variation in CO2 emissions is explained by the GDP. α1 value of 0.001586 and α2 value of -7.6E-08 indicates existence of an inverted U shaped relationship exists between CO2 emissions and GDP in China. In the initial phase, environment tends to deteriorate with the economic growth. However, after a certain level of economic growth, environment quality starts improving.

3. Conclusion

India and China have attained a remarkable growth over the period. Initially, India and China went almost parallel. India's growth rate had come close to China's level after 2000. However, China rocketed beyond limits and thus created a big gap between the economic conditions of two countries. Also the degree of innovation taking place in China has no comparison with India as of now. Technological innovation is contributing to the fall in CO2 emissions and

thereby improving the environmental performance. Trade openness in China is contributing for increased CO2 emissions in China. Economic growth tends to push pressure on the environment in both the countries. EKC relationship is found to exist in China for the period of the study. With the initial economic growth, environmental quality deteriorates and after certain level environmental quality starts to improve. In case of India, EKC relationship does not exist as per the study and Economic growth is leading to poor environmental performance in both short and long run. The results from the study suggest some policy implications for India and China.

India and China are facing rapid economic growth. The use of non renewable energy is however increasing with it. Changes in personal expenditure and service needs of economy are contributing to transition. China will be producing 35% of the world energy concentrated goods in 2040(International Energy Outlook 2018) which is more than twice than that of India. Such energy intensive commodities are highly tradable and are responsible for connecting China globally with the supply chain.

In case of India, largest increase in the energy use would be seen in 2040 i.e. 33% more than the developed countries (International Energy Outlook 2018). Increase in the usage of energy levels in India will come from changes in industrial structure. As per the report, India will not be able to reach the levels of China by 2040 in terms of GDP or energy use. Even though strong development has been attained by India and China in the energy sector, there is always a need for much more progress. One of the important sectors that matters to both the countries is the Power sector. The highest amount of primary energy is used up by this sector.

Both the countries have taken policy actions to switch away from coal to renewable energy. However, in the case of power sector, there has been no development in fuel requirement. It is not possible to reduce the CO2 emissions overnight, thus the countries should use more of renewable energy (such as solar energy, wind power, nuclear energy, hydroelectricity etc). This would minimize the CO2 emissions and also keep the economic growth in level without deteriorating the environment. A significant progress is gained by China in the renewable energy sector whereas, India still lacks far behind. Both India and China should take necessary steps to reduce the CO2 emissions and prevent environmental deterioration. The countries should adopt appropriate policy actions and also follow a roadmap on energy use especially in power sector.

Since technological innovation is contributing to lessen the CO2 emissions for both India and China, the present pace of innovation should be maintained to improve the environmental quality. Various industries contribute to deterioration of atmosphere but by including the clean and green technology in those industries, environmental performance can be improved on the whole. So, more and more investment should be done in Research and Development in the industrial sector. Also university based research can help in improving the situation. Environmental friendly technologies should be brought up. China has recently developed

and improved in this sector but there is a long way to go. India has to take strong initiatives to match the pace of China.

Trade openness creates new options for earning profits, creating jobs, setting up new industries and thereby, cancelling off the negative impact of foreign competition. So as per the results of the study, India should continue with its trade practices. Trade openness will increase the economic growth as well as development of the country by saving the environment. However, China should be cautious in formulating the trade policy and should keep the growth and environmental targets in consideration. Trade openness should be followed as a policy measure in both India and China

In conclusion, trade in favor of environment, technology and policy relating to energy use is very important to realize balanced and sustainable growth of India and China. It is very important to maintain the quality of Environment and this would provide advantage in many ways. It would attract more FDI, help in improving the local and international trade and expanding stock market. It is high time that environmental quality should move hand in hand with the economic growth. However, it is not any single or isolated policy action that is required. Rather, an integrated macroeconomic policy is needed to tackle the situation.

Limitations and Future Prospects

The scope of the study could have been better with the availability of data for recent years and usage of other econometric tools consistent with time series data. The study can be further extended by including various other variables and considering the case of developed countries as well.

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