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Impact of Industrialization, Urbanization and Energy Consumption on Environmental Degradation: Evidence from India

Abstract *Industrialization and Urbanization are the important pillars for economic growth in a country however, a threat to the natural environment. The major aim of this study is to empirically analyze the effect of industrialization, urbanization, and energy consumption on the environment in India. Annual data for the span of 1975-2018 is analyzed. Augmented Dickey-Fuller (ADF) and (PP) tests are adopted for checking the stationarity. After confirming long-run cointegration in all the variables, the study used a linear regression model for the estimates of the value of the coefficient of the variables. The estimates of the model show urbanization and consumption of energy have a positive significant (negative effect on the environment) whereas industrialization has a negative insignificant impact on emissions of CO2. It is recommended based on this study results that real planning regarding urbanization along with energy use is the need for the Indian economy, to control the high emissions of CO2.*

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Introduction

If we look around the world, the variable that differentiates between a developed and developing country is the structure of their economies. This can be seen from the difference in the per capita income of the countries. Most of the developed countries are industrialized one whereas the developing countries are relying on the agriculture sector. It will not be wrong to say that industrialization is the backbone of economic development for a country (Chen et al, 2014).

Studies (Samouel and Aram, 2016; Chen et al, 2014) also suggest that industrialization has a direct link with urbanization. Xu and Lin (2015) stated that

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industrialization is an important factor for the urbanization process and leads to job creation, reduces unemployment, increase income, and other economic activities. Similarly, the urbanization process results in the migration of people from rural towards urban areas due to poverty and fewer employment opportunities (Malik et al., 2017). History also shows that almost all the developed countries are enjoying higher Gross Domestic Product (GDP) along with having a higher rate of urbanization. Urbanization and industrialization create job opportunities, reduces unemployment, uplift life standard, expedite capital accumulation which contribute to economic growth and sustainable development (Raheem and Ogebe, 2017). Both the factors (industrialization and urbanization) are no doubt the drivers of economic growth, which is the objective of most countries (Yansui et al., 2015).

Beyond question, most of the literature (Chen et al, 2014; Xuemei et al, 2012; Poumanyvong & Kaneko, 2010) have supported a theoretical ground for the direct association between industrialization, urbanization, and growth of the economy, however, empirical studies also proofed that both the factors are responsible for the increase in energy consumption and contributes to environmental degradation.

Environmental degradation has become a global issue, especially from the last decade, and attracted the attention of researchers from all over the world. The importance of environmental issues got special attention in the development process of a county since 1972, after the Stockholm conference on Human Environment and Sustainable Development. Researchers are interested to know about the major factors that are responsible for environmental damage (Owusu and Sarkodie, 2016). The major reason documented in literature behind the climate change and damage to the natural environment is the increase in Carbon Dioxide (CO_2 emissions) emissions due to an increase occurred in energy use because of industrialization and urbanization (Sarkodie and Owusu, 2017). From the previous century (19^{th} century), due to high trend of industrialization along with urbanization, problems of the contaminated environment have been on the increase as witnessed from air pollution, fog, climate issues, soil erosion, floods (Sinha and Bhatt, 2017; Wang et al., 2016).

After independence in 1947, the Gross Domestic Product (GDP) of India was very low (just 3% from 1950 to 1970) even though India is on the second number according to population, around the world. This thing motivated the government for taking new initiative formulated different reforms and give importance to industrial development as a result, the GDP growth rate accelerated and reached 7% in the 1990s. Government of India undertaken even more reforms and the growth rate of GDP reached 7.5% in 2000 and onward (Chaitanya, 2007). Urbanization in India is also on the increase since the 1990s as in that period, the growth rate of the economy was high that motivated more people from rural areas towards urban areas or cities for better job opportunities and living standards. The major factors responsible for urbanization in India include huge population and migration of people from rural areas towards cities as people consider cities as real growth and wealth engine, not only in India but also across the world. In 1950, the population of just 5 cities was more than 1 million in India but in 2011 this much of the population was recorded in 53 cities. It is projected that by 2031, 70 cities in India will have more than 1 million population. Likewise in 2011, 3 cities in India were having a population of more than 10 million but projection shows that in 2031, 6 cities will cross this limit. By 2031, the urban population of India will reach 610 million that will be 40% of its total population (Sadashivam and Tabassu, 2016). Out of 20 densely populated cities in 2030, 5 cities will be from India (includes Mumbai and

Kolkata). This shows an alarming situation of urbanization in the case of India (Confederation of Indian Industry, 2010). This picture gives motivation to the present study to analyze empirically the effect of industrialization, urbanization, and energy use on the degradation of the environment in India.

The study is organized into five parts. The distribution of these is as below. Section 2 consists of fast literature. Section 3 is about the methodology and data while results are given in section4. The conclusion and policy implications are placed in section 5.

Literature Review

Theories are available that suggest positive as well as the negative association of urbanization and

industrialization on the environment like The Compact City theory and Ecological Modernization theory favored the positive effect of urbanization on the environment as urbanization increases the best utilization of public infrastructure, increases economies of scale, and helps in reducing environmental damage. Also, due to increase income and high standard of living, and innovation in industrial sectors may reduce environmental damage so contributes positively to the natural environment (Poumanyvong and Kaneko, 2010). On the contrary, The Environmental Transition theory argued that an increase in income, consumption along manufacturing activities due to industrialization and urbanization contribute a negative effect on the natural environment (Mol and Spaargaren, 2000).

The interesting study of Dasgupta and Goran (1994) proposed a direct association of industrialization (income) and the environment in long run, meaning that industrialization is good for the natural environment in a long period. This study was also supported by Grossman and Krueger (1995). They argued that at the pre-industrialized stage of an economy, degradation of the environment got increased because of pollution but, after reaching a certain point (industrialized economies come to turning point), the situation changed due to innovation and an increase in the level of income. The relationship becomes positive between industrialization and the environment. This relationship between industrialization (income) and reducing industrial pollution is called the Environmental Kuznets Curve (EKC) which has been suggested to adopt for the relationship between environmental quality and other macroeconomic variables. many studies (Eaken and Selden, 1995; Galeotti, et al. 2006; Lapinskienė et al. (2013) confirmed the same inverted U-shaped connection between income and degradation of the environment.

Many studies are present that analyzed the effect of industrialization on the environment on the ground of industrial structure like Zhu et al. (2014) found that when industrial structure got shifted from energy-intensive into non-energy intensive, it helps a lot in reduction of CO_2 emissions. Likewise, industrialized countries like Germany, Japan, China, India, Russia, and the European Union are the main contributor to emissions of CO_2 (UN,2017).

Rayhanet al. (2018) conducted a study and found that industrialization is a factor behind water pollution (because of pollutant effluents in water) as well as air pollution (because of solid waste disposal). Also, the emissions of toxic gases from these industries are a major reason behind emissions of CO_2 as all these are the by-products of these industries. Likewise, Shahabad et al. (2017) argued that industrialization results in an increase in the use of polluting vehicles as well as manufacturing trash that increases emissions of CO_2. Hosseini and Kaneko (2013) results were also not different from these

studies. Others like Salim and Shaflei (2014) for nine industrialized economies and Shahbaz et al. (2014) for Bangladesh confirmed the same positive effect of industrialization on emissions of CO_2 (negative effect on the environment) in different periods. Also, Raheem and Ogede (2017) empirically analyzed the data of 20 countries in Africa from 1980 to 2013. The study was conducted to find the total effect, direct effect, and indirect effect of industrialization on emissions of CO_2 and the environment. Interestingly, the results showed that the direct influence of industrialization was positive on emissions of CO_2 but the indirect impact, based on per capita income, of industrialization on emissions of CO_2 was negative meaning that industrialization is good for the environment. The total effect of industrialization on the environment was also positive in the studied area.

In the empirical literature, urbanization is also shown to be an important factor behind environmental quality like Ali et al. (2016) analyzed the association between CO_2 emissions and urbanization, industrialization, energy use for the Nigerian economy. They confirmed a positive and significant association of energy usage whereas the insignificant effect of urbanization on emissions of CO_2. Similarly, Xu and Lin (2015) confirmed the same insignificant effect of urbanization on CO_2 however a nonlinear association between industrialization and CO_2 emissions. Sadorsky (2015) analyzed the data of emerging economies and confirmed a positive association of urbanization and energy use on emissions of CO_2 in the long run, by Autoregressive distributed lags (ARDL) model. Azam and Khan (2016) for Sri Lanka and Pakistan and Azam et al. (2016) for industrialized economics showed the same significant positive impact of energy use and urbanization on emissions of CO_2.

On the contrary, empirical studies also showed that urbanization helps in the reduction of emissions of CO_2. Sharma (2011) analyzed the determinants of CO_2 emissions for 69 countries of the global panel from 1985 to 2005. The countries were sub-divided into 3 panels based on their income level. It was concluded that the association of per capita total primary energy consumption and consumption per capita electricity consumption was negative and significant in the global panel. Also, urbanization and emissions of CO_2 showed a negative significant association for global and in low income, middle income, and high-income panels. Azam and Khan (2016) also confirmed the negative association of urbanization and emissions of CO_2 in Bangladesh and India in their study.

Alam et al. (2014) used the data of the Malaysian economy from 1975 to 2013 for the association between CO_2 emissions and other macroeconomic variables. Based on the generalized method of moments (GMM), they concluded a positive significant effect of energy use on emissions of CO_2. Charfeddine and Ben Khediri (2015) analyzed the data of the United Arab Emirates (UAE) from 1975 to 2011. The variables of the study were CO_2 emissions, urbanization, electricity consumption among others. The empirical results of cointegration tests confirmed the positive significant effect of electricity consumption and urbanization on the environmental quality of the sample area.

In summary, empirical work from overall the world has been done for analyzing the association of many macroeconomic determinants with CO_2 emissions from time to time, on different sample areas, different sample sizes, with the help of different analytical techniques. As our study is showing the effect of urbanization, industrialization, and energy use on emissions of CO_2 that is why the literature presented above covered the association of these specific variables. The major purpose of the present study is the analysis of the association of urbanization, industrialization, and energy use with the

degradation of the environment in India. Table 1 is about the summary of the mentioned literature.

Table 1. Summary of Empirical work on the effect of urbanization, industrialization, energy use with CO_2 emissions

Researchers	Sample and Period	Variables	Model	Conclusion
Poumanyvong and Kaneko (2010)	99 countries (19S95-2010)	Urbanization, usage of energies, emissions of CO2.	STIRPAT model	Direct association of urbanization and energy use with emissions of CO_2.
Sharma (2011)	69 A global panel of countries (1985–2005)	Urbanization, Energy use, per capita GDP and emissions of CO_2	The dynamic panel data model	Inverse significant association of energy use with CO_2 emissions for the panel of the globe. Negative significant association of urbanization with emissions of CO_2 for the global panel as well middle, low- and high-income group.
Xu and Lin (2015)	30 provinces of China (1990-2011)	Urban populationn, emissions of CO_2, Industrialization	Panel Nonparametric regression models.	Positive U type for Central regions and Inverted U type association in Eastern regions between urbanization and emissions of CO_2. Nonlinear Inverted U-shaped association confirmed for Industrialization and CO_2 emissions in 3areas.
Sadorsky (2015)	Emerging economies (1971 – 2009)	Emissions of CO_2, Urban population. GDP	ARDL and STIRPAT model.	Insignificant positive association in urbanization and emissions of CO_2.
Azam and Khan (2016)	Pakistan, India, Bangladesh, India, Sri Lanka (1982-2013)	Emissions of CO_2, Urban population	Least square Method	Negative association of urbanization with emissions of CO_2 in Bangladesh and India. Positive significant association of urbanization and emissions of CO_2 in Sri Lanka and insignificant positive association between the two in Pakistan.
Siddique et al (2016)	South Asia (1983-2013)	Urbanization, energy usage, emissions of CO_2	Panel cointegration	Significance positive association of urbanization and energy use on emissions of CO_2.

Ali et al. (2016)	Nigeria (1971-2011)	Urbanization, emissions of CO2, GDP per capita.	ARDL approach	No Significant association of urbanization and emissions of CO_2. Positive significant association of energy use and emissions of CO_2.
Raheem and Ogebe (2017)	20 Countries in Africa (1980-2013)	Urbanization, income, industrial production, urbanization, emissions of CO_2	Heterogeneous panel estimators	Positive association between emissions of CO_2 with urbanization and industrialization when analyzed in direct sample. Negative association between emissions of CO_2 with the indirect urbanization and industrialization when analyzed indirect (through per capita income).
Pata UK (2017)	Turkey (1974-2013)	Urbanization, GDP, industrial output, use of energy, emissions of CO_2	ARDL testing approach	Positive association of Industrialization, Per capita GDP, energy use with emissions of CO_2 both in short and long time period.
Liu and Bae (2018)	China (1970-2015)	Urbanization, emissions of CO2, real GDP, industrialization, energy use.	VECM, ARDL	Positive association exist for all the variables with emissions of CO_2.

Data and Empirical Method

This section is about the variables, its data sources, explanation, and specification of the model used in this study.

Data Source and Variables Explanation

This research work is carried out on time series data covering the span of 1975 to 2018. There are four variables used in this study. The dependent variable is environmental degradation which is proxied by CO_2 emissions (emissions of CO_2 metric tons per capita. The independent variables are industrialization (industry includes construction value-added percentage of GDP); urbanization (urban population as a percentage of the total population) and energy use (kg of oil equivalent per capita). The data of these variables are retrieved from World Bank Development Indicators (WDI). A linear function is developed to study the link of emissions of CO_2 and its determinants in the long term.

Model Specifications

The link between CO_2 emissions and its various determinants has been analyzed by researchers using different methods. This study follows the analytical techniques employed by Azam et al. (2016) for their studies. Augmented Dickey and Fuller (1979) and Phillips and Perron (1988) tests are adopted for the unit root characteristics of the variables in the study. After confirming the stationarity of all the variables, Johansen's (1991, 1995) cointegration test is adopted to know the long-run link among the variables. Linear Regression is used for the evaluation of the coefficients.

The methodology of Azam et al. (2016) and Jayanthakumaran et al. (2012) is adopted in this study for the association of CO_2 emissions and other variables in the long term as follows.

$$CO_2 = \omega_0 + \omega_1 ind + \omega_2 ur + \omega_3 kt + e_1 \quad (1)$$

Where CO_2 shows CO2 emissions (Metric tons per capita); ind stands for industrialization, ur represents urbanization, kt is energy use and e_1 is an error term.

The expected direction of the above slope coefficients is

$\omega_1 > 0$; $\omega_2 > 0$; $\omega_3 > 0$

Empirical Results

The empirical estimation obtained by all the econometric techniques used in this study is given below.

Result of ADF and PP unit Root Tests

Augmented Dickey-Fuller (ADF) (1979) and Phillips and Perron (1988) tests are applied for unit root estimation in this study. The ADF test can be written mathematically as follows

$$\Delta\varphi_t = \emptyset\varphi_{t-1} + \acute{x}\,\sigma + \epsilon_t \quad (2)$$

where $\emptyset = \rho - 1$ $-1 \leq \rho \leq 1$ for which the model in hypothesized form is:

$$H_0: \emptyset = 0 \; or \; \rho = 1$$

$$H_1: \emptyset < 0 \; or \; -1 \leq \rho \leq 0$$

The t-ratio of the $\emptyset$ -coefficient of ADF test in which test statistic distribution is affected by the serial correlation is adjusted by the Phillips-Perron (PP) test as follows:

$$\acute{t_\emptyset} = t_\emptyset \left(\frac{\gamma_0}{f_0}\right)^{1/2} - \frac{T(f_0 - \gamma_0)\left(se(\widehat{\emptyset})\right)}{2f_0^{\frac{1}{2}}s} \quad (3)$$

Where f_0 is the zero occurrence of residual and γ_0 is the evaluation of error variance. The result of these tests is there in Table 2. CO_2 emissions, energy consumption, and growth are non-stationary by both (ADF and PP test) and become stationary at first difference whereas industrialization got stationary with a second difference by both (ADF and PP test) when included both intercept and trend.

Table 2. Unit Root Test Results

Variables	Result of ADF Test		Result of PP-Test	
	Intercept	Intercept & Trend	Intercept	Intercept & Trend
ind	-5.0428*	-5.1617*	-4.8930*	-5.0684*
ur	2.8779	1.7350	1.5919	0.3132
	-3.5801*	-4.3701*	-3.9021*	-4.4273*
kt	1.4974	-1.5818	0.9858	-1.7212
	-5.2943*	-5.6462*	-5.6099*	-5.9207*
CO_2	0.5984	-2.3118	0.6984	-2.3402
	-7.4555*	-7.5828*	-7.3833*	-7.5331*

*Significant at 1% significance level

Cointegration Test

Whether a long-run cointegration exists, Johansen (1988) suggested likelihood ratio tests. In equation forms, these tests are presented as follows

$$J_{max} = -Tln\left(1 - \widehat{\lambda_{r+1}}\right) \quad (4)$$

$$J_{trace} = -T \sum_{i=r+1}^{n} \ln\left(1 - \widehat{\lambda_{\iota}}\right) \quad (5)$$

Where λ^i is the ith largest known association and T shows the sample size in the above two equations, results are there in Table 3. This rejected the null hypothesis of no cointegration at 1% and a 5% level of significance.

Table 3. Cointegration test

N.Hypothesis	A. Hypothesis	Trace Test	
		Statistics	Critical Value
r = 0	r = 1	63.81*	47.86
r ≤ 1	r = 2	36.62*	29.80
r ≤ 2	r = 3	42.30*	29.79
r ≤ 3	r = 4	17.02**	15.50
r ≤ 4	r = 5	6.14*	3.81

significance Level: *p < 0.01; **p < 0.05;

Regression Result

Table 4. represents the linear regression model result. It reveals that urbanization and consumption of energy have positive and statistically significant whereas industrialization has a negative statistically insignificant impact on the emissions of CO_2, in the case of the Indian economy.

The results further demonstrate that a 1% percent increase in urbanization results in a 0.03% increase in emissions of CO_2 which is statistically significant at 5% and is supported by studies of Li and Lin (2015), Farhani et al. (2013), York (2007). Also, Raupach et al. (2007) argued that the increase in infrastructure and consumption by households are the factors that increase emissions of CO_2 in urban areas. Farhani et al. (2013) added that the urban population contributes to more use of energy and high trade. These contribute negatively to the natural environment. On the other hand, Charfeddine and Khediri (2015) found that in the long run, urbanization is positively associated with the environment.

The coefficient of energy consumption shows that a 1% increase in energy consumption pollutes the natural environment by about 0.003%. and is significant at a 1% significant level which is supported by Hassan (2018) in Malaysia. For Nigeria, the same result was presented by Ali et al. (2016). On the other hand, Charfeddine and Khediri (2015) found that environmental quality got improved in the long run with an increase in electricity consumption.

The result further shows that a 1% increase in industrialization leads to a decrease in the emissions of CO_2 by about 0.002% however, the result is insignificant. It means that in India, industrialization is not harmful to the natural environment. This result is just like the result of Raheem and Ogede (2017). They argued that due to

industrialization, per capita income got increases that improved living standard of people. People's concern about environmental quality increases so that leads to improvement in the natural environment. On the contrary, most of the empirical studies (Shahabaz et al. 2017; Salim and Shaflei, 2014, to name a few) found a positive effect of industrialization on emissions of CO_2 because of much use of polluting types of machinery and vehicles by industries.

Table 4. Regression Result

DV is CO_2	
Variables	**Coefficients**
C	-1.0611 (0.000)
ind	-0.0016 (0.3840)
ur	0.0329** (0.0001)
kt	0.0027* (0.0000)
R^2	0.994
Durbin-Watson stat	1.86
DV stands for Dependent variable	

**Significant at 1% level; and **significant at 5% level.*

Concluding Remarks

Environmental degradation has become a global issue. This global phenomenon is closely linked with the increased demand for energy. Around the world, the emissions of CO_2 are on the increase that resulted in the degradation of the environment. The importance of industrialization and urbanization in the growth process cannot be denied but both the factors are also the major determinants for energy consumption as well. Keeping in view this connection, the main objective of the empirical work was to analyze empirically the cointegration of industrialization, urbanization, and energy use with the emissions of CO_2 in India from 1975 to 2018. For the purpose, time-series data has been collected from WDI. The collected data was first analyzed for unit root then Johensan cointegration test is adopted for the identification of long-term association among the variables. Once the long-run association got confirmed, the parameters are estimated through the linear regression model. The obtained results of the linear regressions model are statistically significant as well as in line with theory.

The results reveal that urbanization and consumption of energy have a positive significant association with the emissions of CO2 while industrialization has a negative association with environmental degradation. It means that industrialization is environmentally friendly in the case of the Indian economy.

The above results recommend that India may give special attention to population control programs to control the high trend of urbanization. Likewise, policies regarding the proper use of energy for industrialization and urbanization may also be given attention to control the deterioration of the environment.

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