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Effects of Oil Consumption, Urbanization, Economic Growth on Greenhouse Gas Emissions: India via Quantile Approach

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ABSTRACT

Although low-carbon economic growth has been emphasized in both the Paris Agreement and the Sustainable Development Goals, this is the first study to examine the interplay between oil consumption, urbanization, and economic growth in India's GHG emissions from 1965 to 2021. A quantile regression analysis found that a 1% rise in greenhouse gas emissions is linked to a 0.34% rise in economic growth, a 0.599% rise in oil consumption, and a 0.28% drop in urbanization. Using the Granger causality technique, researchers found that CO_2 emissions cause economic development and urbanization in only one direction. On the other hand, oil consumption only has a one-way influence on carbon emissions and urbanization, and economic expansion only has a one-way effect on urbanization.

Keywords: Oil Consumption, Urbanization, Economic Growth, Greenhouse Gas Emissions, Quantile Regression
JEL Classifications: O44, Q40, Q56, R11, R23

1. INTRODUCTION

Greenhouse gas (GHG) emissions far surpass what the environment can handle. Most of this is due to the growth of different economic activities. In reality, over the past few years, worsening environmental conditions have been linked more and more to rising global GHG emissions. Estimates show that all human activities worldwide produced about 46 billion metric tons (or the same amount in CO_2 equivalents) of GHGs in 2010. Because of this, environmental degradation has become one of the most critical problems in many developing countries, like India. In 2014, India was alone responsible for 7% of all carbon dioxide (CO_2) emissions worldwide. This was primarily due to the burning of fossil fuels and industrial activity. India is one of the countries with the most people, and its economy is based chiefly on industrial companies, which are the primary source of carbon emissions (Pachiyappan et al., 2022). So, pollution from human activities has been hurting the environment worldwide for a long time. Because of this, it is imperative to decarbonize the global economy in ways that are good for the environment, such as by lowering carbon production and consumption activities (Siddik et al., 2023).

The industrial revolution made urbanization and industrialization the most important ways to modernize the economy and society. However, these paths speed up the use of fossil fuels and cause a lot of carbon dioxide (CO_2) and other GHGs to be released into the air (Li and Lin, 2015). India's total primary energy consumption in 2019 was 570 million metric tons of oil equivalent, which is expected to increase by 63% over the next decade (Energy Statistics, 2020). Nearly 75% of GHG emissions in India come from making and using energy (IEA, 2020). This makes India the third-largest carbon emitter in the world. Carbon emissions have become a problem worldwide, and building a good infrastructure for the economy is essential. The Environmental Kuznets Curve (EKC) hypothesis is now a common way to look at how the environment affects economic growth. The EKC depicts the environment-growth nexus as an inverted U. The damage to the environment worsens as economic growth slows, peaks as growth speeds up, and then gets better as growth continues. The main idea behind the EKC hypothesis is the "develop first, clean up later" argument. In the early stages, governments only care about economic growth and only pay attention to environmental concerns when economic growth is higher (Tenaw and Beyene, 2021). Unfortunately, growing nations such as India adhere to the preceding norm.

Emerging economies and cities are growing because of policies meant to increase national income, which may be bad for the environment. The world's ecosystem needs to be balanced because cities are proliferating. This is because everything people do releases GHGs, which is becoming a concern for more and more people worldwide concerning the effects of urbanization that cause carbon emissions, so they are paying more attention to infrastructure development that is good for the economy and has low carbon emissions. To thrive in a way that is sustainable and good for the economy, all countries must include goals for protecting the environment in their growth plans. However, burning dirty energy sources is a significant source of GHG emissions, which makes it hard to keep the environment in good shape (Raihan et al., 2022). The environment is no longer just a problem for one person or country but for everyone worldwide. Reducing ecological harm and enhancing environmental quality are among the top economic growth priorities. Traditional businesses' reliance on fossil fuels, which drives their economic growth at the expense of natural resources and environmental damage, is not the same as a model for sustainable development. Businesses must promptly undertake economic restructuring under the umbrella of environmental protection. It is imperative to make changes to production and consumption that are good for the environment and use less carbon to decarbonize the global economy. With this in mind, the Paris Agreement under the UN Framework Convention on Climate Change (UNFCCC) has stressed the need to reduce GHG emissions, mainly to keep global warming well below 2 degrees Celsius above pre-industrial levels (Li et al., 2022). The United Nations made 17 broad sustainable development goals (SDG) to promote low-carbon development by combining economic, social, and environmental well-being (Razzak et al., 2023). In particular, SDG8 and SDG13 call for accelerating economic growth in a way that is good for the environment while reducing the adverse effects of growth on the environment.

This study contributes to the environmental economics literature in the following ways: First, it looks at how developing countries like India use oil, become more urban, grow their economies, and release carbon dioxide. As far as the authors know, this study will also be the first to look at these factors together with India's carbon emissions. So, this study is different from others because it looks at developing countries that have yet to get much or any attention in the past. Second, this study employs quantile regression (QR) for empirical analysis. Another thing that makes this study stand out is that it uses the most up-to-date methods to estimate.

This article is structured as follows: The second section is a survey of the existing literature. The third portion contains data and procedures. In the fourth part, empirical results and discussions have been covered. The final portion delivers the conclusions and policy proposal, too.

2. LITERATURE REVIEW

Economists have looked at the link between rising energy use and growing economies. They have used many econometric methods to determine if there is a link between the two. Economists have been motivated to investigate the relationship between energy, economic growth, and the environment since the late 1990s, when the Kyoto Protocol was adopted out of concern for climate change. Many of these studies have focused on the long-standing tensions between energy and economic growth and the environmental costs of rapid economic expansion. Higher value addition, or economic growth, is inextricably linked to production and consumption, which can be good or bad for the environment, depending on what is causing them. Economic activities that use clean resources are generally seen to affect the environment positively. On the other hand, using dirty resources is likely to hurt the quality of the environment (Jahanger et al., 2022).

Household CO_2 emissions grew by 2.9% and 1.1% for every 1% rise in urbanization, according to Li et al. (2015) calculations in China using the input-output method from 1996 to 2012. Jiang and Lin (2012) used the cointegration method to examine how much energy China's growing cities use. He found that the rate of urbanization and the number of new buildings in China greatly affected how much CO_2 the country made. As a result, it was shown that the rate of change in energy intensity was affected by different energy policies. Xu and Lin (2015) looked at how industrialization and urbanization affected China's CO_2 emissions from 1990 to 2011. They did this by using nonparametric additive regression models. In the eastern area, they found that industrialization and CO_2 emissions were linked in the shape of an upside-down U. However, a positive U-shaped pattern in the centre region indicates that different actions should be taken in these two locations. Khan (2020) suggested that the urbanization rate drove the growth of the global economy. It could set the stage for long-term economic growth if handled correctly. It is a worldwide phenomenon linked to the expansion and diversification of economies.

According to Zi et al. (2016), urbanization is directly linked to CO_2 emissions, where seasonal and regional patterns speed up and slow down urbanization and CO_2 emissions. They use a threshold model to test periodic properties and look at data from China's region from 1979 to 2013. Their findings confirm the following effect of urbanization on CO_2 emissions: (a) Emissions increased when the threshold of 0.43 was surpassed. (b) Emissions increased as residential income rose. (c) The effect of urbanization on emissions rose initially but then fell as the industry's share of overall GDP rose. (d) Patterns of threshold points vary geographically.

Using Toda and Yamamoto's method, Jafri et al. (2015) looked at the Granger causality correlations between economic growth, energy consumption, and emissions from 1980 to 2007 in Bahrain, adjusting for factors like capital and urban population. In particular, they found that environmental degradation is linked to urbanization, GDP growth, capital investment, and energy use. Alam (2021) found that trade and economic growth harmed the environmental quality of Bahrain.

Bhattacharya et al. (2020) looked at data from 70 economies. They found that even though industrialization increases carbon intensity, total factor productivity, use of renewable energy, and urbanization help keep it low. Using resources more efficiently, using clean energy, and making cities more sustainable are all ways to decrease carbon dioxide emissions. Nguyen et al. (2020) used data from 33 emerging economies between 1996 and 2014 and the panel-corrected standard errors estimator to figure out how the total amount of energy used affects carbon emissions. Higher energy consumption was shown to be connected with a higher total carbon emission discharge.

In the research done by Murshed et al. (2022) between 2007 and 2018 in seven developing countries, they think that improvements in energy efficiency, the use of renewable energy, financial inclusion, economic growth, globalization, and urbanization will all increase carbon productivity. The research is also essential because it helps figure out how increasing energy efficiency will affect carbon production in the long run. This has yet to be done and is a missing piece of the existing literature. The results back up the idea that a 1% increase in energy efficiency leads to a 0.3% increase in carbon productivity over time. Also, the expected net effects show that improvements in energy efficiency reduce the huge downward pressure on carbon productivity caused by financial inclusion, globalization of trade, and urbanization.

Khan et al. (2022) used data from 1997 to 2018 to look at the effects of using more renewable energy on the environment in the G7 and E7 countries. They took into account economic growth and population size. Economic growth and population size harm environmental quality by lowering load capacity factor levels. They also found evidence that economic growth and population size have a one-way effect on load capacity factor levels in the G7 and E7 nations.

Murshed et al. (2023) looked into whether the Next 11 countries could meet their goals for reducing carbon dioxide emissions if they used energy more efficiently. They looked at financial inclusion, the use of renewable energy, economic growth, international trade, and urbanization. Their carbon dioxide emissions decreased when these countries used more renewable energy. Nevertheless, faster economic growth, more international trade, and more people living in cities led to higher carbon dioxide emissions.

Dogan and Turkekul (2023) looked at the relationship between many aspects of the U.S. economy, such as CO_2 emissions, energy consumption, real GDP, the square of real GDP, trade openness, urbanization, and financial development, from 1960 to 2010. Cointegration is confirmed by bounds testing to exist between the variables under consideration. Both energy usage and urbanization exacerbate long-term environmental deterioration. The Granger causality test shows that CO_2 and GDP, CO_2 and energy use, CO_2 and urbanization, and GDP and urbanization are all caused by bidirectional causality.

Based on the literature review above, different studies have come to different conclusions about how oil use, urbanization, and economic growth affect the environment. Nevertheless, more research is needed to figure out how the use of oil, the urbanization of land, and the growth of the economy all affect the sustainability of the environment. This study will likely fill in these gaps in India's narrative.

3. DATA AND METHODOLOGY

3.1. Data

In this analysis, I use oil consumption as a proxy for energy consumption, economic growth in current US dollars, and urbanization as a measure of the percentage of the population that lives in cities to estimate the impact of these factors on GHG emissions measured in carbon dioxide emissions in metric tons. This study analysed annual statistics from 1965 until 2021. The information about GHG emissions and oil use was gathered from British Petroleum's website. Economic output and urbanization rates were gathered from the World Bank's website as delineated in Table 1.

3.2. Econometric Methodology

In this article, Koenkar and Bassett's (1978) QR method examines how oil use, urbanization, and economic growth affect India's GHG emissions. Before estimating, we must check the log-form data for introductory statistics. The data failed to meet the criteria of linearity, homoscedasticity, and normality. Thus, QR is used due to the absence of a robust distributional assumption.

$$Q_\tau\left(y_i\right)=\beta_0\left(\tau\right)+\beta_{oc}\left(\tau\right)x_{ioc}+\beta_u\left(\tau\right)x_{iu}+\beta_g\left(\tau\right)x_{ig}+\varepsilon_{it}$$

In the quantile above regression equations, *i* represents the period from 1965 to 2021, respectively; *i* represents the unobserved individual impact; and indicates the number of quantiles of the conditional distribution, whereas $\beta_\propto$, β_u, β_g and are variables used against oil consumption, urbanization and economic growth to investigate the impact of these elements on carbon dioxide emissions. Additionally, the τ^{th} quantile of the conditional distribution was used to estimate the coefficients using the following equation:

$$\widehat{\beta_\tau} = \arg\ \min \sum_{i=1}^{n} \rho_\tau\left(y_i = x_i^\tau \beta\right).$$

In the above equation

$$\rho_\tau\ \left(\mu\right)=\mu\ \left(\tau-1\ \left(\mu<0\right)\right), I\left(\mu<0\right)=\begin{cases}1, & \mu<0\\ 0, & \mu>0\end{cases}$$, indicating

the checking function, and I (.) is an indicator function

4. RESULTS

The descriptive statistics look at the variables' means, standard deviations, minimums, and maximums in Table 2. The results show that the average amount of carbon dioxide emissions is 6.49, while the lowest value is 7.84 and the highest is 5.12. In addition, descriptive data reveal that economic growth has a mean of 27.1 and a standard deviation of 0.89. Oil consumption and urbanization have respective mean values of 4.16 and 1.08. Regarding oil consumption, the minimum, maximum, and standard deviation numbers are 5.47, 2.54, and 0.87, while the same numbers for urbanization are 1.36, 0.75, and 0.18. There are a total of 57 observations.

Our study aims to test the null hypothesis that urbanization, oil consumption, and economic expansion do not significantly impact India's carbon emissions. Table 3 shows the results of the QR at the median.

In Table 3, the LNG and LNO are significant since their $P<0.05$, while for the LNU, the significant value is <0.10. Thus, if there is a rise of 1% in the median value of LNG, then the LNC will increase by 0.34% in the median value; likewise, a 1% increase in the median value of LNO will increase the LNC by 0.599% in the median value. Similarly, a 1% increase in the median value of LNU will decrease the LNC by 0.28% in the median value.

The adjusted R-squared is 94%, and the pseudo-R-squared is 95%. So, LNO, LNU, and LNG are responsible for 94% of the difference between the conditional and actual means in LNC. The Quasi-LR statistic value is 1106.02, and the P<5%, which means the quantile model is stable.

In Table 4 the 10th quantile or 0.100 the LNG will increase by 0.379% and after the 30th quantile it starts declining till 90th quantile and in all the quantiles the P-value is significant. While for the LNO is start declining from the 10th quantile till 50th quantile and their onwards its start increasing till 70th quantile and again gains in 90th quantile, for LNO all the P-values is also significant. The LNU has a negative coefficient values whose value is significant at 40th, 80th, and 90th quantile, thus there is inverse relationship between LNU and LNC.

Figure 1 presents the graph of the quantile process, which displays the impacts of LNG, LNO, and LNU on the LNC. Also included in this figure is the graph of the quantile process. The graph depicting LNG demonstrates rising tendencies up to the 30th percentile of the starting quantile, also known as the 10th. At that point, however, the graph starts to decrease and stays that way until the conclusion of the quantile process. Also, the LNU goes up until the 20th quantile, when it goes down until the 40th quantile. It then goes back up until the 70th quantile, when it starts to go down until the end of the quantile process. This pattern repeats itself until the end of the quantile process. Even though the LNO shows an opposite relationship at first, with a trend of going down until the 30th quantile and then going up until the 70th quantile, it quickly shows a trend of going down until the 80th quantile. Then it increases until the 90th quantile, shortly after the 70th quantile. This occurs shortly after the 70th percentile.

Table 5 displays the results of a pairwise Granger causality test, which indicates that economic growth and oil consumption both show one-way Granger causality towards urbanization, and oil consumption also shows unidirectional causality towards carbon emissions. This suggests that urbanization is a direct result of both factors. The increase in economic activity and urbanization are shown to be caused by carbon emissions in a unidirectional manner.

Table 1: Description of data

Symbols	Variables	Description	Source
LNC	Greenhouse emissions	Million tonnes of carbon dioxide emission from energy	BP
LNO	Oil consumption	Million tonnes	BP
LNU	Urbanization	Urban Population in percentage	World Development Indicators (World Bank)
LNG	Economic growth	Constant US$	World Development Indicators (World Bank)

BP: British Petroleum

Table 2: Descriptive statistics

Parameters	Mean	Median	Maximum	Minimum	SD	Observations
LNC	6.49	6.54	7.84	5.12	0.87	57
LNO	4.16	4.14	5.47	2.54	0.87	57
LNU	1.08	1.06	1.36	0.75	0.17	57
LNG	27.1	26.98	28.63	25.81	0.89	57

SD: Standard deviation

Table 3: Quantile regression (median)

Parameters	Coefficient	Probability
LNG	0.34	0.0006
LNO	0.599	0.000
LNU	−0.28	0.0724
C	−5.006	0.0343
Pseudo R^2		0.95
Adjusted R^2		0.94
Quasi-LR statistic		1106.02
Probability (Quasi-LR statistic)		0.000

Table 4: Quantile regression with different quantiles

Parameters/τ		LNG	LNO	LNU	C
0.100	Coefficient	0.379	0.616	−0.04	−6.39
	Probability	0.00	0.00	0.816	0.002
0.200	Coefficient	0.388	0.605	−0.004	−6.598
	Probability	0.0002	0.00	0.983	0.0042
0.300	Coefficient	0.387	0.567	−0.205	−6.19
	Probability	0.00	0.00	0.197	0.006
0.400	Coefficient	0.318	0.607	−0.376	−4.274
	Probability	0.0015	0.00	0.03	0.078
0.500	Coefficient	0.318	0.599	−0.28	−5.006
	Probability	0.0015	0.00	0.07	0.034
0.600	Coefficient	0.326	0.614	−0.25	−4.61
	Probability	0.0004	0.00	0.1	0.036
0.700	Coefficient	0.304	0.638	−0.256	−4.11
	Probability	0.0008	0.00	0.08	0.05
0.800	Coefficient	0.317	0.587	−0.44	−4.026
	Probability	0.0001	0.00	0.02	0.029
0.900	Coefficient	0.211	0.684	−0.509	−1.46
	Probability	0.011	0.00	0.005	0.46

Figure 1: Depicts the quantile process estimates

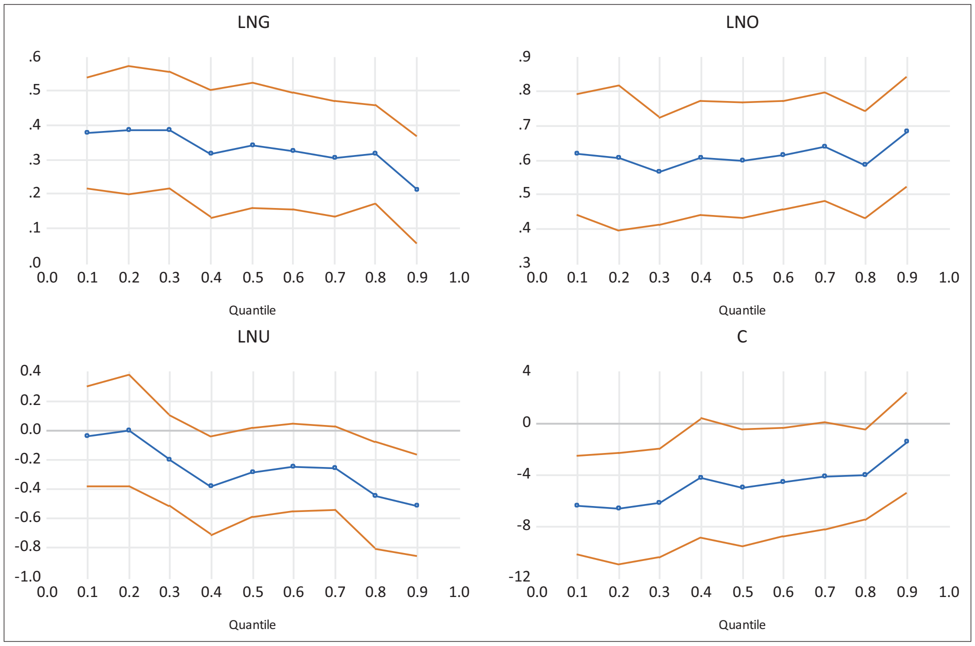

Table 5: Pairwise granger causality

Observations	Parameters	F-statistic	Probability	Inference
55	LNG LNC	1.085	0.35	LNG≠LNC
	LNC LNG	3.75	0.03	LNC→LNG
55	LNO LNC	3.14	0.05	LNO→LNC
	LNC LNO	1.696	0.194	LNC≠LNO
55	LNU LNC	0.87	0.43	LNU≠LNC
	LNC LNU	6.398	0.003	LNC→LNU
55	LNO LNG	0.855	0.43	LNO≠LNG
	LNG LNO	1.687	0.195	LNG≠LNO
55	LNU LNG	0.74	0.48	LNU≠LNG
	LNG LNU	5.22	0.008	LNG→LNU
55	LNU LNO	0.9	0.38	LNU≠LNO
	LNO LNU	5.148	0.009	LNO→LNU

5. DISCUSSION AND CONCLUSION

Environmental sustainability is now more critical than ever for developed and developing economies worldwide. As seen in developed and developing countries, economic growth and social change are only possible with urbanization. Energy consumption and CO_2 emissions directly result from urbanization and industrialization processes. Urbanized zones account for approximately 2% of the earth's land use, yet 75% of the world's energy consumption (Zi et al., 2016).

More harmful fossil fuels are utilized to meet rising energy demands. Although the economy and living conditions did improve, too much power was used to do so. Because of this, pollution and carbon dioxide emissions increased, harming the natural world (Baz et al. 2022). So, most of the world's economies have signed several environmental pacts to support the global goal of slowing the rate of environmental damage. Even though people think there are many ways to stop environmental degradation, limiting the use of fossil fuels has often been seen as the most important thing to do. In light of this, the goal of this study was to find out the effects of oil consumption, urbanization, and economic growth on the environmental quality of India.

This study is meant to shed light on how India's GHG emissions are affected by its use of oil, its fast urbanization, and its fast economic growth. This study looks at information from 1965 to 2021, which is enough to back up its conclusions. First, it was found that the series had problems with linearity, homoscedasticity, and normality. These findings were the basis for the QR. The QR results show that an increase of 1% in GHG emissions causes an increase of 0.34% in economic expansion and 0.599% in oil consumption. However, the QR also shows that urbanization has a negative impact. If GHG emissions increase by 1%, the number of people living in cities will decrease by 0.28%. Using the paired Granger causality test to look at the data in more depth shows that the Granger effect of carbon emissions drives economic growth and urbanization, but only in one direction. On the other hand, there is evidence that the use of oil is a unidirectional cause of urbanization and carbon emissions. Lastly, the economy's growth is a Granger causality that leads to urbanization in a one-way direction.

Because this study only looked at one country and got its data from secondary sources, its results can only be applied to some developing countries. However, they can help the policymakers of the studied country and the policymakers of other developing countries close to India. To continue their research, the other researchers need to use a more robust econometric model, do it in more depth, and figure out how much these factors affect India's micro-level GHG emissions.

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