Income Inequality and Climate Change in India

Anandlogesh RR, Anoushka Agastya, S Vishal, Shreethiga G and Vaidehi Mishra

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ABSTRACT

This study aims to understand the correlation between income inequality and environmental degradation by studying its relationship with air pollution and water pollution in the context of India. Understanding the time-series nature of the data used and deriving insights through Feasible Generalizable Least Squares (FGLS) regression helped address the econometric issues that most studies suffer. We build 2 models, one to to relate CO_2 data with income inequality (in the form of Gini coefficient) and GDP, and the other to relate BOD data to Gini coefficient and GDP. A negative correlation was identified between income inequality and CO_2 emissions and BOD levels.

1. Introduction

One of the first lessons a student of economics receives is that the root of all economics is scarcity. Resources are scarce and human wants are infinite. Yet, the consumption choices we make on a day-to-day basis are rarely informed by the statistics of global resource scarcity and environmental degradation. While there can be no all-encompassing definition of the term, environmental degradation is broadly recognized as a process through which the natural environment is compromised to negatively affect biological diversity and the general health of the environment. With an ever-increasing population and shrinking resources, it is one of the biggest threats our planet faces today. In 1987, the World Commission on Environment and Development (WCED) recognized poverty as a major cause and effect of environmental problems worldwide. It would therefore be futile to deal with environmental problems without a broader perspective that accounts for world poverty and income inequalities.

Research conducted over the past few decades have demonstrated that higher levels of emissions can potentially reduce a region's productive capacity. However, it is also a well-established fact that economic growth necessitates high levels of energy consumption, which implies higher levels of emissions. The Environmental Kuznets Curve (EKC) attempts to initiate a break in this vicious cycle. The EKC proposes that the relationship between economic growth and environmental degradation can be plotted to form an inverted U-shaped curve. As the economy expands, environmental degradation first increases up to a certain level, above which the society can afford more sustainable environmental practices, therefore leading to a decline in further environmental damage. The validity of the EKC remains a highly debatable topic in climate economics, with several scholars of repute arguing both for and against the hypothesis.

Whichever side of the Kuznets' debate one may find themselves on, one can intuitively agree to the argument that environmental degradation does not affect everyone equally. There are intersections of incomes, geography, genders, ethnicities, and communities that are more vulnerable to degradation than others (Kibiria (2016); Kaijser and Kronsell (2014); Hare, Cramer, Schaeffer, Battaglini and Jeager (2011)).

There are a few empirical studies that, although not directly providing evidence for the example of India, might provide significant insights, however the outcomes of these research are uneven, for both air (Goodman, Wilkinson, Stafford and Tonne (2011), M., M. and J. (2000)) and water pollution (Scruggs (1998); Torras and Boyce (1998); Kasuga and Takaya (2017)). A possible explanation, as given in Ridzuan (2021), is that some studies fail to account for the time-series properties of the data under study. The data analysis of non-stationary variables requires caution and care must be taken before drawing inferences.

In this paper, we focus on the nexus between income inequalities and environmental degradation in two important fronts - air and water pollution. We were motivated by Bhattacharya (2020) to examine the relations of income inequality with CO_2 emissions. Such an analysis also helps affirm or deny the Environmental Kuznet's Curve hypothesis. We did a two-step improvement over the existing literature. Firstly, we focused on a careful analysis of the time-series data to prevent misleading regression values. That further led us to see interesting patterns in the emissions data as well as inequality. Secondly, we repeat this approach for BOD data and see how it is related to income inequality. The paper first tests for the integrating effects in the time-series data which can lead to spurious regression by the use of Augmented Dickey-Fuller test. Further, it implements a Feasible Generalizable Least Squares (FGLS) which can circumvent the issue partly.

The entire paper is divided into six sections. Section two presents a brief review of existing literature. The third section delineates the methodology used in the study. The fourth section sets forth a discussion of the results of the study. This is followed by section five, which outlines the main conclusions and policy implications. The final section contains a summary of the entire paper.

2. Literature Review

Carbon emissions across the world have sky-rocketed over the last 30 years, but an important nuance to note is that the inequality of carbon emissions has reduced by 22% across the world from 1990 to 2010. The initial persisting inequality was caused by economic growth in terms of labour productivity, and its reduction is caused by an increase in technology transfer from the developed countries to the developing countries. An added cause is the technology transfer facilitating technology development amongst developing countries themselves (Remuzgo and Sarabia, 2015). A study by Chen, Cheng and Song (2017) added onto the literature the observation that the Gini coefficient of CO_2 emissions from China's production sector is larger than that of the residential sector, representing economic inequality and pointing at where the weights need to be heavier when one attempts to reduce emissions.

Although lesser inequality of carbon emissions implies an increased GDP, it does not necessarily mean lower income inequality. In fact, higher income inequality in low and middle-income economies is associated with lower carbon emissions while higher income inequality in upper middle-income and high-income economies is associated with higher per capita emissions. In the former, the poor live outside the carbon economy. In the latter, the power of the groups that benefit from emissions is strong. On that account, in richer economies, inequality must be reduced or renewable energy technology must be adopted to reduce emissions. However, in poor economies, there is a trade-off between income inequality and carbon emissions (Grunewald, Klasen, Martínez-Zarzoso and Muris, 2017).

Consistent with the hypothesis for low and middle income economies, Liu, Wang, Zhang and Li (2018) showed that income inequality improves environmental quality. But they also showed that it is effective only in the short run and that cleaner economic development and reforms on income distribution are necessary in the long run. Essentially, it argues that in the long run, cleaner energy will reduce carbon emissions and income inequality wouldn't be necessary, confirming the Environmental Kuznets Curve hypothesis. A year later, Liu, Wang, Zhang, Li and Kong (2019) showed that the relationship between economic development and CO_2 emissions is not linear, and a continuously widening income gap only deteriorated environmental quality and increased emissions. Urbanisation is noted as an additional factor contributing to emissions and the promotion of the tertiary sector is noted as a way to reduce emissions.

Consistent with the hypothesis for high income economies, another study focusing on a state-level analysis in the US showed that concentration of wealth and carbon emissions have a positive association but showed that a reduction in income inequality would not change the status quo of emissions. This is because the then poor would begin consuming more and the then rich would begin consuming less, and the changes would cancel out and carbon emissions wouldn't change. The way ahead, therefore, would not be carbon taxes or cap-and-trade schemes but cap-and-dividend-programs (Jorgenson, Schor and Huang, 2017).

On that account, one of the central arguments is that income inequalities are the main cause of environmental degradation. Poverty forces people to resort to unsustainable use of resources for survival. As a result, starker inequalities translate to higher levels of undesirable emissions. Zhang and Zhao (2014), Masron and Subramaniam (2019), and Hassan, Zaman and Gul (2015), confirm this hypothesis for developing countries. Khan (2019) takes this argument a step further in his paper covering ASEAN countries and anticipates that an increase in upskilling and human resource development would reduce poor people's dependence on natural resources for their livelihood, thereby checking emissions. On the other hand, Rizk and Slimane (2018) argue for the opposite, i.e., income inequalities and poverty are products, rather than causes, of environmental degradation.

However, the remaining literature can be broadly divided into two broad classes. Unlike a unidirectional causality confirmed by studies mentioned above, the one class of literature argues for a two-way causal relationship between income inequalities and environmental degradation. Jin, Fu, Li, Wu and Zhang (2018) demonstrate this bidirectional causality by examining poverty alleviation measures and levels of carbon emissions in Chinese municipalities. An interesting insight provided by the paper was that while measures to alleviate poverty increased carbon emissions, the increased carbon emissions in turn brought greater socio-economic losses and reduced people's ability to cope up with poverty on a national level.

Transcending national borders, Dhrifi, Jaziri and Alnahdi (2020) establish bi-directional causality between income inequalities and carbon emissions for Latin American, Caribbean and Asian regions.

The other class of literature posits that the nexus in question is governed by a complex framework of demographic, social, economic, and institutional factors. These include, but are not limited to considerations on decision-making, parliamentary and bureaucratic processes, level of transparency and corporate accountability in the regions where the nexus is being studied. Koçak, Ulucak, Dedeoğlu and Şentürk Ulucak (2019) argue that poverty and carbon emissions in sub-Saharan Africa share a 'trade-off' relationship. This implies that actions directed to the fight against global warming may increase poverty in the region. In such cases, institutional reform and a switch to cleaner sources of energies help carve out a middle path between tackling inequalities and emissions. Uzar and Eyuboglu (2019) examined the causality nexus for Turkey and discovered that high Gini coefficients, energy consumption, industrialization, and trade openness all had a positive correlation with the level of CO_2 emissions. The complex relationships between income inequalities and environmental degradation is further demonstrated by Padhan, Haouas, Sahoo and Heshmati (2019) who discovered that in countries with equal income distribution, an increase in inequalities had a deteriorating effect on the environment. However, in countries with more unequal income distribution, policies for lowering inequalities and poverty led to environmental degradation. The paper held the richer countries more responsible for deterioration in environmental quality as compared to poor countries.

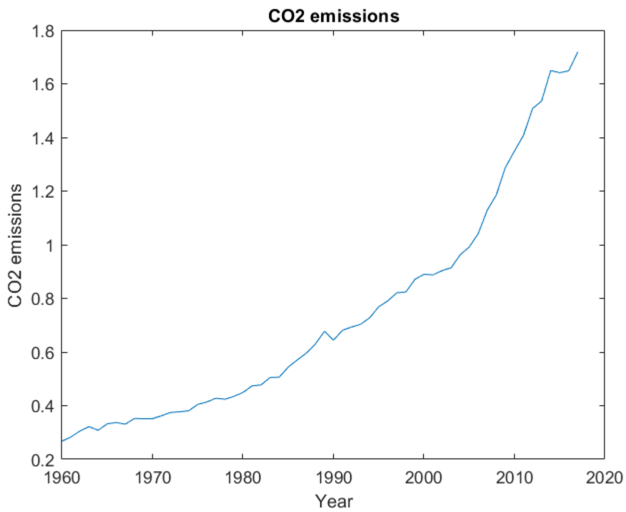

Figure 1: The CO_2 emissions data. Notice the trend effect.

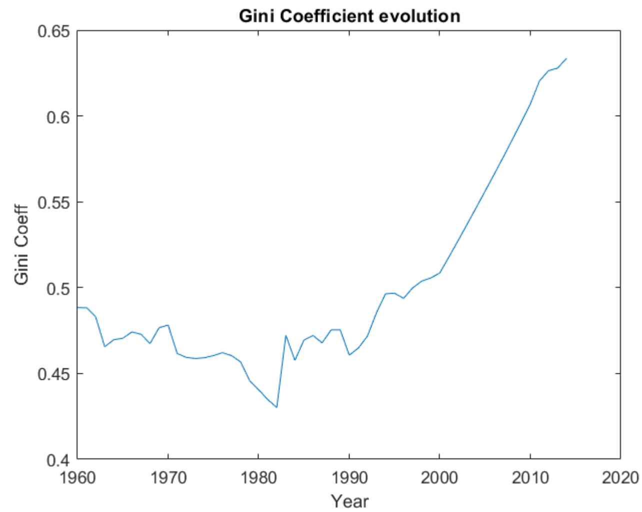

Figure 2: Gini coefficient data. Notice the trend effect.

3. Methodologies used

We used data of CO_2 emissions, Gini coefficient and GDP per capita for India for the years 1960-2018. We performed some initial data cleaning and sanity checks. For exact details on the data analysis, refer to the supplementary material. The entire modelling pipeline was executed on *MATLAB ®R2020b*. Our modelling procedure can be divided into two distinct (albeit interrelated segments):

1. Time series analysis of CO2 emissions and Gini inequality
2. Perform Feasible Generalizable Least Squares to examine relation which can work on data with relaxed assumptions.

3.1. Time series modelling

This process is repeated for the emissions as well as income inequality data. Firstly, the data is observed for any trend or random-walk effects. Trend effects can be observed in both cases as displayed in both figure 1 and figure 2. After that, we perform the **Augmented Dickey-Fuller test**(adf-test) to check for the presence of integrating effects. We found that **both** the variables of interest showed presence of integrating effects at a confidence level of 95%. This shows that many of the earlier regressions in literature are **spurious** and explains why there are contradicting results at times. We difference the series and again perform the adf-test. After differencing, the integrating effects disappeared.

Then, we built an ARIMA model for the individual time series data. The parameters of the ARIMA model were decided by looking at the autocorrelation and partial autocorrelation values of the data. After trying out multiple parameters of the ARIMA model, the final parameters were chosen based on:

- Underfit checking: Residuals are examined. If the mean of the residuals is nearly zero, and the **Ljung-Box test** was performed to verify that the residuals are white.
- Overfit checking: Significance of the coefficients were tested at 95% confidence level.

Finally after this, we examined the residuals and tried to find for changepoints in them, i.e., check whether the parameters of the underlying probability distribution changes somewhere. For the case of Gini coefficient we used a Recursive Least Squares (RLS) approach to check for change in underlying coefficients. We, also examined some anomalous points (high variance) as presented in results. This would give us an idea of the possible impacts of policies on those variables.

Table 1
ARIMA(1,1,1) model estimates for CO_2

Coefficient	Value	StandardError	PValue
AR1	1	0.031197	1.9014e-225
MA1	-0.80292	0.10952	2.2829e-13
Variance	0.00061695	9.0215e-05	7.9943e-12

3.2. FGLS

We build two models. As is the normal procedure, we attempt to stabilise the variables by taking logarithm. One of the main inconsistencies by Ridzuan (2021) is the non-stationarity of the variables involved. We difference the non-stationary variables before performing the regression so that, all time series effects are removed. Next an Ordinary Least Squares (OLS) fit is done. It results in high standard errors. The examined residuals are not white and homoskedastic which are essential assumptions made in a standard linear regression procedure. We then perform the fully generalizable least squares which accounts for these assumptions and arrive at the final estimates. It takes into account non-spherical innovations in the process and estimates the coefficients. Standard errors were lower and significance of coefficients were established.

4. Results and Discussions

We can conclude from the Augmented Dickey-Fuller test (refer supplementary material) that CO_2 emissions and Gini coefficient have integrating effects and are non-stationary variables. Their present value is dependent on the previous values. This has been verified by doing a comprehensive time series analysis of the procured data. In such a condition we cannot use Linear Regression as done in Bhattacharya (2020), but a more rigorous approach for regression needs to be adopted for establishing a correlation between the two variables (Ridzuan, 2021).

Table 2
CO_2 emissions: Results from the FGLS Regression

–	Coefficient	Standard Error
Constant	0.0662	0.0009
Inequality	-0.0974	0.0544
GDP	0.0216	0.009

From table 2, we gather that the Gini Coefficient is inversely proportional to CO_2 emissions (or equivalently, negatively correlated) while the GDP is positively correlated with the CO_2 emissions. The correlation coefficients thus evaluated are reinforcing the hypothesis for low and middle income economies such as India that higher income inequalities, that are measured by the Gini Coefficient, are improving the environmental quality by reducing the net CO_2 emissions as depicted earlier by Liu et al. (2018). As discussed, in the short term, appropriate income inequality is conducive to the reduction of environmental pollution as the lower income groups tend to be thrifty with their expenses and utilize the most out of the natural resources without disturbing the environmental equilibrium by a significantly large margin. However, we must recognize that in the long run when income inequality worsens, the same lower income group would tend to over-exploit natural resources, and an unequal society turns out to be a key driving factor for degradation of the environment and thereby increasing CO_2 emissions as low environmental pollution products tend to have higher technical requirements and therefore higher prices, which are scarcely affordable and can ultimately lead to higher pollution emission trends among the lower income group. The positive correlation between GDP and CO_2 emissions are as hypothesized with respect to the Environmental Kuznets Curve.

We interpret 2 important anomalous points/change-points from the graph of residuals in figure 3. First is an anomalous point 1990, where the residual is highly negative, which means emissions were much lower than

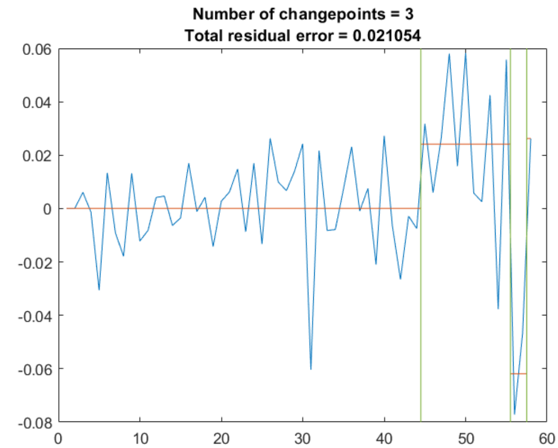

Figure 3: Residuals of CO_2 ARIMA model

predicted by the model. This probably reflects the dip in economic activities in the lead-up to the 1990 economic crisis faced by India. We see a change-point in the form of a shift of the mean of residuals at 2004. This means that emissions saw a significant build-up till 2004, elevating to new levels. It, perhaps, reflects the cumulative effects of reforms from 1991. Although these claims still need strong justification, this simple attempt is to demonstrate a way of interpreting data to obtain meaningful conclusions with respect to policies. A similar approach could be adopted in the future, to possibly check the effectiveness of policy instruments that the governments around the world use to control emissions.

Table 3
BOD Levels: Results from the FGLS Regression

–	Coefficient	Standard Error
Constant	0.5335	0.4380
Inequality	-0.2589	0.2118
GDP	-0.3190	0.3938

From table 3, we gather that the Gini Coefficient is also inversely proportional (negatively correlated) to the BOD levels in rivers and that the correlation between GDP and BOD levels has not been sufficiently well established due to the magnitude of standard error being greater than the magnitude of the coefficient obtained through the FGLS analysis. It could be argued that the results are due to the sample size we used. In small samples, we are left with the result such that it rejects the hypothesis that BOD levels in rivers have a positive correlation with income inequality as measured by the Gini Coefficient as proved by Ridzuan (2021). Given the small sample space and inconsistent data quality used for analysis, we cannot entirely rely on the results of the same. The data has been collected from ENVIS, one of the agencies of the Central Pollution Board of India for the major rivers of India from 2007 to 2017 and it has been noticed that there are slight inconsistencies with respect to extraction of data at respective sites on different rivers which is to day that as of today there are greater number of sites to collect the readings for BOD levels than there were 10 years ago; giving skewed results for even averages over the years for most rivers. Having said that, we would like to establish that the relationship between decreased water quality (as measured by BOD levels) and income equality (as measured by Gini Coefficient) is intuitively proposed to be positive that is an increase in income inequality will lead to increase in water quality deterioration as the higher income groups are consuming and polluting water more than the lower income groups. A two-way causal relationship can also be explored for further studies since we can establish that the lower income groups are more prone to waterborne diseases as they are exposed to poor quality of water and this would overall affect their productivity at work and further increase the income gaps in the society.

5. Conclusion

India, as a country, has been fighting the issues of environmental degradation and income inequality for decades. Through this paper, we hope to assess the correlation between these fronts to identify potential patterns for policy makers. Care was taken to address the econometric issues of the data used for the analysis, providing a new perspective to the discussion from the contemporary literature. The data was first tested using Augmented Dickey-Fuller test and model built using feasible generalizable least squares (FGLS).

We observed that income inequality and CO_2 emissions are negatively correlated. Similar trend was observed between income inequality and BOD levels, a common indicator for water pollution. This pans out in accordance to the study by Liu et al. (2018), that in short term, the income inequality is necessary to reduce environmental degradation. The positive correlation observed between GDP and CO_2 conforms with the Environmental Kuznets Curve (EKC) hypothesis. However, there seems to be little to no correlation between GDP and BOD levels. This could be due to the insufficient sample size and data quality used for FGLS analysis.

The study can be expanded by employing likelihood approaches as in Johansen et al. (1995) to further relax the assumptions made.

All in all we can conclude that the crucial indicators of climate change - pollution levels in water and air are linked to income inequalities in the society. Given that we have established how income inequality and CO_2 emissions are negatively correlated, we can establish the fact that higher income inequalities can lead to lesser climate change (due to lesser CO_2 emissions) for low and middle income economies such as India. However, this conclusion is dynamic and is set to change with time and future analysis of the correlations of CO_2 emissions and income inequality.

6. Policy Recommendations

Our paper not only aims to contribute to the vast repository of existing literature on the subject but also hopes to draw particular attention towards its implications in policy making. Environmental quality requires strong policies and institutional structures designed to reduce emissions across sectors. As the fifth largest economy in the world, India should take serious efforts to monitor the quality and the environmental costs of economic growth. While income inequalities were found conducive to the environment to some extent, in the long run, an unequal society is found to be a key factor behind increasing CO2 emissions and thereby, environmental degradation. Though the country has always been fiercely protective of its economic growth, it would be more productive in the long run to shift the focus from increasing aggregate GDP statistics to bridging the gaps in income and standards of living. This can be done through investing in universal access to health and education, enforcing land reforms, implementing redistributive policies, protecting equal rights and opportunities for vulnerable sections of society, and encouraging indigenous, sustainable methods of production.

Further, it must be noted that the current model of progressive income and environmental taxation warrants a thorough review and subsequent reform. While the country does not have an explicit market-based mechanism for carbon pricing, it has a plethora of mechanisms that put an implicit price on carbon. These include Perform, Achieve and Trade (PAT) scheme, the (discontinued) clean energy cess, Renewable Purchase Obligations (RPO) and Renewable Energy Certificates (REC). However, these schemes have achieved limited success and India is yet to implement a proper target-based mechanism for controlling emissions. The country has a framework for emissions trading but pollution control boards in different states are yet to be incentivized and trained to effectively implement the proposed monitoring and enforcement procedures. In 2019, Gujarat became the first state in India to introduce cap-and-trade legislation to control carbon emissions. This system enables local governments to set limits on the maximum amount of emissions it will tolerate. These ‘emission allowances’ are auctioned to companies till the ‘cap’ is reached. Companies whose emissions are not covered by these allowances are forced to either reduce their total or buy allowances from other companies. This system of emissions control is novel in the sense that it enforces strict emission standards without taxing companies directly. Similar results can be achieved by levying Pigovian taxes on firms, as it would force them to stick to a level of pollution that ensures profit maximization. These measures hold significant promise, especially in a country like India, where economic growth cannot be ‘traded off’ for a better environment. With the clock ticking on its pledge to reduce emissions by 33-35% in 2030 compared to 2005 levels, India needs to look into building cleaner technologies and better environmental capacities. Such capacity building includes mainstreaming the environment into development processes, training manpower, and enabling data collection for better implementation and evaluation of national and regional environmental policies. With access to proper data, it would be possible to calculate near accurate abatement costs and thereby, make better policy decisions on sector-wise emission reductions.

7. Data Sources

1. CO_2 Emissions - WorldBank (a)
2. Per Capita GDP - WorldBank (b)
3. Gini Index - WorldInequalityDatabase
4. BOD Level - ENVIS

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