Effect of Income Inequality on Environment Performance Index

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Abstract

Raju will write the abstract

Key words: Inequality, environment, Gini, EPI

Introduction

Raju will add some more stuff if needed

Income inequality is one of the biggest issues grappling both developing and developed countries alike. While most development agendas in the past have focused heavily on poverty, it has been clearly established that income inequality is the pressing issue now. The UN Sustainable Development Goals have also put a strong emphasis on income inequality. Increased urbanization and growing reliance on international trade have increased even further the differences between the poor and the rich and through globalization it has become more visible to all. Inequality has been considered the cause of many social, political and economic crisis around the world. Plethora of research on inequality show that it affects education, healthcare (Lynch et al. 2000), the economy, and even voter turnout and elections in many countries. However, the focus of our research won't further explore any of these social or political issues. We aim to research the effect of inequality on the environment. We find this interesting because climate change is one of the biggest threats that our generation is facing, but it is very much disconnected with other social and economic issues that scholars usually talk about. Showing a relationship between inequality and environment can be extremely important to create a better roadmap for development, since policymakers may find better approaches to solve these issues if they are found to be somehow corelated.

Inequality:

Mario: Cite the source of two bold words below. Bibtex not found

According to the ***IMF***, the gap between the rich and the poor is at its highest in decades. The organization argues that inequality could be a sign of lack of income mobility and opportunity. Furthermore, it has significant implications for growth and macroeconomic stability, it can concentrate political and decision making power in few hands, lead to a suboptimal use of human resources, cause investment-reducing political and economic instability and increase the risk of crisis.

The most widely used estimator for inequality is the GINI coefficient. Developed in 1912, by Italian statistician Corrado Gini, it is a way of comparing how distribution income in a country compares with another in which everybody earned the same amount. Inequality on the Gini scale is measured between 0, where everybody is equal, and 100, where all the income is earned by one person. Despite some criticism about some ***inaccuracies*** on certain percentages of the population, the index is still the golden standard for measuring inequality in societies.

Environment:

Raju write something on Enviroment and Carbon emissions
Show environment issues around the world. UN sustainability stuff (100 words) Carbon Emissions and other ways to measure how the envrionment is doing (100 words)

Environment Performance Index: The Environmental Performance Index (EPI) is an indicator that seeks to quantify the environmental performance of a state's policies. The precursor to this metric was the Pilot Environmental Performance Index, first released in 2002 and designed to supplement the environmental targets in the United Nations Millennium Development Goals. The EPI is developed by the Yale Center for Environmental Law & Policy and ranks countries' performance in two areas: protection of human health and protection of ecosystems. The Index scores national performance in nine issue areas comprised of more than 20 indicators. Here is a table with the basic information about the framework of the indicator.

Environmental Health(50%)	Ecosystem Vitality(50%)
Health impacts(33%)	Water Resources (25%)
Air Quality(33%)	Agriculture (10%)
Water and Sanitation (33%)	Forests (10%)
	Fisheries (5%)
	Biodiversity and Habitat (25%)
	Climate and energy (25%)

In its 15th year, the EPI report for 2016 was launched at the World Economic Forum. The organizers declared that the Index is more relevant than ever to achieving the United Nations' Sustainable Development Goals and carrying out the Paris Agreement.

Literature Review: Interconnectedness between Inequality and Environment

A few scholars have already connected the dots and analyzed the relationship between inequality and environment. Nobel Laureate Joseph E. Stiglitz argues that inequality can contribute to environmental degradation because the poor tend to have less interest in pursuing policies designed to protect the environment and therefore good environment policies will be less supported (Conca and Dabelko 2014). He also argues that the relationship goes both ways in the sense that good environmental policies will help build social cohesion and reduce inequality (Conca and Dabelko 2014). J. Timmons Roberts believes that global warming is all about inequality based on who created it and who suffers from it the most (Roberts 2001). Nazrul Islam, a Senior Economic Affairs Officer at the Development Policy Analysis Division of UN DESA provides an analytical framework to explain negative correlations between inequality and quality of environment and suggests that reducing inequality will help protect the environment (Islam 2015). He adds that gender inequality is another dimension that affects environment thus providing us even more reason to examine this case (Islam 2015). Wilkinson and Pickett argue that equal societies are better in terms of social cohesion and public spiritedness, which they link to being fundamental in responding to environmental issues (Wilkinson and Pickett 2011). They show statistically that more equal countries recycle a higher proportion of their waste, a clear indication of how inequality affects the environment (Wilkinson and Pickett 2011). Sternreview report asserts that climate change is an externality whose cause and consequence both involves deep inequalities (Stern 2007). Several other scholars have vigorously analyzed environment and human security (Barnett and Adger 2007), climate change in poor and unequal countries (Gordon 2007), inequality and resource management (J.-M. Baland and Platteau 1999), inequality and environmental sustainability (J. Baland, Bardhan, and Bowles 2007), and inequality as a cause of environmental degradation (Boyce 1994) - all of which provide ample theoretical basis to continue this research.

Methodology

We have used quantitative analysis using R programming to test the hypothesis. The descriptive and inferential statistical measures used in the paper are showcased using regression tables, plots, graphs and maps, all of which are made using R. The results obtained from quantitative analysis is meticulously coupled with qualitative literature review that consisted of scholarly articles and reports by experts of the fields. We have analyzed scholarly sources that have influenced the discussion on the relationship between inequality and environment.

To do a statistical analysis of the issue, it is extremely important to locate data sources. The World Bank Database has most of the indicators necessary to do a thorough analysis of the topic. Some of the indicators used to carry out the research were: Gini Coefficient, Environment Performance Index, GDP per Capita Purchasing Power Parity, and Population Density. The data was extracted from the World Bank API, and Yale Center for Environmental Law & Policy. Since the data were obtained from multiple sources, they had to be cleaned and merged, which resulted in a panel dataset from years 2002 to 2014. Year-specific data was used to draw several maps and plots. However, for the inferential analysis using regression, the entire panel data with all the relevant dependent, independent, and control variables were used.

Operationalization

Count the number of countries and fill the gaps ... below in the passage

Dependent Variable: The dependent variable for our research is Environment Perfomance Index, written as *EPI*. Our dataframe consists of EPI for .... countries from 2002-2014. It is provided by the Yale Center for Environmental Law & Policy. The value of EPI ranges from 0 to 100. Higher the EPI value, the better a country performs environmentally. Although we do have EPI for 2016, we have decided to omit that year since we do not the data for other variables after 2014.

Explanatory Variable: The main independent (explanatory) variable used for our research is the Gini coefficient, written as *Gini*. Our dataframe consists of Gini for .... countries from 2002-2014. Due to the fact, that Gini is not measured every year by the respective countries, data for some of the years are missing.

Control Variables: The first control variable is GDP per capita (PPP). It is written as *GDPperCapPPP*. Our dataframe consists of GDP per Capita (PPP) for .... countries from 2002-2014 and it was obtained from the World Bank API and merged into the dataframe that consisted EPI and Gini. The second control variable is Population Density and it is written as *PopulationDens*. Our dataframe conists of Population Density for .... countries from 2002-2014 and it was obtained from the World Bank API and merged into the dataframe that consisted EPI and Gini.

Mario explain why log of GDP is taken
Raju Write more on the theoretical relevance of the chosen control variables above

Research Question: Our research question is "Does income inequality affect the environment performance index?" Through this question, we are planning on analyzing the relationship between inequality and environment so that we can better understand the policy implication of these highly relevant areas.

Regression Equation: The regression equation is written as follows:

$$EPI = \beta_0 + \beta_1(Gini) + \beta_2 log(GDPperCapPPP) + \beta_3(PopulationDens) + \epsilon$$

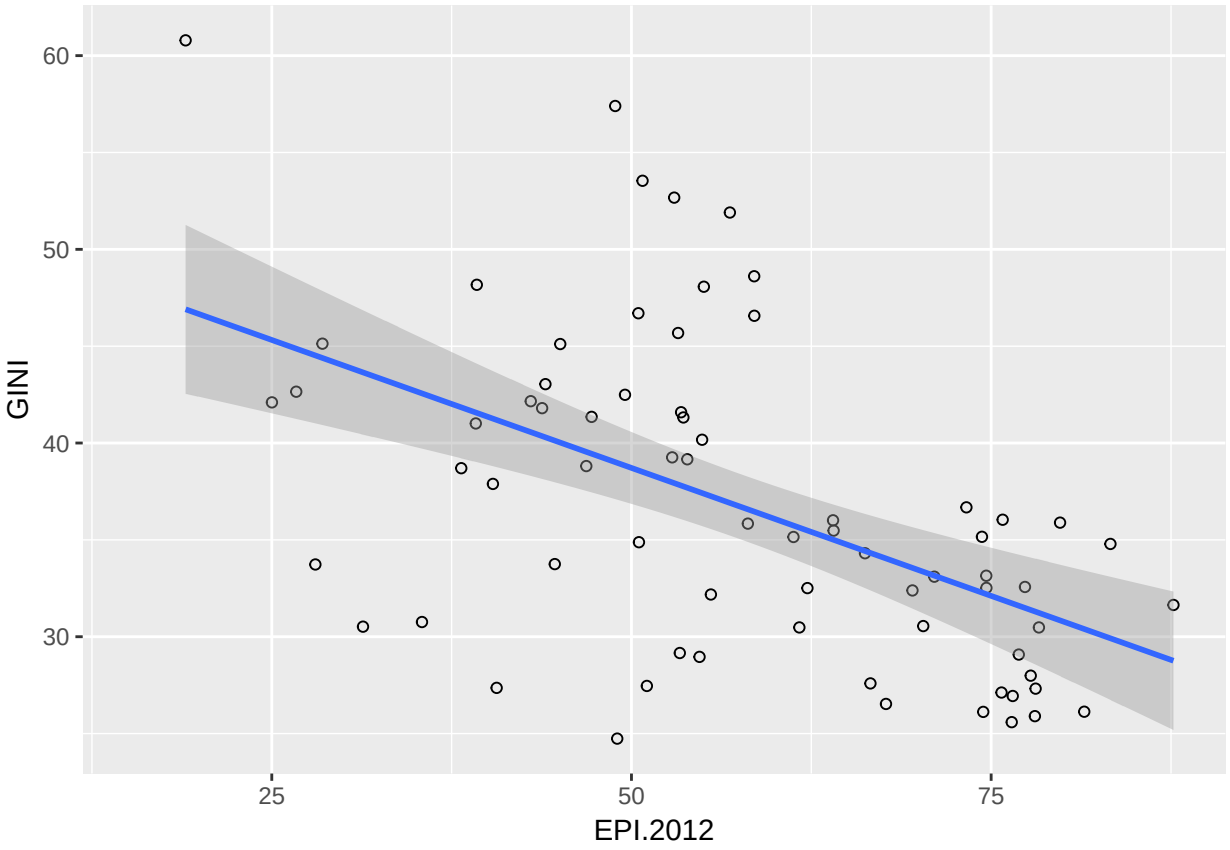
Descriptive Analysis

Mario: can you see if we can add all the maps from the website here under this section since they have descriptive nature. I tried to copy the code chunks for "printing the maps"" here but it doesn"t generate anything when I knit it on pdf.

Simple regression plot: **Raju describe what the plot shows**

```
## Warning: Removed 105 rows containing non-finite values (stat_smooth).
```

```
## Warning: Removed 105 rows containing missing values (geom_point).
```



Inferential Analysis

A pooled Ordinary Least Squares(OLS) regression estimation is used to estimate the effect of Gini coefficient on EPI over the given time period.

In the pooled OLS regression estimate above, we can see that a one-unit increase in Gini Coefficient decreases the environment perfomance index by 0.28 units. This means that as countries become more unequal, their environment perfomance decreases. A change of 0.28 units is quite a significant change considering the range of the EPI. Finland who is on the top of EPi has a score of 90.68 and Somalia on the bottom has 27.66. The map shows on the website shows graphically that a good EPI score could be related with a low Gini coefficient. The regression estimate validates the intuition and the graphical representation. We also see that the coefficient estimate for Gini is extremely significant at 1 percent significance level. The OLS estimate also shows the high significance of GDP Per Capita (PPP) on determining EPI. At 1 percent significance level, a 1 percent increase in GDP Per Capita (PPP) increase the EPI by 11.87 units. This is the extremely significant effect and validates the argument that more developed countries are more capable of performing better on environmental issues.

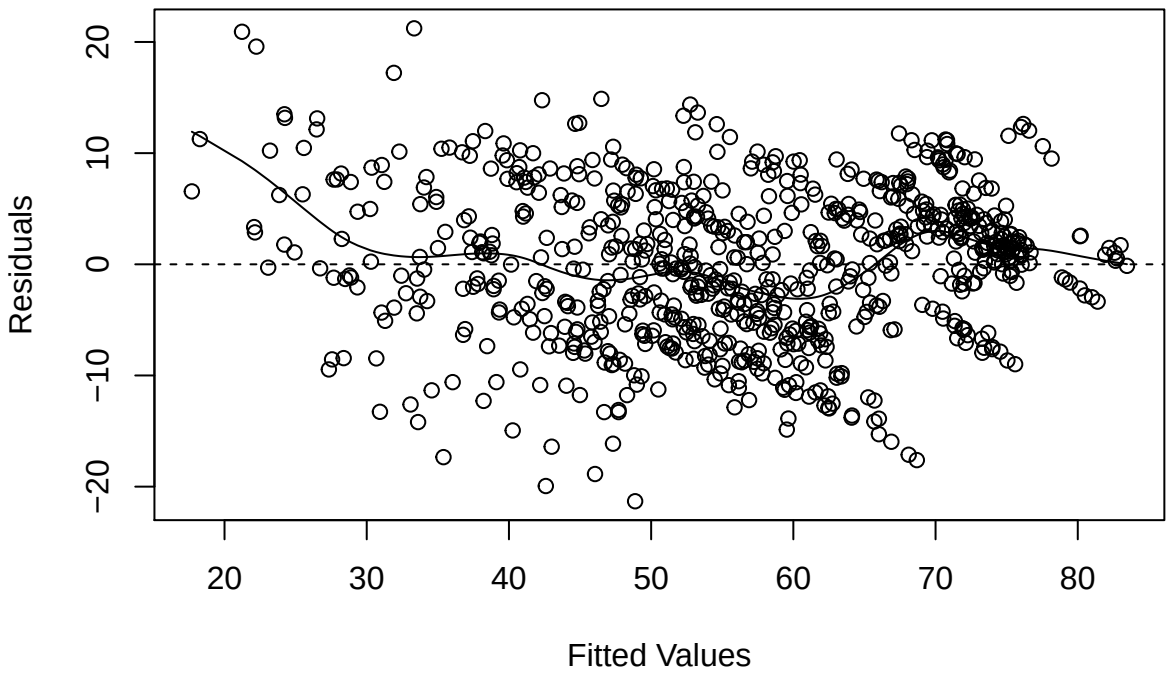
However, considering this is a panel data, there is a likelihood that there is a presence of time-invariant panel effects $\alpha_i ! = 0$. If $\alpha_i ! = 0$, OLS residuals would suffer from serial correlation and panel heteroscedasticity and

Table 2: Effect of Income Inequality on EPI(Pooled OLS)

	Dependent variable:
	EPI
Gini	-0.28^{***}
	(0.03)
log(GDPperCapPPP)	11.87^{***}
	(0.25)
PopulationDens	-0.0001
	(0.002)
Constant	-42.86^{***}
	(2.88)
Observations	763
R^2	0.81
Adjusted R^2	0.80
Residual Std. Error	6.81 (df = 759)
F Statistic	$1{,}046.28^{***}$ (df = 3; 759)
Note:	*p<0.1; **p<0.05; ***p<0.01

OLS estimation will be inefficient. The residual vs fitted plot below shows the presence of heteroscedasticity in the regression model and therefore makes a case to test if other estimation methods will be more efficient in this particular case.

Residual vs Fitted Plot:



When time-invariant panel effects are present we should estimate our panel not with (pooled) OLS, but with the fixed-effects or random effects estimator. We can test for the presence of time-invariant panel effects in the Fixed-effects model by applying an F-test on the joint significance of α_i s.

The within estimate of our research model generates the result as follows. F-test of the joint significance of α_i s shows that Fixed Effects estimate is better than Pooled OLS in this case as shown by the highly significant F-statistic at 1 percent significance level.

We can test for the presence of time-invariant panel effects in the Random-Effects model by applying a Breusch-Pagan LM test on the significance of α_i in the error term.

Show Breusch-Pagan test for Random Effects

Couldn't figure out how to do this. The result of this one should show whether pooled OLS or RE is better.

The choice between a Fixed Fffects(FE) estimator or a Random Effects (RE) estimator is determined by the Hausman test. The result of the Hausman test below shows a p-value of less than 0.05 thus suggesting that the null hypohesis is rejected and hence, RE is biased and it is better to use FE estimator. Therefore, the time-invariant error is treated as a constant and not as a random error term.

```
Hausman Test
```

data: EPI ~ Gini + log(GDPperCapPPP) + PopulationDens chisq = 214.18, df = 3, p-value < 2.2e-16 alternative hypothesis: one model is inconsistent

Since we have established that a FE estimate is the best option for our research, we can now use it to interpret the results. This is given by the second column in Table 4. The result shows a much lesser effect of Gini coefficient on EPI. A one unit increase in Gini decreases the EPI by 0.06 units. Although the effect is much

Table 3: Effect of Income Inequality on EPI(Fixed Effects)

	Dependent variable:
	EPI
Gini	-0.06^{***}
	(0.02)
log(GDPperCapPPP)	4.21^{***}
	(0.22)
PopulationDens	-0.002
	(0.01)
Observations	763
R^2	0.45
Adjusted R^2	0.33
F Statistic	171.35^{***} (df = 3; 621)
Note:	*p<0.1; **p<0.05; ***p<0.01

lesser, the direction of the effect stays intact. The effect is also highly significant at 1 percent significance level. The effect of GDP per Capita (PPP) is also much lesser yet highly significant and strong. A 1 percent increase in GDP per Capita (PPP) increases the EPI by 4.21 units at 1 percent significance level. The R-square value of 0.45 suggests that 45 percent of the change in EPI is described the model, hence suggesting the appropriateness of chosen variables and the model itself. The effect of Population density stays insignificant.

Robustness

Checking heteroscedasticity:
Mario: can we show this in a graph as well. And can we show the FE estimate table again after correcting for heteroscedasticity. Also can we show the results below in a better format

t test of coefficients:

```
Estimate Std. Error t value  Pr(>|t|)
```

Gini -0.0647441 0.0189614 -3.4145 0.0006806 ***log(GDPperCapPPP) 4.2096753 0.2158075 19.5066 < 2.2e-16*** PopulationDens -0.0022625 0.0090834 -0.2491 0.8033762
— Signif. codes: 0 ‘’ ***0.001*** ’’ *0.01* ’’ 0.05 ‘.’ 0.1 ‘’ 1

t test of coefficients:

```
Estimate Std. Error t value Pr(>|t|)
```

Gini -0.0647441 0.0291444 -2.2215 0.02668 *
log(GDPperCapPPP) 4.2096753 0.4477696 9.4014 < 2e-16 *** PopulationDens -0.0022625 0.0121276 -0.1866 0.85207
— Signif. codes: 0 ‘’ ***0.001*** ’’ *0.01* ’’ 0.05 ‘.’ 0.1 ‘’ 1

t test of coefficients:

Table 4: Effect of Income Inequality on EPI

	Dependent variable:		
	EPI		
	OLS		*panel linear*
	(1)	(2)	(3)
Gini	−0.28***	−0.06***	−0.07***
	(0.03)	(0.02)	(0.02)
log(GDPperCapPPP)	11.87***	4.21***	5.42***
	(0.25)	(0.22)	(0.22)
PopulationDens	−0.0001	−0.002	−0.004
	(0.002)	(0.01)	(0.004)
Constant	−42.86***		5.46**
	(2.88)		(2.44)
Observations	763	763	763
R^2	0.81	0.45	0.52
Adjusted R^2	0.80	0.33	0.52
Residual Std. Error	6.81 (df = 759)		
F Statistic	1,046.28*** (df = 3; 759)	171.35*** (df = 3; 621)	241.21*** (df = 3; 759)
Note:			*p<0.1; **p<0.05; ***p<0.01

Estimate Std. Error t value Pr(>|t|)

Gini -0.0647441 0.0291444 -2.2215 0.02668 *
log(GDPperCapPPP) 4.2096753 0.4477696 9.4014 < 2e-16 *** PopulationDens -0.0022625 0.0121276 -0.1866 0.85207
— Signif. codes: 0 ‘’ ***0.001*** ’’ *0.01* ’’ 0.05 ‘.’ 0.1 ‘’ 1

t test of coefficients:

Estimate Std. Error t value Pr(>|t|)

Gini -0.0647441 0.0293950 -2.2026 0.02799 *
log(GDPperCapPPP) 4.2096753 0.4511679 9.3306 < 2e-16 *** PopulationDens -0.0022625 0.0123163 -0.1837 0.85431
— Signif. codes: 0 ‘’ ***0.001*** ’’ *0.01* ’’ 0.05 ‘.’ 0.1 ‘’ 1

Conclusion

Raju: write the conclusion

Commands

Please see the attached file at the end of the document to see all the commands used and for reproducibility. # Bibliography

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