DOES BETTER ENVIRONMENTAL GOVERNANCE REDUCE ANTHROPOGENIC CARBON DIOXIDE EMISSION? A CROSS-COUNTRY ANALYSIS

T S Krishnan

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1
INTRODUCTION

Following is the excerpt of a recent press interview with Ashish Kothari (Co-founder of Kalpavriksh, an environmental action group based in India):

> I don't think the jholawallah[1] is redundant or inaccessible even today, but indeed environmentalists and social activists need to reinvent themselves into a number of other avatars too. The simple chappal-clad[2] activist that works to help communities in resisting destructive forces of 'development' and communalism continues to be valuable; look at almost any successful resistance movement and you'll find them.
>
> But the laptop-toting researcher or activist who can help a community access national and global networks or help them critique mining project reports, or do such critiques themselves, is also crucial. As is a passionate and articulate middle-class person who can talk to students in commerce, engineering and computer colleges, who can write powerful articles for the media, or make creative pitches on the so-called 'social networking' sites.
>
> Also important is the role of the activist lawyer who fights in the National Green Tribunal or the courts, or the one who sits on government committees and remains true to the principles of the environment and justice.[3]

This excerpt is a grounded description of one dimension of environmental governance. Environmental governance encompasses rules, processes, and practices that are related to various forms of environmental management like conservation, protection of natural resources, etc. by government institutions, business firms, and civil society groups.[4] Understanding the role and impact of environmental governance is key area of research in ecological economics.[5] To give an intuitive appeal of what environmental governance means, let us describe few examples. The Chipko movement during 1970s was initiated by peasants in Uttarakhand (a State in India) to protest rampant deforestation.[6] This movement was a non-violent protest by hugging trees to prevent them being chopped down for making commercial products like sports goods, etc.[7] Apart from this, there are several popular examples of environmental governance initiatives (like Carbon Tax, Clean Power Plan, etc.) by developed countries like United States of America, Germany, Switzerland, etc. We would like to point out that developing countries without a significant manufacturing or industrial base also have environmental governance initiatives. For example, Nepal is a land-locked country and its economy is driven primary by agriculture and services. More than 90% of Nepal's workforce is employed in agriculture and services and the remaining percentage employed in crafts-based industry.[8] Nepal has been at the forefront in driving environmental governance efforts, from the first five year plan (1956-1961), despite several implementation challenges.[9] Important public policies

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1 In Hindi (a language spoken in India) denotes an intellectual social activist.

2 In Hindi (a language spoken in India) denotes an activist who works at the grassroots level.

3 Nihar Gokhale, 'The Jholawalla Image is Still Valuable. But, Activists Must Reinvent Themselves: Ashish Kothari' (*Catch News*, 12 November 2015) <http://archive.catchnews.com/environment-news/the-jholawalla-image-is-still-valuable-but-activists-must-reinvent-themselves-ashish-kothari-1447337919.html> accessed 11 April 2016.

4 Maria Lemos and Arun Agrawal, 'Environmental Governance' (2006) 31 *Annual Review of Environment and Resources* 297.

5 Jouni Paavola, 'Institutions and Environmental Governance: A Reconceptualization' (2007) 63 *Ecological Economics* 93; Victor Galaz and others, 'Global Environmental Governance and Planetary Boundaries: An Introduction' (2012) 81 *Ecological Economics* 1.

6 Ramachandra Guha, *The Unquiet Woods: Ecological Change and Peasant Resistance in the Himalaya* (University of California Press 1990).

7 ibid.

8 National Planning Commission, 'Nepal Status Paper' (Government of Nepal 2012) <https://sustainabledevelopment.un.org/content/documents/1018nepalnationalreport.pdf> accessed 10 April 2017.

9 Deep Prakash Ayadi, 'Environmental Governance and its development in Nepal' (2012) <www.researchgate.net/publication/237075470_Environmental_Governance_and_its_development_in_Nepal> accessed 11 April 2016; Madhukar Upadhya and Bibek Raj Kandel, 'Understanding the State of Environmental Governance in Nepal' in Sacchidananda Mukherjee and Debashis Chakraborty (eds), *Environmental Challenges and Governance: Diverse perspectives from Asia* (Routledge 2015).

related to environmental protection, in Nepal, are National Conservation Strategy 1988, Nepal Environmental Policy and Action Plan 1993, Tourism Policy 1995, Solid Waste Management Policy 1996, Hydropower Development Policy 2001, Nepal Biodiversity Conservation Strategy 2002, National Wetland Policy 2003, etc.[10] The community forestry programs, unique to Nepal, initiated in 1993 and now spread across Nepal is a role model for other countries to follow.[11] Scholars in legal studies studying environment and development have qualitatively described environmental governance aspects in various parts of the world. For example, conservation of ocean and marine resources in South Pacific islands; environmental courts in India for dealing with environmental and ecological issues; conditions that encourage participation of ordinary citizens in environmental protection and policy making in East Africa; interventions and judgements made by the Supreme Court of India for environmental protection.[12] These scholars provided vivid description and qualitative analysis of the benefits of such environmental governance initiatives to protect the environment. However, policy makers drafting environmental treaties/legislations or organizations funding environmental NGOs would routinely face this question: '*The efforts you guys put in…are they getting translated into concrete environmental benefits?*' In this paper, we use several such examples of environmental governance initiatives across the world and 'quantify' its impact using numerical measures. Quantifying this impact using objective data would help in a more nuanced understanding of this relationship. Furthermore, this approach is consistent with the calls made for empirically oriented research by scholars in legal studies. For example, Professor Michael Faure

opined regarding the empirical evidence for studying the impact of environmental laws (an important dimension of environmental governance):

> To a large extent, this evidence is not provided by lawyers. When making environmental law and choosing environmental instruments, environmental lawyers have many ideas and perhaps hopes for environmental law in promoting sustainable development. But do we actually know how effective the chosen instruments are? In other words: what do we know empirically? Even though environmental lawyers are probably the lawyers most interested in research on the effectiveness of law and policy, empirical legal work in this domain remains relatively limited.[13]

Across the world, governments, multi-national corporations, nongovernmental organizations, and scientists have come together in the recent decades to create laws, agreements, and institutions intended to solve large-scale environmental problems like acid rain, ozone depletion, loss of biodiversity, excess greenhouse gas emission, etc.[14] We focus on one large-scale environmental problem i.e. excess greenhouse gas emission. CO_2 is a greenhouse gas that traps heat in environment and contributes to global warming and one of the major determinants of environmental quality in a country.[15] There is need to reduce anthropogenic emission of such greenhouse gases to mitigate global warming. In this paper, we investigate the question: *Has environmental governance been effective to reduce anthropogenic emission of CO_2?* Our hypothesis is better environmental governance would lead to reduced anthropogenic CO_2 emission. This could be due to improved environmental literacy and pro-environmental behaviour by citizens, presence of environmental policies that regulate the amount of

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10 Ayadi (n 9).

11 ibid.

12 Dejo Olowu, 'Environmental Governance Challenges in Kiribati: An Agenda for Legal and Policy Responses' (2007) 3(3) *Law, Environment & Development Journal* 259; Raghav Sharma, 'Green Courts in India: Strengthening Environmental Governance?' (2008) 4(1) *Law, Environment & Development Journal* 50; Nicholas Kimani, 'Participatory Aspirations of Environmental Governance in East Africa' (2010) 6(2) *Law, Environment & Development Journal* 200; Geetanjoy Sahu, 'Implications of Indian Supreme Court's Innovations for Environmental Jurisprudence' (2008) 4(1) *Law, Environment & Development Journal* 3.

13 Michael G Faure, 'Instruments for Environmental Governance: What Works?' in Paul Martin, Zhiping Li, and Tianbao Qin (eds), *Environmental Governance and Sustainability* (Edward Elgar 2012).

14 James Gustave Speth and Peter M Haas, *Global Environmental Governance* (Island Press 2006).

15 Danny Harvey LD, 'A Guide to Global Warming Potentials (GWPs)' (1993) 21 *Energy Policy* 24.

vehicular pollution, environmental activism by NGOs and citizens to protect environmental degradation, etc.

This paper is organized as follows. In section 2, relevant literature is reviewed. In section 3, econometric modeling methodology is described including data collection and model specification. Model results and model diagnostics are explained in section 4. Section 5 concludes with findings and limitations of the study.

2
LITERATURE REVIEW

The impact of overall governance quality (no specific emphasis on environmental governance) on anthropogenic CO_2 emission has been studied using cross-national panel data.[16] The dataset consisted of 124 countries spanning the time period from 1984 to 2002. Equation (1) describes the functional specification used:

CO_2 emission per capita = f [GDP per capita, (GDP per capita)², population density, quality of governance, political institutions, socio-economic conditions, education level, education expenditure, interaction between governance and political institutions, interaction between education expenditure and education level, time trend] (1)

Data on anthropogenic CO_2 emission was obtained from World Development Indicators, published by the Data & Research Group of World Bank. Quality of governance is a composite index of quality of bureaucracy, corruption in the government, and democratic accountability obtained from the International Country Risk Guide, published by the Political Risk Services Group, New York. It was found that countries having better quality of governance, stronger political institutions, better socioeconomic conditions, and greater investment in education have lower anthropogenic CO_2 emission.[17] GDP per capita

and GDP per capita[2] were used as explanatory variables due to the Environmental Kuznets Curve (EKC) hypothesis. The EKC hypothesis postulates that pollution level in a country follows an inverted U-shaped relationship with the level of income or economic growth.[18] An important implication of EKC hypothesis is the realization that economic growth need not always lead to environmental degradation. Scholars have proposed various explanations for the existence of EKC.[19] We do not summarize those explanations in this paper.

In another closely related study, the authors studied the relationship between anthropogenic CO_2 emission and quality of governance on a cross-national panel dataset of G-20 countries for the time period 1996-2010.[20] The CO_2 emission data was obtained from International Energy Agency database. They used six governance measures provided by the World Bank, World Governance Indicators, as proxies for countries' governance quality. The six governance measures are: voice and accountability, political stability & absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption.[21] No other control variables were used by the authors. Using non-parametric techniques, they found that the relationship between governance quality and CO_2 emission is nonlinear i.e. countries' higher governance quality does not always lead to lower CO_2 emission. The governance measures used in both studies are related to the general quality of institutions of a country and not specific to activities related to environmental governance.[22] To rectify this gap, our study uses specific measures for environmental governance.

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16 Kuheli Dutt, 'Governance, Institutions and the Environment-income Relationship: A Cross-country Study' (2009) 11 *Environment, Development and Sustainability* 705.

17 ibid.

18 Gene M Grossman and Alan B Krueger, 'Economic Growth and the Environment' (1995) 110 *The Quarterly Journal of Economics* 353.

19 Theodore Panayotou, 'Demystifying the Environmental Kuznets Curve: Turning a Black Box Into A Policy Tool' (1997) 2 *Environment and Development Economics* 465; David I Stern, 'Progress on the Environmental Kuznets Curve?' (1998) 3 *Environment and Development Economics* 173.

20 George E Halkos and Nickolaos G Tzeremes, 'Carbon Dioxide Emissions and Governance: A Nonparametric Analysis for the G-20' (2013) 40 *Energy Economics* 110.

21 A detailed description of these measures can be found here: Daniel Kaufmann, Aart Kraay and Massimo Mastruzzi, 'The Worldwide Governance Indicators: Methodology and Analytical Issues' (2011) 3 *Hague Journal on the Rule of Law* 220.

22 Dutt (n 16); Halkos and Tzeremes (n 20).

3

ECONOMETRIC MODELLING METHODOLOGY

We use data from 120 countries for the years 2002 and 2005 and model using panel data regression. Table 1 summarizes the variables used, intuition behind using it, and expected sign of estimates. This is the theoretical framework we developed from existing literature. Data for all variables except environmental governance index was obtained from World Development Indicators, published by the Data & Research Group of World Bank.[23] The environmental governance index for countries was obtained from Environmental Sustainability Index Project of Yale University and Columbia University.[24] Environmental governance index, that specifically measures governance issues related to environment, was available only for the years 2002 and 2005. This composite index captures 'corruption, percentage of total land area under protected status, rule of law, local activities by public, government effectiveness, knowledge creation in environmental science and policy, and World Economic Forum survey on environmental governance'.[25] This index includes the specific dimensions of environmental governance. Though other indices like Environmental Performance Index are available for years 2006, 2008, 2010, 2012, 2014, and 2016, this index does not measure the specific dimensions of environmental governance.[26] For example, this index captures broader dimensions like human health impacts, level of safe sanitation, forest cover & biodiversity, and trends & intensity of CO_2 emission. It does not include specific dimensions of environmental governance like knowledge creation in environmental sciences, activities by the public to protect environment, etc. Another potential problem in the Environmental Performance Index is the presence of a measure of CO_2 emission (i.e. trends & intensity of CO_2 emission) which is our dependent variable of interest (CO_2 emission per capita). Thus, the existing data on Environmental governance index for 2002 and 2005 is the most appropriate (i.e. second-best) one to answer our research question. Though this data is 'seemingly' old, we justify its merit by basing our logic on the adequacy of research question, theoretical framework, and lack of perfect data availability.

Let us explain how the various measures in this composite index explain environmental governance. For example, high or low corruption alone cannot explain much about environmental governance in a country. A country having high corruption, low knowledge creation in environmental science & policy, and less environmental activities by the public, would have a lower Environmental governance index when compared to another country having low corruption, high knowledge creation in environmental science & policy, and more environmental activities by the public. These measures, which form the composite index, are relative and needs to be weighed with other measures to understand environmental governance of a country.

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23 <http://data.worldbank.org/> accessed 10 April 2017.

24 World Economic Forum - WEF - Global Leaders for Tomorrow Environment Task Force, Yale Center for Environmental Law and Policy - YCELP - Yale University, and Center for International Earth Science Information Network - CIESIN - Columbia University, '2002 Environmental Sustainability Index (ESI)' (NASA Socioeconomic Data and Applications Center 2002) <http://dx.doi.org/10.7927/H4SB43P8> accessed 5 March 2012; Yale Center for Environmental Law and Policy - YCELP - Yale University and others, '2005 Environmental Sustainability Index (ESI)' (NASA Socioeconomic Data and Applications Center 2005) <http://dx.doi.org/10.7927/H40V89R6> accessed 5 March 2012.

25 ibid.

26 <http://epi.yale.edu/> accessed 10 April 2017.

Table 1: Description of variables

Variables	Description	Intuition based on theory	Expected sign
Dependent variable			
CO_2 emission per capita	(CO_2 emission in metric tons)/ (population)		
Independent variables			
GDP per capita	(GDP in thousand $)/ (population)	Upward slope of inverted U-shaped curve of EKC hypothesis.	+
$(\text{GDP per capita})^2$	-	Downward slope of inverted U-shaped curve (it may happen that there is no downward slope because evidence of EKC hypothesis is mixed for CO_2).	+/-
Fossil fuel usage	(Fossil fuel energy consumption/Total energy consumption)*100	CO_2 emission due to vehicles, industries, etc. This may also explain some portion of the stringency of environmental regulation.	+
Environmental governance index	Composite index	Better environmental governance reduces CO_2 emission	-

Researchers have supported and rejected evidence for the existence of EKC for CO_2 emission using various cross-country datasets.[27] We do not provide a detailed review of literature on EKC hypothesis for CO_2 emission. Our intention is to provide theoretical justification for including GDP per capita and (GDP per capita)^2 as control variables for estimating the impact of environmental governance on anthropogenic CO_2 emission.

Let us explain the rationale of fossil fuel usage variable in more detail. What does this variable mean? Inclusion of this fossil fuel usage variable is intended to capture three scenarios: (1) Fossil fuels used to meet the power requirements in countries where agriculture is the major source of income (2) Fossil fuels used to meet demand of vehicular fuel in countries with high number of motored vehicles (3) Environmental regulations that are intended to limit fossil fuel usage or promote clean fuel usage. If we include clean fuel usage variable (also available in the World Bank database), it will be correlated with the fossil fuel usage variable i.e. in a country like UAE, the fossil fuel usage is close to 100% and the clean fuel usage is close to 0%. Hence, we decided against using clean fuel usage variable for the analysis.

There might seem a possibility for the existence of reverse causality i.e. higher CO_2 emission leading to

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27 Amy K Richmond and Robert K Kaufmann, 'Is There a Turning Point in the Relationship Between Income and Energy Use and/or Carbon Emissions?' (2006) 56 *Ecological Economics* 176; Marzio Galeotti, Alessandro Lanza, and Francesco Pauli, 'Reassessing the Environmental Kuznets Curve for CO_2 Emissions: A Robustness Exercise' (2006) 57 *Ecological Economics* 152.

better environmental governance. Our argument is higher CO_2 emission does not lead to better environmental governance in a country. Rather, better environmental governance in a country is due to high environmental literacy, spill-over effects of environmental literacy and awareness from other countries, awareness of human-made damages to the environment that are directly not related to CO_2 emission, etc.[28]

Let us describe how we arrived at the sample of 120 countries and the sample characteristics. The World Bank database had CO_2 emission data for 220 countries during the years 2002 and 2005. But, Environmental governance index for these two years was available only for 143 and 147 countries respectively. We choose 120 countries, because they had data for all the variables listed in Table 1. Developed countries with stricter implementation of environmental laws (ex: countries in North America, Europe, Oceania, Middle East part of Asia) constitute 40% of the sample. Developing countries with weaker implementation of environmental laws (ex: countries in South Asia, South America) constitute 60% of the sample. These 120 countries contributed to 57% of global CO_2 emission in 2002 and 2005. Summary statistics of our panel dataset consisting of 120 countries for the years 2002 and 2005, can be found in Table 2.

Table 2: Summary statistics of the panel dataset

Variable		Mean	Std. Deviation	Observations
CO_2 emission per capita	overall	5.185	5.709	N = 240
	between		5.697	n = 120
	within		0.525	T = 2
GDP per capita	overall	8862.43	12775.21	N = 240
	between		12440.76	n = 120
	within		3013.471	T = 2
(GDP per capita)^2	overall	2.41E+08	5.60E+08	N = 240
	between		5.18E+08	n = 120
	within		2.16E+08	T = 2
Fossil fuel usage	overall	67.822	27.828	N = 240
	between		27.840	n = 120
	within		1.616	T = 2
Environmental governance index	overall	0.0025	0.687	N = 240
	between		0.658	n = 120
	within		0.200	T = 2

28 Lyla Mehta, Melissa Leach, and Ian Scoones, 'Environmental Governance in An Uncertain World' (2001) 32(4) *IDS Bulletin* 1; Debra J. Davidson and Scott Frickel, 'Understanding Environmental Governance: A Critical Review' (2004) 17 *Organization & Environment* 471; A Damodaran, 'Fiat and Forbearance: The Challenge of Capturing Plurality and Diversity in Environmental Governance' (2012) 1 *IIM Kozhikode Society & Management Review* 33; Jouni Paavola, 'Institutions and Environmental Governance: A Reconceptualization' (2007) 63 *Ecological Economics* 93.

To answer the research question, we use the following linear specification:

CO$_2$ emission per capita = f [GDP per capita + (GDP per capita)^2 + fossil fuel usage + environmental governance index] (2)

We perform linear regression analysis to quantify the impact of environmental governance index. Given that

we have panel data, we check for the presence of individual (country specific) effects and time effects. The presence of these effects may call for using appropriate estimation procedures because OLS (Ordinary Least Squares) regression estimators are biased and inconsistent in their presence. We need not check for time effects because only two years are present in dataset. We suspect the presence of country specific effects. The steps followed to analyse this panel data are listed below:

Step 1: Run OLS regression on panel data

Step 2: Run fixed effects regression - are individual fixed effects significant?

Step 3: Run random effects regression - are individual random effects significant?

Step 4: Decide on fixed versus random effects

Step 5: Model diagnostics

These steps are motivated from econometric modelling literature.[29] We describe these steps in the next section. Panel data regression is executed using STATA software (StataCorp., 2007).[30] The dataset, codes used, STATA outputs are not included in this paper. They can be made available upon request.

4
MODEL RESULTS AND DIAGNOSTICS

Step 1

The pooled regression estimates (i.e. OLS estimator) and their statistical significance are summarized in Table 3.

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29 Badi H Baltagi, *Econometric Analysis of Panel Data* (4th edn, John Wiley & Sons 2008); Anthony Owusu-Gyapong, 'Alternative Estimating Techniques for Panel Data on Strike Activity' (1986) 68 *The Review of Economics and Statistics* 526.

30 StataCorp, 'Stata Statistical Software: Release 10' (2007).

Table 3: Pooled OLS

Variable	Expected sign	Obtained coefficient	p-value
GDP per capita	+	.0007	0.0001
(GDP per capita)^2	+/-	-9.90E-09	0.0001
Fossil fuel usage	+	.0613	0.0001
Environmental governance index	-	-3.259	0.0001

The estimated model is statistically significant i.e. it has an F-value of 114.2 that is statistically significant at 5% significance level. The estimated model fits significantly better than a model with no predictors. The sign of obtained coefficients meets theoretically expected signs. The interpretation of our parameter of interest is: a unit increase in environmental governance index reduces average CO_2 emission by 3.2 metric tons per capita. This OLS estimation is consistent only if there are no individual effects.

Step 2

To test for individual effects, we run fixed effects regression. The fixed effects model controls for all time-invariant differences between countries. The estimated coefficients of fixed effects model cannot be biased because of omitted time invariant characteristics like geographical advantages of oil reserves, political system, etc. The fixed effects regression estimates (Within estimator) and their statistical significance are summarized in Table 4.

Table 4: Fixed effects regression

Variable	Expected sign	Obtained coefficient	p-value
GDP per capita	+	0.0001	0.0001
(GDP per capita)^2	+/-	-1.65E-09	0.007
Fossil fuel usage	+	0.0528	0.054
Environmental governance index	-	0.0088	0.972

Fixed effects regression in STATA provides the result of restricted F-test for the significance of country specific effects. In this case it yields an F- value = 75.82 which is statistically significant at 5% significance level. This indicates that individual effects of each country are jointly significant. It also means that OLS estimator which omits these individual country effects suffers from an omission variables problem rendering them biased and inconsistent. Hence, Within estimator is preferred to OLS estimator. But, our parameter of interest does not have intuitive interpretation. The obtained estimate for environmental governance index is statistically insignificant even at 90% significance level and has positive sign which is contrary to theoretical reasoning. This may be because country specific time invariant effects, that were wiped out by Within estimators, would have captured much of the information that environmental governance index explains. Strength of a country's environmental governance is depended on the political system which is time invariant of that country.

Step 3

To test whether individual effects are random, we run random effects regression. Random effects model assumes country specific random error term to be uncorrelated with regressors which allows time-invariant variables to play a role in explaining the dependent variable's variation. Random effects model allows us to generalize the inferences beyond the sample used. The random effects regression estimates, also called GLS (Generalised Least Squares) estimator, and their statistical significance are summarized in Table 5. The GLS estimator incorporates the variance structure of error components. The default option in STATA uses Swamy and Arora method for estimating the variance components.

Table 5: Random effects regression

Variable	Expected sign	Obtained coefficient	p-value
GDP per capita	+	0.0003	0.0001
$(\text{GDP per capita})^2$	+/-	-3.36E-09	0.0001
Fossil fuel usage	+	0.0824	0.0001
Environmental governance index	-	-0.361	0.168

The p-value of Wald Chi-square is statistically significant at 5% significance level in the estimated model. This means that all coefficients are significantly different from zero. We did Breusch-Pagan Lagrange Multiplier (LM) test and Likelihood-Ratio (LR) test to check if variances of the random individual effects are different from zero. The null hypothesis of LM test is variances of random individual effects are zero i.e. no significant difference across countries. The test statistic rejected the null hypothesis at 5% significance level i.e. random country effects are significant and their variance is not zero. The null hypothesis of LR test is the same as LM test. The LR test statistic rejected the null hypothesis at 5% significance level i.e. random country effects are significant and their variance is not zero. Hence, GLS estimator is preferred to OLS estimator. The obtained coefficients of variables have intuitive signs. Our parameter of interest, though has an intuitive sign, is not statistically significant at 5% level after controlling for the random country specific effects. The interpretation of the coefficient of environmental governance index is: a unit increase in the index across time and between countries reduces average CO_2 emission by 0.36 metric tons per capita. So far, we have established that Within and GLS estimators are preferred to the OLS estimator. The remaining relevant question is whether it is reasonable to assume that individual effects are fixed or whether they are a consequence of some other random process. This question is addressed below.

Step 4

In this step we decide between choosing GLS estimator and Within estimator. We conduct Hausman specification test, which is based on the difference between fixed and random effects estimators. It basically tests whether the country specific random errors are correlated with regressors. The null hypothesis is they are not correlated. Random effects model assumes exogeneity of all regressors with the random individual effects. In contrast, fixed effects model allows for endogeneity of all regressors with these individual effects. If the assumption of random effects model is correct, then the additional information provided in this model leads to a more efficient estimator than Within estimator. The failure of this orthogonality assumption makes the random effects model similar to an omitted variable misspecification so that its GLS estimator is biased and inconsistent. On the other

hand, even if orthogonality condition is violated, the Within estimator remains unbiased and consistent. The Hausman chi-square statistic is not found to be statistically significant at 5% significance level i.e. we cannot reject the null hypothesis. The assumption of random effects model cannot be rejected. This means that GLS estimator is preferred over Within estimator. We finalise the estimated random effects model summarised in Table 5.

Step 5

In finalising the random effects model, we have assumed that disturbances have homoscedastic variances and constant serial correlation through the random individual effects. We cannot be confident about the p-values reported in Table 5, because tests for heteroscedasticity and serial correlation are not done. Testing for heteroscedasticity and serial correlation in random effects panel data model is an active research area. Research for better test statistics is being pursued actively. The existing literature ignores one when dealing with another i.e. when one deals with heteroscedasticity, serial correlation is ignored and when one deals with serial correlation, heteroscedasticity is ignored.[31] Our dataset is a micropanel with less time periods. Econometric theory says that such datasets are least likely to have problems of serial correlation.[32] We check for the presence of heteroscedasticity by executing the following steps:

a) run iterated GLS model assuming heteroscedasticity

b) run GLS model assuming homoscedasticity

c) run LR test where null hypothesis is heteroscedasticity exists

The results failed to reject null hypothesis i.e. heteroscedasticity is present in the model. We compute robust standard errors, described by Table 6, to control for heteroscedasticity.

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31 Baltagi n (29); Badi H Baltagi, Byoung Cheol Jung, and Seuck Heun Song, 'Testing for Heteroskedasticity and Serial Correlation in A Random Effects Panel Data Model' (2010) 154(2) *Journal of Econometrics* 122.

32 Baltagi n (29).

Table 6: Robust standard errors

Variable	Expected sign	Obtained coefficient	p-value
GDP per capita	+	0.0003	0.0001
(GDP per capita)^2	+/-	-3.36E-09	0.002
Fossil fuel usage	+	0.0824	0.0001
Environmental governance index	-	-0.361	0.169

We find that the environmental governance index is not significant at 5% significance level. However, it is significant if we raise the significance level to 17-20%. What significance level should we use? The answer to this question depends on what level of error we are willing to tolerate. Statistical significance (i.e. p-value) is merely the probability of committing Type 1 error. Error arises because of sampling i.e. based on a 'sample' study researchers hypothesise about the 'population'. In this study, the null hypothesis is: improvements in environmental governance have no effect on anthropogenic CO_2 emission. We can commit two types of error while accepting or rejecting this hypothesis based on sample results. These are Type 1 error and Type 2 error.

Type 1 error: We hypothesize that improvements in environmental governance reduces anthropogenic CO_2 emission. But, actually improvements in environmental governance have no such effects.

Type 2 error: We hypothesize that improvements in environmental governance have no effect on anthropogenic CO_2 emission. But, actually improvements in environmental governance reduces anthropogenic CO_2 emission.

Both errors are bad. But, they cannot be avoided because hypothesis is tested on a sample. Committing a Type 1 error could lead to Government spending money or encouraging environmental governance initiatives in spite of not realising any benefits through reduced anthropogenic CO_2 emission. Committing a Type 2 error could lead to Government spending its scarce resources on other projects and with minimal focus on environmental governance efforts. The p-value reports only the probability of committing Type 1

error. In this study, given the nature and consequence of committing a Type 1 error, we can safely increase the acceptable error level to 17-20%. Using this argument, we can still defend the practical significance of environmental governance index. Another plausible explanation for the observed significance level, could be due to limited data availability. This study also demonstrates that application of GLS estimator to random effects model is an appropriate approach to use because it is more efficient than OLS. This also means that existence of unobservable time-invariant country specific effects is not sufficiently important to warrant the adoption of a fixed effects specification.

To see how the results would differ across developed and developing countries, we split the dataset into two subsets: developed countries and developing countries. This splitting was done based on the income group of countries created by the World Bank.[33] High income countries were classified as developed and all other countries were classified as developing for the purpose of this analysis. The same analysis methodology was executed in both datasets to see how the coefficient of environmental governance index differs across the two sets of countries. It is interesting to observe an increase in environmental governance index leading to a decrease in anthropogenic CO_2 emission for both developed and developing countries. However, the statistical significance and magnitude of this impact differs. Coefficient of environmental governance index is statistically significant at 5% significance level for developed countries and 50% significance level for developing countries. The magnitude of CO_2 emission reduction is 1.69 metric tons for developed countries and 0.07 metric tons for developing countries.

relation between environmental governance and anthropogenic CO_2 emission. Reduction in per capita CO_2 emission by 0.36 metric tons (Table 6) when environmental governance index changes by one unit across time and between countries is significant, considering the magnitude of reduction that is achieved. Our study justifies the role of existing environmental laws, environmental activism by government and non-government institutions, and calls for more inter-country and intra-country laws and policies to reduce anthropogenic CO_2 emission. The study can be improved by using a better index of environmental governance (if available) for more time periods. Increasing time periods in the panel dataset will help capture the dynamic effects of change in anthropogenic CO_2 emission and will help obtain a better model. This paper has not accounted for oceans absorbing anthropogenic CO_2 emission resulting in ocean acidification and plants absorbing anthropogenic CO_2 emission for producing oxygen. The anthropogenic part in this paper includes only emission from burning fossil fuels and cement manufacturing. There are other sources of anthropogenic CO_2 emission that are not included in our study. This paper also makes a strong assumption that environmental governance influences CO_2 emission in the same year. Future studies can rectify these identified limitations.

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CONCLUSION

Responding to the calls made by scholars in legal studies studying environment and development, this paper does empirical research to understand the

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[33] <http://wits.worldbank.org/CountryProfile/Metadata/en/Country/All> accessed 10 April 2017.