Economics
The Open-Access, Open-Assessment E-Journal

Discussion Paper
No. 2017-16 | April 06, 2017 | http://www.economics-ejournal.org/economics/discussionpapers/2017-16

Governance, vulnerability to climate change, and green growth: international evidence

Thai-Ha Le, Youngho Chang, and Donghyun Park

Abstract
The authors examine the role of governance and vulnerability to climate change in green growth using a global panel dataset. They find that governance has a positive effect on environmental performance and vulnerability to climate change has a negative effect. Promoting good governance and reducing climate change vulnerability can thus contribute to a cleaner environment. They find qualitatively similar results for the sub-sample of high- income countries, but governance has an insignificant effect for the sub-samples of upper- middle-income, and lower-middle-and-low-income countries. High-income countries have strong environmental policies to protect the environment whereas other countries need to strengthen their relatively weak environmental policies. This suggests a need for substantial economic, technological and financial support from the international community for strengthening the environmental institutional capacity of developing countries.

JEL Q56
Keywords Governance; vulnerability to climate change; air quality; PM2.5; green growth

Authors
Thai-Ha Le, ✉ RMIT University (Vietnam Campus), 702 Nguyen Van Linh, Tan Phong Ward, District 7, Ho Chi Minh City, Vietnam, ha.lethai@rmit.edu.vn
Youngho Chang, Nanyang Technological University, Singapore
Donghyun Park, Asian Development Bank, Philippines

Citation Thai-Ha Le, Youngho Chang, and Donghyun Park (2017). Governance, vulnerability to climate change, and green growth: international evidence. Economics Discussion Papers, No 2017-16, Kiel Institute for the World Economy. http://www.economics-ejournal.org/economics/discussionpapers/2017-16

Received March 1, 2017 **Accepted as Economics Discussion Paper** April 3, 2017
Published April 6, 2017

1. Introduction

At initial stages of industrialization, countries prioritize economic growth and job creation rather than cleaning up air and water pollution. Furthermore, poor countries often do not have adequate resources for tackling environmental degradation and are saddled with relatively weak environmental regulations. Consequently, the pollution level of poor countries deteriorates rapidly as they industrialize. However, as a country grows richer, its citizens tend to value the environment more highly, and thus demand stronger regulatory institutions. As a result, it is possible that leading industrial sectors become cleaner and pollution peaks as a country reaches a certain threshold income level and then falls toward pre-industrial levels as income rises even further (Dasgupta et al., 2005).

The scenario outlined above suggests that policy-makers in many developing countries are explicitly or implicitly pursuing a policy of "grow first, clean up later". The same scenario does not bode well for the environmental prospects of developing countries. Since it could take a long time for many low- to middle-income countries to reach the threshold income level at which their citizens begin to vocally demand a cleaner environment, they may have to suffer worsening pollution and environmental degradation for many decades. The so-called inverted U-shape relationship between income level and pollution level is known as the Environmental Kuznets Curve (EKC) but it has been challenged by many economists. In particular, several studies on the EKC do not support the existence of a simple, straightforward relationship between pollution and per capita income due to the presence of other structural factors. In this context, we go beyond the EKC by incorporating two structural factors, namely, governance and vulnerability to climate change.

Our results confirm that the simple link between income and environment suggested by the conventional EKC is mis-specified. In particular, we find that governance has a significant effect on environmental quality for the full sample of countries. The other factor

we incorporate is vulnerability to climate change, which is not due to climate alone but instead reflects a diverse constellation of underlying factors. These include the socio-political environment, economic structure, and institutional and political characteristics (Diaz and Ortega, 2011). Environmental outcomes can be significantly affected by these factors. Using advanced econometric techniques and newly available data, we aim to contribute to the existing literature on the environment and sustainable growth by incorporating these two important variables into a more complete model of environmental change.

Air pollution has been a serious problem across the world. The cost for countries is enormous. Air pollution affects economies and quality of life, and it causes major chronic diseases and even death. The health impact of air pollution is much larger than the estimates of only a few years ago. Every year, three million people around the world die due to outdoor pollution. The World Health Organisation (WHO) estimates that in 2012, there were around 7 million premature deaths linked to air pollution, more than double previous estimates. Of the 7 million, air pollution claimed 3.7 million lives and indoor air pollution caused 4.3 million lives. Based on the WHO Global Urban Ambient Air Pollution Database as of May 2016, which covers 3,000 cities in 103 countries, approximately more than 80 per cent of people living in urban areas are breathing air laden with pollutants far above WHO limits. The reality is even more disturbing since many countries have random monitoring systems or none at all (Gulf News Editorial, 2016). As such, environmental issues in general and air pollution in particular are of interest not only to researchers but also policy makers around the world. Since the world economy is highly diverse and consists of countries at different stages of economic development, we analyse and compare countries grouped by income level.

Specifically, we investigate the relationship between governance, vulnerability to climate change, and environmental performance for a panel data of 122 countries from 2000 to 2012. Our main findings are follows. For the full sample of countries, better governance

improves environmental performance while higher vulnerability causes environmental degradation. This result suggests that better governance and reduced vulnerability benefits the environment. As such, policies that improve governance and reduce vulnerability to climate change can promote a cleaner environment.

Unlike the clear overall pattern of the full sample results, the empirical evidence for different income groups of countries is mixed. The results for the sub-sample of high-income countries are qualitatively similar to the full sample results. However, the results for the sub-samples of upper-middle-income and lower-middle-and-low-income countries differ from the full sample results. Vulnerability to climate change still harms environmental performance, but governance becomes insignificant. Overall, our evidence indicates that developed countries are more successful than developing countries in addressing environmental problems. As such, there is a need for substantial economic, technological and financial support from the international community to strengthen the environmental institutional capacity of developing countries.

The remainder of this paper is organised as follows. Section 2 reviews the literature on the economy-environment nexus, especially studies on emissions pollutants. Section 3 presents our empirical model, data, and methodology. Specifically, we introduce governance and vulnerability to climate change as new explanatory variables, and explain how we incorporate them into the empirical analysis. Section 4 reports and explains our empirical results. Section 5 discusses the policy implications of our main findings. Section 6 concludes the paper.

2. Literature Review

The link between income and environmental quality has been extensively studied. The evidence indicates that not all pollutants follow the inverted U-shape curve pattern suggested by the EKC hypothesis (Lipford and Yandle, 2010). The main reason for this is that the EKC mis-specifies the relationship between growth and the environment. A key source of mis-specification is the omission of governance or institutional quality when estimating the relationship. Wood and Herzog (2014) assert that economic freedom, one measure of the quality of economic institutions, plays a critical role in the linkage between economic development and environmental quality. Failure to incorporate this factor in economic models of pollution could thus cause spurious results.

Regarding the effects of governance and institutional quality on the environment, Carlsson and Lundstrom (2001) present four simplified hypotheses, including (i) government size effect, (ii) efficiency effect, (iii) trade regulation effect, and, (iv) stability effect. First, the government size effect hypothesises a hump-shaped relationship between government size and emissions. Specifically, when the government is small, much of government expenditures are typically allocated to basic infrastructure such as roads and power plants. As government size increases, however, expenditures will include redistributive transfers to mitigate income inequality. Lower inequality has a positive effect on the demand for cleaner environment (see, for example, Magnani, 2000). If the environment is considered a luxury public good, it will be demanded only at large levels of government size – i.e. when the demand for other public goods has been fulfilled.

The efficiency effect arises under the assumption that economic freedom leads to efficient and competitive markets. The correlation between economic freedom and environmental quality is expected to be positive. First, an efficient use of resources could result from, for example, externality-correcting taxes which reduce emissions per unit of

environmental resources. Second, efficient and competitive markets can better satisfy government regulations and consumer preferences. Competitive pressures will force firms to adapt to changes in the market environment in order to survive. Clearly, these two effects are only relevant in the presence of environmental regulations or strong consumer demand for cleaner environment (Carlsson and Lundstrom, 2001).

The trade regulation effect relates to restrictions and taxes on trade. Trade liberalization could have both positive and negative effects on the environment. On one hand, trade liberalization can improve resource allocation of resources, including environmental resources. Freer trade leads to cross-border diffusion of new clean technologies that reduce pollution. On the other hand, the scale effect, proposed by Antweiler et al. (2001), refers to how freer trade increases output, which in turn increases pollution. More trade also changes the composition of industry, which can have either a positive or negative effect on pollution, depending on factor endowments. Antweiler et al. (2001) showed that freer trade can lead to an overall cleaner environment for some pollutants. However, pollution can increase in some locations due to technology diffusion and a change in industrial composition.

Finally, the stability effect implies that a stable macroeconomic environment with low inflation rate and clear pricing signals results in more efficient investment and consumption decisions. Another important part of the stability effect is more secure property rights and enforceable contracts (see, for example, Panayotou, 1997). These factors facilitate long-term investments including environmental investments. On the other hand, stability also promotes investment and consumption in general, which can harm the environment.

There have been a number of cross-country studies that relate environmental quality to governance or institutional quality (see, for instance, Panayotou, 1997; Lopez, 1997; Barrett and Graddy, 2000; Bhattarai and Hammig, 2001; Antweiler et al., 2001; Carlsson and Lundstrom, 2001; Stroup, 2003; Bernauer and Koubi, 2009; Leitao, 2010; Wood and Herzog,

2014). Specifically, for property rights and quality of institutions, Panayotou (1997) initiated the interest in institutions and highlighted that higher economic growth and population density moderately raise the environmental price of economic growth, but these effects could be offset by improved policies. Bhattarai and Hammig (2001) also found the positive effects of better political institutions and governance for forest preservation while using indices of political rights and civil liberty as measures of institutional quality. For trade restrictions, López (1997) asserted that the faster rate of deforestation in Ghana is attributable to substantial trade liberalization in the country. Antweiler et al (2001) argued that the environmental effects of trade could be broken down into composition, growth, scale, and technique effects.

Leitao (2010) and Bernauer and Koubi (2009) opined that political institutions play a critical role in improving environmental quality. Using a sample of 42 countries during the period from 1971 to 1996, Bernauer and Koubi (2009) found that democracy has a positive effect on air quality. Furthermore, their results also reveal that environmental protection is generally more favoured by presidential systems than parliamentary systems. They also showed that the environment protection is enhanced by the green parties while being reduced by labour union strength. Barrett and Graddy (2000), Carlsson and Lundstrom (2001), Stroup (2003), and Wood and Herzog (2014) find evidence that economic freedom has a favourable environmental impact. Using a multi-country data set over the period from 2000 to 2010, Wood and Herzog (2014) established evidence that economic freedom is vital for tackling local environmental problems (which is measured by the concentration of fine particulate matter) but having minimal effect on reducing carbon dioxide emissions.

While these studies acknowledge that corruption, political institutions, or social structure are instrumental in accurately measuring the connection between economic activity and environmental quality, they do not fully account for those factors in their analysis (see,

for example, Panayotou, 1997; Barrett and Grady, 2000; Bhattarai and Hammig, 2001; Bernauer and Koubi, 2009; Leitao, 2010; Lin and Liscow, 2013). As such, our study contributes to the literature by more explicitly incorporating governance into the empirical analysis.

Relative to the governance-environment literature, there are far fewer studies on the link between vulnerability to climate change and environmental quality. According to The Intergovernmental Panel on Climate Change (IPCC), vulnerability is defined as "the extent to which climate change may damage or harm a system" (Watson et al., 1996). Vulnerability to climate change is not due solely to climate but is determined by multiple factors such as the socio-political environment and the economic structure (Diaz and Ortega, 2011). This suggests that the relationship between vulnerability and the environment may not be straightforward. For example, poor tropical countries may be highly vulnerable to rising sea levels but their underdevelopment and relatively small consumption may limit their damage on the environment.

The literature offers alternative definitions of vulnerability. Tinnerman (1981) defines it as the degree to which a system reacts adversely to the occurrence of an event. Liverman (1990) defines vulnerability on the basis of socio-economic, political, and geographical conditions. IPCC (2014) defines it as "a system's capacity to absorb and recover from the occurrence of a hazardous event". In general, vulnerability depends on the sensitivity of the different elements composing a system and the connectivity between the elements. The complex nature of vulnerability rules out a simple, straightforward relationship between vulnerability and the environment.

Overall the literature has not identified a straightforward relationship between governance, vulnerability to climate change and environmental quality. This could be attributable to several factors. First, empirical studies have not controlled for more structural

factors in modelling the relationship. Second, the empirical methods employed in the estimation have often failed to account for statistical problems in data such as cross-sectional dependence, heteroscedasticity, and serial correlation. Third, the level of a country's income and economic development is ignored.

In this study, we aim to fill the three gaps in the literature outlined above. Specifically, (1) we build up a baseline model which includes more relevant variables that may affect environmental performance; (2) we employ an advanced empirical methodology that controls for a number of problems in estimating panel data; and (3) besides estimating the global sample, we break the sample down into three subsamples of countries at different income levels to examine how the environmental effects of governance and vulnerability vary according to income.

3. Empirical Framework

In this section, we present the data and methodology used for our empirical analysis.

3.1. Data and Model

The aforementioned literature suggests there is a relationship between environmental quality and various variables such as income, governance structure, and institutional quality. The baseline model of our empirical analysis is constructed as follows:

$$ENV_{it} = \alpha_{it} + \beta_{1i} GOV_{it} + \beta_{2i} VUL_{it} + \beta_{3i} Y_{it} + \beta_{4i} ENE_{it} + \varepsilon_{it} \qquad [1]$$

where i = 1, 2, 3, … N for each country in the panel and t = 1, 2, 3, … T refers to the time period. ENV_{it} is the indicator of environmental quality, proxied by pollutant emissions, GOV_{it} is the indicator of governance, VUL_{it} is the indicator of vulnerability to climate change, Y_{it} is per capita real GDP in constant 2005 US$, ENE_{it} is the primary energy

consumption per capita, and ε_{it} is the error term. The novelty of this structure is to explicitly consider the possible impact of the level of energy consumption on the relationship between governance, vulnerability to climate change and air quality. The primary energy usage per capita is added to the regressions since a large share of pollutant emissions come from the energy sector. Hence this control variable reflects potential pollutant emissions loading. All variables are converted into natural logarithms and hence their differenced logarithms imply the growth rate of the relevant variables.

The coefficients $\beta_1, \beta_2, \beta_3, \beta_4$ correspond to the elasticities of environmental quality indicator with respect to governance, vulnerability to climate change, real GDP per capita, and primary energy use per capita, respectively. The sign and statistical significance of β_1 and β_2 is of main interest for our study. In theory, as presented in the literature review section, the environmental effects of governance and vulnerability are uncertain.

We choose the Index of Economic Freedom as a proxy for the governance. The index is provided by the Heritage Foundation (2016) and constructed based on trade freedom, business freedom, investment freedom, and property rights. The index measures economic freedom of 186 countries over the period from 1995 to 2016 but data availability differs for each country. The index ranges from 0 to 100 and the higher score the freer. We believe that this Index of Economic Freedom captures, to a significant degree, the four theoretical effects of governance on the environment: (i) government size effect, (ii) efficiency effect, (iii) trade regulation effect, and, (iv) stability effect. For robustness check, in addition to the Index of Economic Freedom, we use the index for Government Effectiveness, for which higher values indicate higher levels of effectiveness. The Government Effectiveness index is obtained from World Bank (2016)'s Worldwide Governance Indicators, available for the years 1996 to 2015.

We acknowledge that a better proxy for governance factor would be variables related to pollution regulations, a proxy for which is the World Bank's Country Policy and Institutional Assessment (CPIA) indicators on the environment. However, this data series is only available from 2005-2014. Given that our data on air quality is only available until 2012, the investigation period from 2005 to 2012 is insufficient to conduct any meaningful empirical analysis. Alternatively, one might think about including dummy variables or indices which could represent the degrees to which regulations seek to control fine particulate matter (PM) emissions, such as vehicular emissions standards (e.g., Euro 2 or Euro 4), technological standards for coal power plants (e.g., whether flue desulphurisation is required), national air quality standards, and so forth. Unfortunately, all of these possible data series are inadequate, in terms of both time-series and cross-section of countries.

For vulnerability to climate change, we employ the Vulnerability index from the University of Notre Dame Global Adaptation Index (ND-GAIN, 2016). The vulnerability score "measures a country's exposure, sensitivity and capacity to adapt to the negative effects of climate change" (ND-GAIN). Specifically, six life-supporting sectors are captured in the measure of vulnerability by ND-GAIN, including: ecosystem service, food, health, human habitat, infrastructure and water. A higher score indicates greater vulnerability. For robustness check, we use another proxy, namely the Sensitivity score from ND-GAIN. This score measures the degree to which a country is reliant on a sector adversely impacted by climate hazard, or the proportion of the population particularly prone to a climate change hazard (ND-GAIN). The sensitivity of a country can fluctuate over time.

For an environmental quality indicator, the population weighted exposure to particles smaller than 2.5 microns in diameter, known as PM2.5, is obtained from Yale Center for Environmental and Policy (2016). Apart from data availability for a relatively large number of countries, we chose PM2.5 in our study since the fine particulate matter (PM2.5) problem

has attracted a lot of scientific and public attention. This is attributable to its effects on visibility, human health, and global climate. According to the Yale Center for Environmental and Policy, PM2.5 is generally the product of combustion, whether manmade like car emissions and coal burning, or natural like forest fires and volcanic activity. PM2.5 is recognized as "a major global killer" by the WHO (WHO, nd). Since PM2.5 is fine enough to lodge deep into human lung and blood tissue, populations exposed to PM2.5 are at risk of heart and lung diseases, ranging from stroke to lung cancer, which might cause death in severe cases. Furthermore, fine particulates including PM2.5 are a main contributor to the incidence of pneumonia at the global level, which is a major cause of child mortality worldwide (WHO, 2016). Despite its well-known health impact, PM2.5 is not monitored properly in many countries, due to lack of capacity, resources, or public demand.

Particulate matter is believed to be carcinogenic (IARC, 2013). Improving air quality in general and reducing PM2.5 emissions in particular has the potential to provide enormous economic benefits. In the United States, the 1990 Clean Air Act Amendments estimated that the direct economic benefits of reducing PM2.5 and ground-level ozone are about 90 times the implementation costs. Approximately 85% of the economic benefits are attributable to fewer premature deaths related to reducing PM2.5 in the outdoor environment, with 230,000 premature deaths avoided in 2020 alone (UNEP, 2014).

Data for per capita real GDP (constant 2005 US$) and per capita primary energy use are extracted from World Development Indicators (2016). All the data used in this study are pooled annual time series. Our country sample includes 122 countries and our sample period spans 2000 to 2012. Data availability was the main criterion for both country sample and time period. Since the countries in our sample are at various stages of economic development, in addition to the full sample, the countries are divided into three sub-samples according to the World Bank's income classification. Specifically, one sub-sample comprises high-income

countries, another sub-sample comprises upper-middle-income countries, and a third sub-sample comprises lower-middle-income and low-income countries.[1] Table 1 summarises the list of countries in the sample.

[1]According to the World Bank's income classification, the groups are: low income, US$1,035 or less; lower middle income, US$1,036 - US$4,085; upper middle income, US$4,086 - US$12,615; and high income, US$12,616 or more.

Table 1
List of countries in the study sample

Income Groups	Country list (122 countries in total)
High-income countries (49 countries)	Argentina, Australia, Austria, Bahrain, Belgium, Canada, Chile, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, South Korea, Kuwait, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Oman, Poland, Portugal, Qatar, Russian Federation, Saudi Arabia, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Trinidad and Tobago, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela
Upper-middle-income countries (35 countries)	Albania, Algeria, Azerbaijan, Belarus, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Gabon, Iran, Jamaica, Jordan, Kazakhstan, Lebanon, Libya, Malaysia, Mauritius, Mexico, Mongolia, Namibia, Panama, Paraguay, Peru, Romania, South Africa, Thailand, Tunisia, Turkey, Turkmenistan
Lower-middle and low-income countries (38 countries)	Armenia, Bangladesh, Benin, Bolivia, Cambodia, Cameroon, Egypt, El Salvador, Ethiopia, Georgia, Ghana, Guatemala, Haiti, Honduras, India, Indonesia, Kenya, Kyrgyz Republic, Moldova, Morocco, Mozambique, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Philippines, Senegal, Sri Lanka, Tajikistan, Tanzania, Togo, Ukraine, Uzbekistan, Vietnam, Yemen, Zambia, Zimbabwe

Source: World Bank's income classification. The groups are: low income, $1,045 or less; lower middle income, $1,046–4,125; upper middle income, $4,126–12,735; and high income, $12,736 or more.

Table 2 provides the means of the raw data of the variables. Overall, for most indicators, the group of high-income countries perform better than the group of upper-middle-income countries, and both groups perform better than the group of lower-middle and low-income countries. The only exception is the population weighted exposure to PM2.5, for which high-income countries perform best (lowest figure), followed by lower-middle and low-income countries and then upper-middle-income countries.

Table 2
Mean of the variables in the study (time period: 2000-2012)

Variables	All countries	High-income countries	Upper-middle-income countries	Lower-middle and low-income countries
ECONOMIC FREEDOM	61.414	68.955	57.683	55.127
GOVERNMENT EFFECTIVENESS	55.392	80.248	45.908	32.076
VULNERABILITY	0.399	0.314	0.409	0.498
SENSITIVITY	0.366	0.305	0.375	0.436
GDP (in US$ per capita)	12,599.654	27,703.538	4,123.968	930.147
ENERGY USE (in kg of oil equivalent per capita)	2,625.702	4,988.623	1,520.559	596.673
PM2.5 (in micro-grams per cubic meter)	10.100	9.425	10.535	10.160

Source: Authors' calculation

3.2. Methodology

To examine the relationships between particulate matter emissions (*PM2.5*) and governance (*GOV*), vulnerability to climate change (*VUL*), real GDP per capita (*GDP*), and primary energy use per capita (*ENE*) for 122 countries across the world for the period 2000 to 2012, a panel data model is used in this study since it has many advantages over cross-sectional or time series data. First, by pooling the time series data across countries, panel data allows for more observations and leads to higher power for the Granger causality test (Pao and Tsai, 2010). This advantage is particularly relevant in the case of short time series. Second, as compared to time series and cross-sectional data, panel data allows for "more informative data, more variability, less collinearity among the variables, more degrees of freedom, and more efficiency" by controlling for individual heterogeneity (Baltagi, 2005).

Depending on whether there is a seeming long-run relationship (i.e., the presence of cointergration), we estimate the parameters in the cointegrating vector. Estimations are performed on the four following samples. The first sample includes all the 122 countries in our study sample. The second sample consists of only high-income countries, the third sample includes only upper-middle-income countries, and the fourth panel comprises only lower-middle and low-income countries.

Three preliminary tests are performed prior to estimating the panel models. The Wooldridge test (see Drukker, 2003 and Wooldridge, 2002) was performed to test for serial correlation in panel-data models, and the Modified Wald statistic (Greene, 2008) was derived as part of the test for the presence of group-wise heteroskedasticity in the fixed effect model. We also use the Lagrange multiplier CD_{LM} test by Pesaran (2004) to check for cross sectional dependency. This is because this test is more suitable for our data where the number of observations, N is large and the number of time period, T is small ($T<N$). The results show the presence of serial correlation and group-wise heteroskedasticity. Furthermore, there is

also evidence on the presence of cross-sectional dependence under a fixed effect (FE) specification.[2] The results are found to be robust to different measures of governance and vulnerability.[3]

We thus estimate the proposed models by employing the robust standard errors by Driscoll and Kraay (1998) for panel regressions, taking into account cross-sectional dependence (SCC). To this end, we use the Driscoll and Kraays' (1998) standard errors produced by the xtscc program presented in Hoechle (2007) for linear panel models. Besides being heteroscedasticity consistent, this estimation accounts for cross-sectional dependence problems and corrects for auto-correlation of any order. When we adjust the standard error estimates in this way, it could be guaranteed that the covariance matrix estimator is consistent and independent of the cross-sectional dimension N (i.e., also for $N \to \infty$) (Hoechle, 2007). The xtscc program by Hoechle (2007) works well with balanced panels as well as unbalanced panels such as the one we use.

4. Empirical Results

This section reports and discusses the empirical results of this study. Accordingly, the first step is to perform panel unit root tests that take into account cross-sectional dependence, including Im et al. (IPS) (2003)'s and Pesaran (2007)'s unit root tests. The results suggest that the variables have a unit root in level but are stationary in first difference.[4] Since all variables are integrated of order one, we examine the cointegration relationship among our variables of interest *ENV, GOV, VUL, GDP* and *ENE* using the Durbin Hausman-group mean

[2] The Hausman test (with pooled OLS is preferred under the null hypothesis, while under the alternative, fixed effects is at least consistent and thus preferred) was conducted for all models in our study. The results suggested that fixed effects are preferred for all the models, regardless of the different measures of governance and vulnerability. The Hausman test results are not presented here to conserve space, but they are available upon request.

[3] The results of these three preliminary tests are not presented here to conserve space, but they are available upon request.

[4] The unit root test results are not presented to conserve space, but they are available upon request.

test (DHg) and panel test (DHp) developed by Westerlund (2008). This test takes into account cross-sectional dependence modelled by a factor model so that the errors of Eq. (1) are obtained by idiosyncratic innovations and unobservable factors that are common across units of the panel (Auteri and Constantini, 2005). Heterogeneous autoregressive parameters are assumed across panel units in this case (Auteri and Constantini, 2005). The results indicate that the variables *ENV, GOV, VUL, GDP* and *ENE* are bound by a cointegrating relationship. This result holds across different income groups of countries, regardless of different measures of governance and vulnerability.[5] Our finding of a long-term relationship among the variables supports the presence of important channels through which a country's governance and vulnerability to climate change can affect the environment, as reviewed in Section 2.

Given the presence of cointergration, this study next estimates the parameters in the cointegrating vector that show the long-run relationship. This study first employs variance inflation factor (VIF) in the proposed model in order to identify potential multicollinearity (Alin, 2010). VIF is an effective tool for multicollinearity assessment with its straightforward and comprehensive calculations. The higher value of VIF indicates the higher collinearity between the related variables. In our study, the obtained VIF values are all below than 10, suggesting that there is no multicollinearity in this dataset.[6]

This study then estimates the long-run parameters in the cointegrating vector using Driscoll and Kraays' (1998) standard errors for linear panel models produced by the xtscc program as in Hoechle (2007).[7] The results are reported in Table 3. Since all variables are expressed in natural logarithms, the coefficients could be interpreted as long-run elasticities.

[5] The cointegration results are not reported here to conserve space, but they are available upon request.
[6] The VIF test results are not reported here to conserve space, but they are available upon request.
[7] Before the estimation, the stability of the relationship between the variables of interest was examined using the Di Iorio and Fachin (2007)'s test for breaks in cointegrated panels. The results indicate the acceptance of the null hypothesis of no break. This finding implies that the relationship among the investigated variables is stable and not subject to structural breaks during the investigation period. The results are not presented here to conserve space, but they are available upon request.

The full-sample results show that governance promotes environmental performance while vulnerability degrades the environment. As discussed in Section 2, the effect of governance and vulnerability to climate change on the environment is uncertain. For example, while trade liberalization can benefit the environment by promoting the cross-border diffusion of cleaner technologies, it can also harm the environment by expanding output and consumption. In addition, the complex multidimensional nature of vulnerability to climate change, which depends only partly on the climate, introduces uncertainty into the vulnerability-environment nexus. Our evidence suggests that the factors which underlie a positive governance-relationship dominate those that underlie a negative relationship and likewise, the negative underlying factors dominate the vulnerability-environment relationship.

These results hold qualitatively for the high-income sub-sample. On the other hand, for the sub-samples of upper-middle-income countries and low and lower-middle-income countries, vulnerability has a significant effect on environmental performance, but governance is no longer significant. Our results are robust to different measures of governance and vulnerability as well as environmental performance. The findings imply that while high-income countries have strong environmental policies that benefit the environment, some upper-middle-income countries and low and lower-middle-income countries have relatively weak environmental policies which need to be strengthened.

Table 3
Long-Run Estimation Results

ALL COUNTRIES				
	(1)	(2)	(3)	(4)
	PM2.5	PM2.5	PM2.5	PM2.5
ECONOMIC FREEDOM	-0.555***		-0.557**	
	(-3.498)		(-3.336)	
VULNERABILITY	0.716***	0.692***		
	(8.158)	(7.239)		
GDP	-0.070*	-0.152***	-0.008	-0.099***
	(-2.355)	(-11.675)	(-0.244)	(-5.746)
ENERGY	0.058	0.108***	0.094***	0.148***
	(1.909)	(5.546)	(3.905)	(11.999)
GOVERNMENT EFFECTIVENESS		-0.045*		-0.064**
		(-2.333)		(-3.298)
SENSITIVITY			0.100**	0.077**
			(3.201)	(3.334)
_CONS	1.702***	0.785***	1.611***	0.681***
	(4.949)	(53.408)	(4.565)	(32.417)
N	1586	1586	1586	1586
HIGH-INCOME COUNTRIES				
	(1)	(2)	(3)	(4)
	PM2.5	PM2.5	PM2.5	PM2.5
ECONOMIC FREEDOM	-1.715***		-1.737***	
	(-4.390)		(-4.735)	
VULNERABILITY	0.171***	0.192***		
	(4.920)	(4.004)		
GDP	-0.280***	-0.134***	-0.270***	-0.126***
	(-15.802)	(-9.386)	(-7.799)	(-4.821)
ENERGY	0.188***	0.185***	0.179***	0.176***
	(12.169)	(8.285)	(6.594)	(5.083)
GOVERNMENT EFFECTIVENESS		-0.040***		-0.067***
		(-4.816)		(-3.820)
SENSITIVITY			0.150**	0.136*
			(3.340)	(2.409)
_CONS	3.662***	1.225***	3.709***	1.257***
	(6.043)	(21.979)	(6.308)	(23.769)
N	637	637	637	637
UPPER-MIDDLE-INCOME COUNTRIES				
	(1)	(2)	(3)	(4)
	PM2.5	PM2.5	PM2.5	PM2.5
ECONOMIC	-0.189		-0.227	

FREEDOM				
	(-1.793)		(-1.578)	
VULNERABILITY	1.433***	1.342***		
	(16.667)	(17.520)		
GDP	0.290***	0.336***	0.309***	0.362***
	(29.155)	(21.128)	(41.801)	(21.292)
ENERGY	0.259***	0.323***	0.405***	0.474***
	(9.982)	(13.754)	(12.956)	(19.923)
GOVERNMENT EFFECTIVENESS		-0.062*		0.081
		(-2.677)		(0.066)
SENSITIVITY			0.314***	0.253***
			(11.945)	(13.922)
_CONS	0.888***	0.456***	0.989**	0.464***
	(3.785)	(7.544)	(3.049)	(6.163)
N	455.000	455.000	455.000	455.000
LOWER-MIDDLE AND LOW-INCOME COUNTRIES				
	(1)	(2)	(3)	(4)
	PM2.5	PM2.5	PM2.5	PM2.5
ECONOMIC FREEDOM	-0.413		-0.309	
	(-1.390)		(-1.070)	
VULNERABILITY	1.456***	1.335***		
	(18.910)	(23.828)		
GDP	-0.019	0.100***	0.006	0.089***
	(-0.489)	(13.706)	(0.153)	(10.571)
ENERGY	0.137***	0.068***	0.055**	0.108***
	(4.394)	(4.075)	(3.223)	(5.405)
GOVERNMENT EFFECTIVENESS		0.053		0.098
		(0.341)		(0.292)
SENSITIVITY			0.501***	0.476***
			(7.554)	(6.010)
_CONS	1.630***	0.919***	1.120*	0.585***
	(3.612)	(18.942)	(2.683)	(11.642)
N	494	494	494	494

Source: Authors' calculation. Note: ***, ** and * respectively indicate statistical significance at the 1%, 5% and 10% levels. t statistics are in parentheses.

Our results are in line with UNEP Year Book 2014 Update, which finds that air pollution in high-income countries has declined in recent periods, partly due to tighter emissions controls, including on vehicles. On the other hand, as a result of rapid growth of road traffic in emerging middle-income countries like China and India, air pollution has outpaced the adoption of tighter vehicle emissions standards. Our findings are also consistent with a World Bank study which highlighted the critical part of "institutional development, with significant roles for private property protection, effectiveness of the legal/judicial system and efficiency of public administration" (Dasgupta et al. 2001, p. 173). Overall, our analysis recognizes the central role of governance factors in environmental performance (Dasgupta et al. 2005, p. 416).

Possible interpretations of our findings are as follows. Some countries specialise in relatively clean industries and production techniques as they become richer. Higher income can also provide more fiscal resources for public investment in environmental protection (Bhagwati, 1993). On the other hand, developing countries face significant governance and environmental issues in tackling environmental policy issues, which may be the reason why they find it hard to move from relatively poor and dirty to relatively poor and clean. Furthermore, the environmental awareness of the general public tends to be lower in developing countries and there are thus fewer mechanisms for advocacy. For instance, in China, while there seems to be a growing level of dissatisfaction with pollution in big cities such as Beijing, there is little public debate about solutions. The prevailing perception among stakeholders seems to be that environmental deterioration is a price worth paying for economic growth. Compared to developed countries, in many developing countries, there are fewer mechanisms in place for citizens to lobby for green transformation. For example, in China there are no institutional channels for public and social organisations to participate in

environmental protection, and only very few environmental non-governmental organisations exist.

5. Policy Implications

Pollution is a critical environmental challenge facing the world today, causing ill health, death and disabilities of millions of people annually.[8] The large adverse effects of pollution have led to anti-pollution efforts in both developed and developing countries. Our full sample empirical results indicate that better governance improves environmental performance while higher vulnerability to climate change causes environmental degradation. Policies that improve governance and reduce vulnerability to climate change can thus promote a cleaner environment.

Developed countries have already achieved relatively high general living standards and they can thus afford to make a concerted effort to improve the environment. More specifically, they have the resources, technology and institutional capacity, including strong and effective governments, to address environmental issues. This explains why developed economies like the United States, Western Europe and Japan, where the public's demand for a clean environment is robust, place relatively high priority on environmental sustainability.

For developing countries, however, pursuing environmental goals may undermine economic growth, which is vital to lifting low general living standards and reducing poverty. Inclusive growth requires structural transformation from agriculture to manufacturing and services, but industrialization requires intensive use of energy resources which entails pollution and environmental degradation. Developing countries pursuing growth and development often give much higher priority to industrialization than environmental issues. For instance, China paid little attention to the environment during decades of world-topping

[8] According to GAHP (2014) report, pollution is responsible for 8.9 million deaths around the world each year – or more than one death in seven worldwide. Out of these, 94% (8.4 million deaths) are in low- and middle-income countries, which, according to the report, are "the least equipped to deal with the problem".

economic growth. Many developing countries are adopting the Chinese model of industrialization and growth which is highly energy intensive (Omoju, 2014).

Our sub-sample results suggest that high-income countries have strong environmental policies and institutional capacity to protect the environment whereas middle- and low-income countries need to strengthen their environmental policies and institutional capacity. Laws and formal governmental structures have been established in many developing countries in order to address environmental problems, but have had only limited success in tackling those problems. There is no one size fits all model for managing the environment. Economic incentives and other market-based strategies can contribute to a cleaner environment (Bell and Russell, 2002). However, approaches that worked in developed countries might not work in developing countries with limited resources and little market experience (Bell and Russell, 2002). In addition, all policy instruments require monitoring, enforcement, and clean government, which are currently lacking or relatively weak in developing countries (Bell and Russell, 2002).

We discuss in further detail a few policies which can promote environmental governance and reduce vulnerability to climate change, especially in developing countries. These include development initiatives that are in harmony with social and economic needs, as well as environmental sustainability programs such as promoting public awareness of environmental issues, developing environmental democracy, and building climate change resilient transport infrastructure and managing traffic congestion, among others (UNFCC, 2011).

Developing countries need to develop political mechanisms for citizens to lobby for green transformation. Decisions about land and natural resources made by governments, businesses and other institutions inevitably affect the health, livelihoods and quality-of-life of local communities. Therefore, the general public has a right to be involved in environmental

decision-making (Worker, 2015). More specifically, the general public should be able to know what is at stake, participate meaningfully in environmental decision-making, and challenge decisions that disregard human rights or harm ecosystems (Worker, 2015). These rights are widely cited as core principles of responsive, fair, and effective environmental governance (Worker and De Silva, 2015). However, not all developing countries are environmental democracies. For instance, in developing countries like Pakistan, Philippines, and Republic of Congo, citizens need to make expensive and time-consuming requests to obtain basic information such as statistics on air or drinking water quality and in many cases, such requests are not honoured (Worker, 2015).

Traffic management is another critical issue in the pursuit of cleaner environments in developing countries. Motorised traffic is commonly known as one of the main sources of the PM fractions which cause ill health. However, non-exhaust PM emissions, for instance, brake and tyre wear or resuspended particles from pavement materials, are also responsible for adverse health effects. Climate change resilient transport infrastructure includes alternative modes of service delivery that will reduce carbon emissions, less polluting transport energy sources such as Liquefied Petroleum Gas or LPG, improved motor vehicle fuel efficiency, and more and better public transport. For instance, reducing automobile use in urban areas requires an affordable and high quality urban public transport system.

Furthermore, most of the transport infrastructure in developing countries was designed and constructed at a time when climate change was not a threat and thus its impacts were mostly ignored. Climate change has a disproportionate effect on developing countries, many of which lie in tropical areas, and furthermore, some effects of climate change such as increase in temperature and sea level rise can damage some road and railway infrastructure. When flooding occurs due to heavy rain, some roads and bridges will get damaged. Rehabilitating such damaged transport infrastructure will be costly. As such, it is critical to

develop transport infrastructure that can withstand or resist the adverse effects of climate change. Such transport infrastructure will reduce the degree of vulnerability to climate change.

Traffic congestion also exacerbates pollution and GHG emissions. However, in many developing countries, resource-constrained traffic management agencies are challenged to mitigate congestion since they do not have access to the sophisticated tools commonly used in advanced economies for monitoring real-time traffic conditions and for collecting and analyzing historic travel time data. In this context, the World Bank is collaborating with various partners, through the use of open-source software, to help traffic management agencies in Southeast Asia alleviate congestion and reduce GHG emissions. For example, the World Bank has recently worked with the government of Cebu City in Philippines to develop an open-source platform in order to collect and analyze traffic speed data derived from taxi drivers' smartphones (World Bank, 2015).

In summary, the efforts of developing countries to achieve a cleaner environment, especially reduction in pollutant emissions, would benefit greatly from substantial economic, technological and financial support from the international community. The support will improve the environmental institutional capacity and augment the scare environment-protecting resources of developing countries, and mitigate the costs they incur in fighting pollution.

6. Concluding Observations

Our study highlights the importance of governance and vulnerability to climate change in pursuing green growth. While there is a vast empirical literature on the Environmental Kuznets Curve (EKC), not all pollutants follow the inverted U-shaped EKC pattern (Lipford and Yandle, 2010). This is partly due to the omission of important structural

factors underlying the relationship between income and emissions. For example, the ability of a government to tackle environmental degradation could be hindered by bureaucratic inefficiency, the impact of special-interest groups, and the resistance of state-owned enterprises. Such institutional factors are captured in the Index of Economic Freedom, which is the main indicator we use in our study. We explicitly incorporate two key factors, namely governance and vulnerability to climate change, into our empirical analysis of air pollution in a global sample of countries.

More specifically, we examine the relationship between environmental performance and governance, climate change vulnerability, and other factors for a panel data of 122 countries from 2000 to 2012. For the full sample of countries, we find that better governance improves environmental performance while greater vulnerability causes environmental degradation. In theory, the effect of governance and climate change vulnerability on the environment is uncertain but our evidence indicates that better governance and reduced vulnerability benefits the environment. This suggests that policies which improve governance and reduce vulnerability to climate change can contribute to a cleaner environment.

The evidence for different income groups of countries is more ambiguous. The results for the full sample of countries hold qualitatively for the high-income sub-sample. However, for the sub-samples of upper-middle-income countries and low and lower-middle-income countries, vulnerability to climate change adversely affects environmental performance but governance is no longer significant. The evidence thus suggests that developed countries are more successful than developing countries in tackling environmental destruction. Developing countries are still struggling to find ways to grow rapidly without harming the environment. Our results are robust to different measures of governance, vulnerability to climate change, and environmental performance.

Our empirical findings underline the central role of a strong institutional framework in addressing environment challenges in developing countries. Accordingly, we suggest a number of areas to improve environmental governance in the developing world. Improved governance also helps to reduce vulnerability to climate change. Possible areas of improvement include better traffic management, improved public environmental awareness, and stronger environmental democracy that gives citizens a voice in environmental policy debates. Finally, the efforts of developing countries to grow rapidly without harming the environment would benefit greatly from the support of the international community. The support will improve their environmental institutional capacity and augment their environment-protecting resources.

References

Alin, Aylin. 2010. "Multicollinearity." *Wiley Interdisciplinary Reviews: Computational Statistics* 2 (3): 370-374.

Auteri, Monica, and Constantini Mauro. 2005. "Intratemporal Substitution and Government Spending: Unit Root and Cointegration Tests in a Cross Section Correlated Panel". XVII Conference Paper, Societa Italiana di economia pubblica, Pavia, Universita, URL: http://www-3.unipv.it/websiep/wp/419.pdf

Antweiler, Werner, Copeland Brian, and Taylor Scott. 2001. "Is free trade good for the environment?" *American Economic Review* 91: 877-908.

Baltagi, Badi. 2005. Econometric Analysis of Panel Data. John Wiley & Sons, New York.

Barrett, Scott, and Kathryn Graddy. 2000. "Freedom, growth, and the environment". *Environment and Development Economics* 5 (4): 433-456.

Bell, R.G. and Russell, C. 2002. "Environmental policy for developing countries". *Issues in Science and Technology* 18 (3): 63-70.

Bernauer, Thomas, and Vally Koubi. 2009. "Effects of political institutions on air quality". *Ecological Economics* 68 (5): 1355-1365.

Bhagwati, Jagdish. 1993. "The Case for Free Trade". *Scientific American* 269 (5): 42-43.

Bhattarai, Madhusudan, and Michael Hammig. 2001. "Institutions and the environmental Kuznets curve for deforestation: a cross-country analysis for Latin America, Africa and Asia". *World Development* 29 (6): 995-1010.

Carlsson, Fredrik, and Susanna Lundström. 2001. "Political and Economic Freedom and the Environment: The Case of CO2 Emissions". Working Paper in Economics No 29. Department of Economics, Goteborg University.

Dasgupta, Susmita, Benoit Laplante, Hua Wang, and David Wheeler. 2005. "Confronting the Environmental Kuznets Curve". In: *Economics of the Environment: Selected Readings*, 5th ed., edited by R. Stavins, 399-422. New York: W.W. Norton.

Dasgupta, Susmita, Ashoka Mody, Subhendu Roy and David Wheeler. 2001. "Environmental regulation and development: A cross-country empirical analysis." *Oxford development studies* 29 (2): 173-187.

Di Iorio, Francesca, and Stefano Fachin. 2007. "Testing for breaks in cointegrated panels-with an application to the Feldstein-Horioka puzzle". *Economics: The Open-Access, Open-Assessment E-Journal* 1.

Diaz, Pedro, and Saul Ortega. 2011. "Contribution toward climate change vulnerability and resilience from institutional economics". *Economia agrarian y recursos naturales* 11: 143-160.

Driscoll, John C., and Aart C. Kraay. 1998. "Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data". *Review of Economics and Statistics* 80: 549–560.

Drukker, David M. 2003. "Testing for serial correlation in linear panel-data models". *Stata Journal* (3) 2: 168-177.

Global Alliance on Health and Pollution (GAHP). 2014. "Pollution the Silent Killer of Millions in Poor Countries". November 2014. Accessed on 2nd December 2016. Available at: http://www.gahp.net/new/pollution-the-silent-killer-of-millions-in-poor-countries/

Greene, William H. 2008. Econometric analysis (6th ed.). Upper Saddle River, NJ: Prentice Hall.

Gulf News Editorial. 2016. "Air pollution is a global problem of high importance". Accessed on 8th June 2016. Available at: http://gulfnews.com/opinion/editorials/air-pollution-is-a-global-problem-of-high-importance-1.1827558

Heritage Foundation. 2016. Index of Economic Freedom. Accessed on 10th February, 2016. Available at: http://www.heritage.org/index/explore?view=by-region-country-year

Hoechle, Daniel. 2007. "Robust standard errors for panel regressions with cross-sectional dependence". *The Stata Journal* 7 (3): 281-312.

IARC (International Agency for Research on Cancer). 2013. "Outdoor air pollution a leading environmental cause of cancer deaths". Accessed on 10th June, 2016. Available at: https://www.iarc.fr/en/media-centre/iarcnews/pdf/pr221_E.pdf

Im, Kyung So, M. Hashem Pesaran, and Yongcheol Shin. 2003. "Testing for unit roots in heterogeneous panels". *Journal of Econometrics* 115: 53-74.

IPCC (Intergovernmental Panel on Climate Change). 2014. "Climate Change 2014: Impact, Adaptation and Vulnerability". IPCC working group II Contribution to AR5. Available at: http://ipcc-wg2.gov/AR5/

Leitao, Alexandra. 2010. "Corruption and the Environmental Kuznets Curve: Empirical Evidence for Sulfur". *Ecological Economics* 69 (11): 2191–2201.

Lin, C-Y. Cynthia, and Zachary D. Liscow. 2013. "Endogeneity in the environmental Kuznets curve: An instrumental variables approach". *American Journal of Agricultural Economics* 95 (2): 268-274.

Lipford, Jody W., and Bruce Yandle. 2010. "Environmental Kuznets curves, carbon emissions, and public choice". *Environment and Development Economics* 15(4): 417-438.

Liverman, Diana M. 1990. "Vulnerability to global environmental change". *Understanding global environmental change: The contributions of risk analysis and management* 27-44.

Lopez, Ramon. 1997. "Environmental Externalities in Traditional Agriculture and the Impact of Trade Liberalization: the Case of Ghana". *Journal of Development Economics* 53: 17-39.

Magnani, Elisabetta. 2000. "The Environmental Kuznets Curve, Environmental Protection Policy and Income Distribution". *Ecological Economics* 32: 431-443.

ND-GAIN. 2016. Accessed on 10th February, 2016. Available at: http://index.gain.org/about/methodology

Omoju, Oluwasola. 2014. "Environmental pollution is inevitable in developing countries". Breaking Energy. September 23rd, 2014. Accessed on 1st December 2016. Available at: http://breakingenergy.com/2014/09/23/environmental-pollution-is-inevitable-in-developing-countries/

Panayotou, Theodore. 1997. "Demystifying the Environmental Kuznets Curve: Turning a Black Box into a Policy Tool". *Environment and Development Economics* 2 (4): 465–484.

Pao, Hsiao-Tien, and Chung-Ming Tsai. 2010. "CO2 emissions, energy consumption and economic growth in BRIC countries". *Energy Policy* 38: 7850-7860.

Pesaran, M. Hashem. 2004. "General diagnostic tests for cross section dependence in panels". Cambridge Working Papers in Economics No 0435. University of Cambridge.

Pesaran, M. Hashem. 2007. "A simple panel unit root test in the presence of cross-section dependence". *Journal of Applied Econometrics* 22: 265-312.

Stroup, Richard L. 2003. "Economic freedom and environmental quality". *Proceedings, Federal Reserve Bank of Dallas* 73-90.

Timmerman, Peter. 1981. "Vulnerability, resilience and the collapse of society: a review of models and possible climatic applications, environmental monograph 1". Institute for Environmental Studies, University of Toronto, Toronto.

UNFCCC (United Nations Framework Convention on Climate Change). (2011). "The Least Developed Countries. Reducing Vulnerability to Climate Change, Climate Variability and Extremes, Land Degradation and Loss of Biodiversity: Environmental and

Developmental Challenges and Opportunities". Accessed on 3rd December, 2016. Available at: http://unfccc.int/resource/docs/publications/ldc_reducingvulnerability.pdf

UNEP (United Nations Environment Programme). 2014. "UNEP Year Book 2014 emerging issues update: Air Pollution: World's Worst Environmental Health Risk". Accessed on 10th June, 2016. Available at: http://www.unep.org/yearbook/2014/PDF/chapt7.pdf

Yale Center for Environmental and Policy. 2016. Accessed on 8th June, 2016. Available at: http://www.epi.yale.edu/

Watson, Robert T., Marufu C. Zinyowera, and Richard H. Moss. 1996. "Climate change 1995. Impacts, adaptions and mitigation of climate change: scientific-technical analyses". Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press

Westerlund, Joakim. 2008. "Panel cointegration tests of the Fisher effect". *Journal of Applied Econometrics* 23 (2): 193-233.

WHO (World Health Organization). 2016. "Children: reducing mortality". Accessed on 10th June, 2016. Available at: http://www.who.int/mediacentre/factsheets/fs178/en/

WHO (World Health Organization). nd. "Indoor air thematic briefing 2". Accessed on 10th June, 2016. Available at: http://www.who.int/indoorair/info/briefing2.pdf

Wood, Joel, and Ian Herzog. 2014. "Economic Freedom and Air Quality". Fraser Institute, Vancouver, Canada.

Wooldridge, Jeffrey M. 2002. Econometric Analysis of Cross Section and Panel Data. Cambridge, MA: MIT Press.

Worker, Jesse. 2015. "The Best and Worst Countries for Environmental Democracy". World Resources Institute's Blog Post. May 20th, 2015. Accessed on 1st December 2016. Available at: http://www.wri.org/blog/2015/05/best-and-worst-countries-environmental-democracy

Worker, Jesse, and Lalanath De Silva. 2015. "The Environmental Democracy Index." Technical Note. Washington, D.C.: World Resources Institute. Accessed on 3rd December 2016. Available online at: www.environmentaldemocracyindex.org.

World Bank. 2016. Worldwide Governance Indicators. Accessed on 8th June, 2016. Available at: http://info.worldbank.org/governance/wgi/index.aspx#home

World Bank. 2015. "How an Open Traffic Platform is Helping Asian Cities Mitigate Congestion, Pollution". Feature Story: October 19th, 2015. Accessed on 1st

December 2016. Available at: http://www.worldbank.org/en/news/feature/2015/10/19/how-an-open-traffic-platform-is-helping-asian-cities-mitigate-congestion-pollution

World Development Indicators. 2016. Accessed on 8th June, 2016. Available at: http://data.worldbank.org/data-catalog/world-development-indicators