The Global Environmental Performance Report 2015

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Final Reading of IS620 (May5, 2015)
The data used is taken from EPI Yale University, CIA World Factbook, PolityIV dataset, World Development indicators database, Alesina et.al. (Harvard), Transparency International, and Correlates of War Project

1 EXECUTIVE SUMMARY

This report examines the socio-economic factors of countries environmental performance. It based on a master set of cross sectional data and one country time-series compiled from several sources to understand the common driver for countries to protect global environment. The dependent variable used is Environmental Performance Index (EPI), which is developed to show countries policy in protecting human and its ecosystem. The main independent variables are natural log of GDP per capita, IGO membership and democracy.

This report mainly uses two articles to develop theoretical framework; the first article on non-linear relationship of ethnic diversity and EPI strengthens the basic assumption of wealth as strong predictor of environmental policy, and adds ethnic diversity variable as one of the controlling variable. The second article focuses more on the interaction effect of democracy and IGO membership to EPI. This effect is re-examined in this report but without showing similar result.

This analysis consistently shows that economic development is statistically significant in explaining environmental performance controlling other socio-economic variables. There is a linear and positive relationship between both variables.

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2 INTRODUCTION

The most recent report by the Intergovernmental Panel on Climate Change (IPCC) shows that there is clear evidence for a .6 degrees Celsius rise in global temperatures and 20 cm rise in sea level during the 20th century. Accordingly, environmental issue is not merely a scientific concern anymore; all life has been affected by it. It has impacted the politic, economy, social and even individual's choice of lifestyle. Moreover, environmental degradation negatively affects our life. It has worsened the problems of water scarcity, unsafe drinking water, and poor sanitation. Lack of environmental protection has led to much biodiversity loss and the spread of disease.

Nonetheless, to sacrifice our own welfare for the sake of future generations and for other species is not an easy thing to do. Most of us value more about our standard of living than we do about the health of some species we only see on television. And the truth, even harder to admit, is that most of us care more about our own welfare than the welfare of people living three or four generations to come. But the fact of the matter is protecting the livelihood of our planet, the needs of future generations, and the existence of other species depend on changing these operational values.

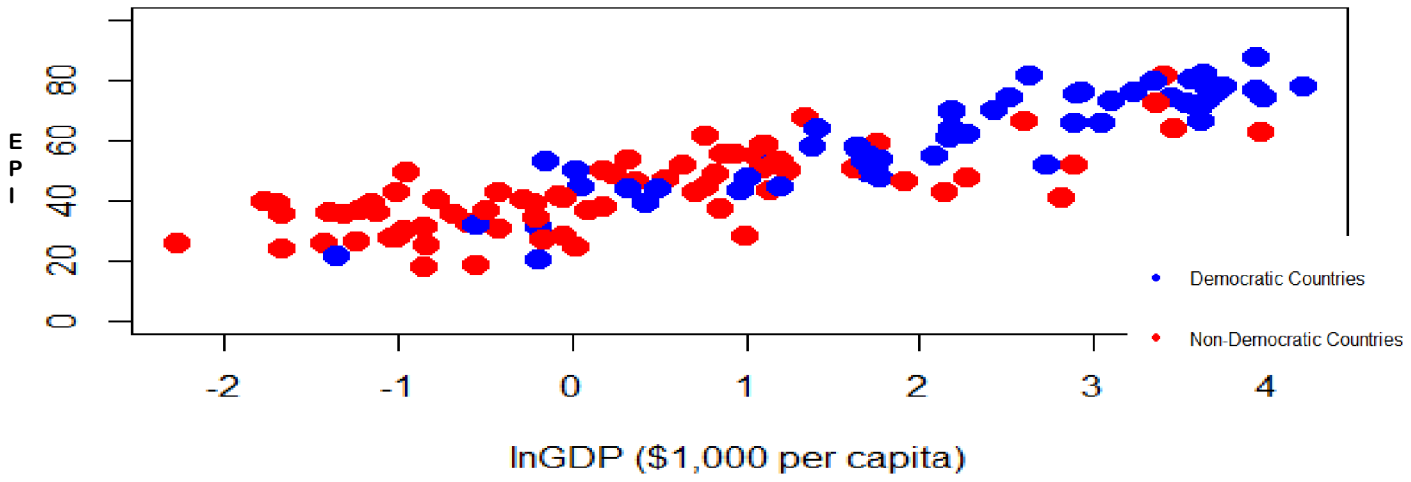
There was an unprecedented number of world leaders attended the 2014 UN Climate Summit. They pledged their countries' effort for environmental sustainability, but are they meeting their goals? The Environmental Performance Index (EPI) is designed to measure country-scale performance on a core set of environmental policy goals that reflect the policy priorities of environmental authorities around the world. EPI ranks how well countries perform on high-priority environmental issues in two broad policy areas: protection of human health from environmental harm and protection of ecosystems. In collaboration with the World Economic Forum, the EPI was developed by Columbia and Yale Universities and provides a quantitative performance measure of how well countries are meeting environmental goals in six well-defined policy categories: environmental health, air pollution, water, biodiversity and habitat, productive natural resources, and climate change. This rank raises a

question as to why some countries are able to successfully meet these environmental policy goals and why others fail.

3 LITERATURE REVIEW

There are some factors identified by researchers related to country's environmental performance. Some studies have explained that several "hard" factors, defined as economic and political factors that drive goals and agendas across countries, such as level of development, corruption, economic freedoms, government effectiveness, and access to information. Other researchers have theorized "soft" factors or the social and cultural make-up of the country, such as ethnic diversity and democratic freedoms, affect a country's ability to meet environmental policy goals. The literature has largely concluded that more developed countries with higher levels of economic freedoms, effective and transparent governments, and low levels of corruption tend to be more successful in meeting environmental goals.

Those findings are confirmed in some fashion by our basic model of lnGDPc and EPI controlling democracy. It confirms our assumption that countries' economic welfare has positive effect to their environmental performance by controlling other variables. The natural log of GDP per capita (lnGDPC) is a powerful predictor of environmental performance (EPI) score. The following graph shows the relationship between lnGDPC and EPI score, while grouping them into democratic and non-democratic countries. Nevertheless, we have not yet successfully built a model that combines other theoretically-important variables such as institutional, culture, and international exposure. We need to have more comprehensive socioeconomic factors related to country environmental performance. Accordingly, in order to develop hypothesizes and a better fit model, we will review the first literature in this reading.



Review of the first article: Jayoti Das and Cassandra E. DiRienzo. "Is Ethnic Diversity Good for the Environment? A Cross-Country Analysis, "Journal of Environment & Development 19, no. 1 (2010): 91-113.

SUMMARY: the authors of this article try to establish the existence of a non-linear relationship between environmental performance and ethnic diversity, while controlling for factors known to affect a country's ability to meet environmental standards. This study finds that countries with moderate levels of ethnic diversity experience the greatest environmental performance as they reap the benefits of a civically engaged society with creative, innovative, and efficient human talent pool and do not bear the negative effects of a highly fractionalized society that typically suffers from poor communication and social cohesion, among other societal ills. The policy implications are important, as policy makers need to understand how ethnic diversity affects a country's ability to meet environmental goals such that these effects are accounted for in new environmental policies and initiatives. Their recommends time series analysis for further research development.

THEORETICAL FRAMEWORK: the paper starts by examining multi-disciplinary researches on the impact of ethnic diversity. Most studies conducted in Education, Management and Business fields suggest its positive relationship to the dependent variables. Diversity can have positive effect in term of creating social engagement, raising social and political awareness among the society, and developing creativity and innovative solution which all of those supportive for environmental protection. On the other group of study, ethnic and cultural diversity has negative effect on economic outcomes, such as nation building, economic growth, quality of government services and institutions and can slow collective action and communication. The ethnically fractionalized countries suffer from poor communication and lack social cohesion as ethnic groups can have different values and do not necessarily correspond effectively, which can hamper environmental protection effort.

By combining these two perspectives, they develop a theoretical framework stating ethnic diversity has dual effects (base on its level) toward environmental performance. It assumes that there is an

optimum level of ethnic diversity which supportive to high level of environmental performance, where too-less or too-much in diversity leads to lower level of environmental performance. There is a non-linear relationship.

VARIABLES, DATA and METHODS: This study uses the EPI to proxy country environmental performance. The data used is from the same source we used in the first reading but different year (2008) while the main independent variable, which is ethnic diversity (E), is taken from Alesina's et.al (2003).

The method is a cross-sectional analysis using ordinary least-squares/OLS model. It starts by using the base bivariate model of EPI and ethnic diversity to examine a possible nonlinear relationship. A scatter plot with a fitted polynomial line suggests that as countries move from extreme ethnic homogeneity and become diversified, environmental performance tends to improve, and, as countries become highly ethnically fractionalized, the negative effect of ethnic diversity are realized and environmental performance tends to fall. This preliminary examination suggests an inverted U-shape relationship. The next step is by incorporating control variables of socioeconomic and institutional in order to have a more sufficient model. The regression model estimated is:

$$EPI = \beta o + \beta 1\ EFW + \beta 2\ lnCPI + \beta 3\ PRCL + \beta 4\ Egov$$

$$+ \beta 5\ lnGDPPC + \beta 6E + \beta 7E2 + \varepsilon$$

CONTROL VARIABLES: 1) Economic Freedom of the World or EFW index (2003) co-published by Gwartney and Lawson (2006) and the Fraser Institute, 2) Corruption Perception Index or CPI (2007) from Transparency International, 3)Freedom House index or PRCL (2006) measuring democracy, 4) E-Government Index or EGOV (2007) for measuring government efficiency developed by the United Nations, and 5) GDP per capita (2007) from the World Bank is used a proxy of economic development.

RESULTS: The regression analysis provides a model with results provide support for the regression with an Adjusted R2 of 0.7309 and a significant F at the 99% confidence level. In regard to the coefficient estimates, with the exception of PRCL and LnCPI, the

control variables are significant. Although the insignificant effect of corruption on environmental performance was not expected, the insignificant effect of PRCL is not surprising given that democratic freedoms can have both positive and negative effects on environmental performance. Most important, the coefficient on E is significant and positive at 95% confidence, whereas the coefficient on the squared term, E2, is negative and significant at the 99% confidence level, and a partial F test indicates that E2 adds explanatory power to the model.

These results establish the existence of an inverted U-shape relationship between country environmental performance and ethnic diversity, even after controlling for other factors known to affect country environmental performance. These findings suggest that the highest environmental performance measures are achieved at a moderate level of ethnic diversity. It is argued in this study that ethnically homogeneous societies may not recognize the value of some civic and social concerns such as environmental care; however, extreme ethnic heterogeneity can slow collective action and communication and hinder environment protection effort. Thus, a moderate level of ethnic diversity is optimal for a country working to achieve environmental goals.

FINAL EVALUATION: This is a very interesting study of how ethnic diversity influences environmental performance. It is the first of its kind. The writers have developed a statistical model from a well-structured theoretical framework. It is easy to fall into the trap by just having a test of rejecting or confirming the existing relationship or in other words, a test of whether ethnic diversity has positive or negative effect on the dependent variable. The idea of having a non-linear relationship is remarkable. Indeed it comes from a comprehensive literature review they done. Furthermore, the use of bivariate analysis in their preliminary examination is very useful. It effectively helps the reader to understand the importance of the theoretical framework of the paper and confirming its primary assumption.

The reasons of choosing the control variables are well-explained. Although it appropriately discusses the previous researches that directly related to country environmental performance, the issue of

multicollinearity among variables is not well-explained. The authors' preference of using no dichotomous variables is rather surprising, especially the use of PRCL in measuring democracy. Although it confirms our first reading that democratic freedoms can have both positive and negative impact to environmental protection effort, it might be more interesting to use dichotomous variable of democratic and non-democratic countries in this analysis.

Regarding the quality of the presentation, the model is presented clearly, with graph of its preliminary examination, descriptive statistics and correlation matrix of all variables discussed, and the result of the test. Nevertheless, having more visual aids in form of descriptive graphs (histogram) will help the presentation. There are only two figures presented in the paper: scatter plot of bivariate relationship both in its preliminary examination and the predicted graph. The use of log of CPI and GDPC is not properly explained. It will be helpful to have a comparison of regression analysis using log and without log in the appendix.

Last but not least, the discussion of outliers weakens the main argument. The homogeneous countries with good governance and economic development perform quite well in environmental protection. In other words, having moderate ethnic diversity does not necessarily lead to high environmental performance. This is the reason of why we cannot quite confidence of using ethnic diversity as predictor of environmental performance.

In overall, the technical material is effectively communicated with constant relations with their thesis and with explanations of the necessary details so the audience both students and high level academic scholars of International Studies who know only the basics of statistical methods are able to understand it. The writers recommend a time series analysis in order to get a firmer causal explanation. This type of analysis is planned to be part of the final reading of this project. All in all, this literature is substantially beneficial for the project. It strengthen the assumption of the linear relationship of natural logGDPc and EPI, and contributes to this project of the theoretical importance of using ethnic diversity as one of the controlling variables.

Review of the second article: Gabriele Ruoff. "Grow rich and clean up latter? Joint effects of IGO membership and democracy on environmental performance in developing countries,"*Journal of Environment & Development??*19, no. 1 (2010): 91-113.

SUMMARY: this article examines the effect of integration to international system in combination with democratic system of government to countries environmental performance. The empirical analysis of panel data for 115 developing countries in 1970-2000 shows that IGO membership, one important manifestation of political integration into the international system, reduces air and water pollution in democracies and autocracies. Moreover, democracy amplifies the positive integration effect with respect to SO2 emissions, but less with respect to CO2 emissions and water pollution.

THEORETICAL FRAMEWORK: the paper starts by examining the relationship between economic factor (GDP) and environmental performance. He mentioned previous study of the Environmental Kuznets Curve (EKC)that an increase in national income should be associated with better environmental performance in industrialized countries whereas developing countries should be confronted with deteriorating environmental performance when their GDP per capita grows (a non-linear inverted U-shaped relationship).

Since the author focuses more on developing countries, she starts by analyzing the linear relationship in the developing countries instead of non-linear relationship suggested by EKC. A simple representation of the empirical pattern between environmental performance (defined here in terms of sulfur-dioxide (SO2) emissions) and GDP per capita suggests there is a wide variation in pollution levels around the regression line indicates that national income is not as decisive for national environmental performance as the literature on the EKC suggests. Further, she argues that integration into the international system, measured in terms of membership in international intergovernmental organizations (IGOs), can help developing countries to “cut through” the EKC (that is reach the turning point at lower levels of environmental degradation, and/or earlier on in the stage of economic development). Membership in IGOs improves environmental performance in

developing countries because IGOs can constitute a channel through which these countries may receive technologies and resources necessary to reduce pollution. In addition, IGO membership can allow for issue linkage and the diffusion of knowledge on environmental protection issues implying that these countries may undertake actions to take care of their environment even at this early stage of economic development.

Moreover, she argues that although the type of the political system should not have an independent effect on environmental quality in developing countries, its interplay with IGO membership should be decisive for improved environmental performance. He adds that the positive effect of international integration is intensified in democratic political systems implying that at any given level of IGO membership environmental performance will be better in democracies relative to autocracies.

The author proposes two hypothesizes:

H1: Developing countries that are a member to more IGOs provide higher levels of environmental performance.

H2: Democracy enhances the positive effect of IGO membership on environmental performance.

VARIABLES, DATA and METHODS: This study uses time-series cross-country analysis covering the years 1970 to 2000 to empirically test the two hypotheses. Using the classification on countries income of the World Bank, he comes up with sample of 115 developing countries with a GNI per capita level of less than 9,266 US dollar using the year 0f 2000 as the threshold.

The dependent variables used is SO^2, CO^2, BOD (emission from water pollutants). The natural log of those three variables is used. Meanwhile, the yearly cumulative of IGO membership and the dichotomous variable of Polity IV are used for independent variables. GDP per capita, economic growth, FDI, trade openness, and population density are added as controlling variables. The regression model estimated is:

$$\ln SO^2 + \ln CO^2 + \ln BOD = \beta o + \beta 1\ IGO + \beta 2\ Dem + \beta 3\ GDPc + \beta 4\ lnOpen + \beta 5\ Growth + \beta 6\ FDI + \beta 7 Pop + \varepsilon$$

CONTROL VARIABLES: 1) SO2 emission per capita (2005) published by Stern, 2) SO2 emission per capita (2006) from the World Bank, 3)BOD (2006) from the World Bank, 4) IGO membership (2004) by Correlates War Project, 5) Democracy index (1996) developed by Alvarez dichotomous, 6) Openness and 7) GDP per capita (2002) from Gleditsch, 8) Growth, 9)FDI, and 10)Population density are taken from World Bank Development Indicators.

RESULTS: The regression analysis related the first hypothesis shows that IGO membership has a positive influence on environmental performance of developing countries by any the three indicators ($SO^{2,}$ CO^2, or BOD). The interpretation of the model says if a country's membership increases by one unit (i.e. one further membership) the model predicts a reduction in this country's SO2 emissions by 2% and a reduction in its CO2 and BOD emissions by 1%.

Related to the interaction effect of IGO membership and political system (H2), the model showsas predicted by the theory IGO membership reduces SO^2 emissions significantly no matter whether the country is a democracy or an autocracy. However, the effect is much more pronounced in democracies than in autocracies, which is supportive to hypothesis 2. Hence, a one-unit increase in IGO membership implies about a 1% reduction in SO2 emissions in an autocratic country whereas it implies about a 2.5% decrease in a full democracy.

FINAL EVALUATION: Ruoff develops an interesting framework encompassing two significant variables in international relations: international interaction in term of IGO membership and domestic political system, which are very relevant to this project. Not only the significance, but she manages to show their interaction related to environmental performance. Furthermore, her study also provide critical policy implication showing that there is way for developing countries to increase their environmental performance through international collaboration besides the traditional way of increasing wealth independently.

The time-series cross section analysis is effectively presented. The controlling variables are also well selected. The empirical results are presented very clearly. The interesting part is on how she uses the

graphs to show interaction effect of IGO membership and democracy to each dependent variables. This visual aids help to clarify the result of the analysis. The technical material is effectively communicated with constant referrals to the thesis and with explanations of the necessary details.

Moreover, she later on disaggregates the IGO membership to understand which type of IGO membership gives highest effect. She convincingly presents the argument that membership in international organizations is robustly associated with a reduction in pollution levels. Altogether, it is interesting to see whether the same effect prevail when using different indicator of environmental performance.

4 COURSE PROJECT- THEORETICAL FRAMEWORK

The purpose of this project is to understand the relationship of socioeconomic factors with countries' environmental performance. Our first hypothesis states that there is a positive relation of countries economic welfare to environmental performance controlling other variables as the first article mentions before.

H1: The higher the GDP of a country, the higher the environmental performance index is.

The second literature refuses to use the non-linear relationship of wealth and environmental performance of EKC because it only focuses only on developing countries. This project also assumes linear relationship but with different reason. The EPI shows more on the policy of countries instead of real environmental output, such as CO^2 emission, or water resources, as shown by EKC. Theoretically, it is more appropriate to assume linear relationship that higher GDP leads to better environmental policy.

Moreover, by using the insight gained from the second literature, our second and third hypotheses are the same. This project conducts reexamination by making some adjustments of the variables. The general purpose of international governmental organizations is to enable or facilitate cooperation at the international level and thereby to enable countries to solve problems, which they often are unable to solve independently, and hence to realize benefits from mutual cooperation. IGOs promote cooperation by reducing transaction costs, by limiting uncertainty, by widening the shadow of the future, by increasing reputational costs and by allowing credible commitments.

H2: Developing countries that are a member to more IGOs provide higher levels of environmental performance.

Furthermore IGO membership is assumed to have effect on intensifying the positive effect of international integration. In this case democracies should relatively have better effect than autocracies

H3: Democracy enhances the positive effect of IGO membership on environmental performance.

The first adjustment is this report uses the latest EPI score (2014) as proxy of environmental performance while the same ethnic diversity (E) data from Alesina et.al. (2003) is still used. The second adjustment is related to the treatment of dependent variable. The literature provides a general description of the world EPI score by mentioning example of some countries' scores. It categorizes countries into countries with low/poor EPI scores, countries with moderate EPI scores, countries with high EPI scores. This second reading moves beyond that. Instead of merely descriptive function and uses OLS only, it also uses the dichotomous EPI scores in its analysis. It categorizes countries into green and non-green countries. Furthermore, a Poisson regression and Binominal model are also developed in this report.

5 VARIABLES

Economic development, IGO membership, Democracy, and Environment

This study hypothesizes the natural log of GDP per capita is a powerful predictor of EPI. As societies become wealthier, they can will be able to sacrifice their wealth for other species or future generations. The data used is from the world development indicator year 2013.

Environmental Performance Index-We use 2014 EPI score provided by Yale Center for Environmental Law and Policy (YCELP), Yale University and Center for International Earth Science Information Network (CIESIN), Columbia University as our dependent variable.

Democracy- there are some arguments whether democracy has positive or negative effect on environmental protection. Democracies tend to be associated with better property rights regulation, which can provide incentive for protection of natural resources. Democracies also are considered more responsive to environmental degradation compare to non-democracies. Nonetheless, democracies are often associated with free markets, and if these are unregulated, there will create environmental exploitation. In term of democracy, this study uses Polity IV data (democ) and later on creates dummy variable from it.

IGO membership- the data used is from Correlates of War Project. It is the aggregate of countries membership in IGO in the year of 2005.

Controlling Variables

Corruption- corruption of government can cause misallocation of resources, which then make the environmental protection inefficient. Corruption can also hinder the implementation of environmental regulations. We use data of Corruption Perception Index (CPI) year 2014.

Economic freedom- economically free nations tend to have more efficient market. This efficiency creates better protection to the environment. We uses EFW index (2014) in this test.

Ethnic diversity- the ethnic diversity data (Ethnic) comes from Alesinaet. al index (the Fraser Institute) who classified differentethnic groups as those speak different language and/or have different racial and physical characteristics.

These two tables show the variable summary and descriptive statistics, and correlation matrix of all variables. Merging those variables makes us to lose some of the important data. There are some missing values in some of the variable. There are only 105 countries left on the list. This fact shows the limitation of our analysis.

Table 1. Variable Summary and Descriptive Statistics

	Proxy (Name, Year reported)	*Mean*	*SD*	*Min*	*max*
n = 105					
Country environmental performance	Environmental Performance Index (EPI, 2014)	53.13	16.78	18.43	87.67
Economic freedom	Economic Freedom of the World (EFW, 2014)	6.17	1.26	3.03	8.8
Corruption	Corruption Perception Index (CPI, 2014)	46.74	19.14	19	92
Economic development	GDP per capita (GDPc, 2013)	16580.2	21618.63	226.5	100818.5
Ethnic diversity	Ethnic Fractionalization Index (EFI, 2003)	0.43	0.25	0.01	0.93
Democracy	Polity IV (Democ)	6.55	3.54	0	10
IGO membership	Correlates of War Project(IGOnum, 2005)	70.89	18.46	37	125

Table 2. Correlation Matrix

	EPI	Ethnic	GDPc	EFW	CPI	democ	igonum	dem
EPI	1.00							
Ethnic	-0.46	1.00						
GDPc	0.75	-0.33	1.00					
EFW	0.63	-0.33	0.63	1.00				
CPI	0.80	-0.42	0.81	0.64	1.00			
democ	0.44	-0.36	0.26	0.35	0.45	1.00		
igonum	0.47	-0.25	0.44	0.39	0.44	0.42	1.00	
dem	0.51	-0.42	0.34	0.42	0.51	0.82	0.42	1.00

The GDP and CPI are much correlated with EPI, but they are also much correlated each other (0.81). The easiest way when dealing with multicollinearity issue is we drop one of the variables, but then we will face specification bias. It arises from incorrect specification of the model used. Theoretically, we need variable for economic growth (GDPc) and government transparency (CPI). It will create bias in our model if we drop one of those. Since both variables are substantively different, we still use GDPc and CPI in our model. Adding to that, GDPc will be transformed using natural log.

6 MODEL

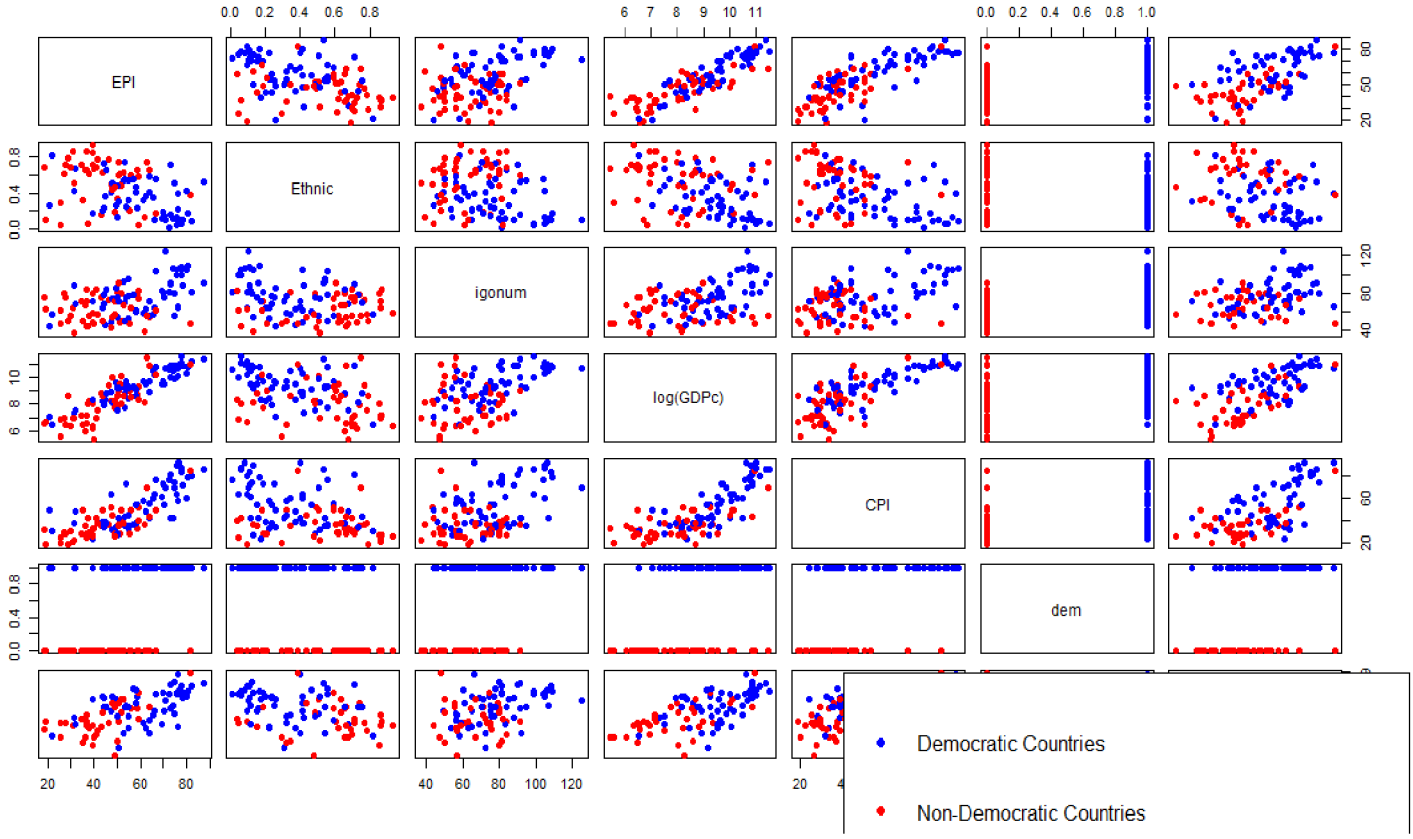
This OLS model shows a model of environmental performance as a function of GDPc, IGO membership and Democracy controlling other variables. The complete model 1 generated is:

EPI = -21.39 – 2.8(Ethnic) + .04(IGOnum)
+ 7.16(lnGDPc) + .22(CPI) + .74(Democ) - .07 (EFW)

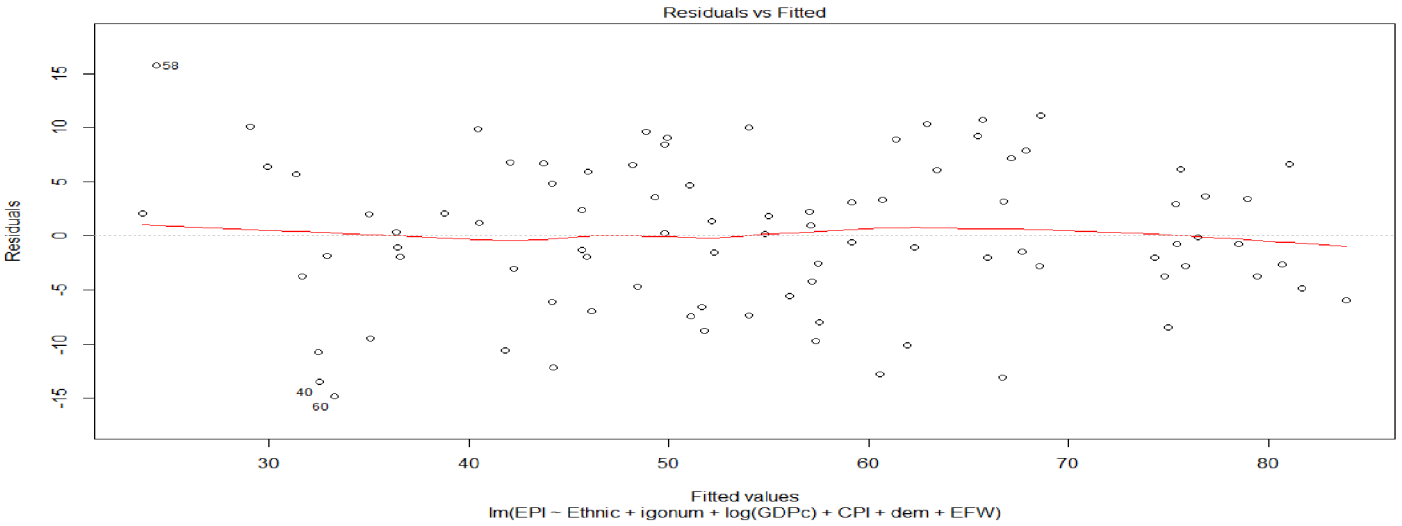
This model has an R2 of .83, which means that this model can explain about 83 percent of the variation in EPI score. It is considerably a strong fit model. As our expected, the natural log of GDPc has positive relationship with EPI. The higher the level of welfare of country, there is higher environmental performance. It also statistically significant at level <.0001 (t value =7.53). The CPI also has positive relationship and statistical significant, less corruption leads to higher EPI. Contrary to our expectation, other variables especially our other main variable of Democracy and IGO membership are not statistically significant.

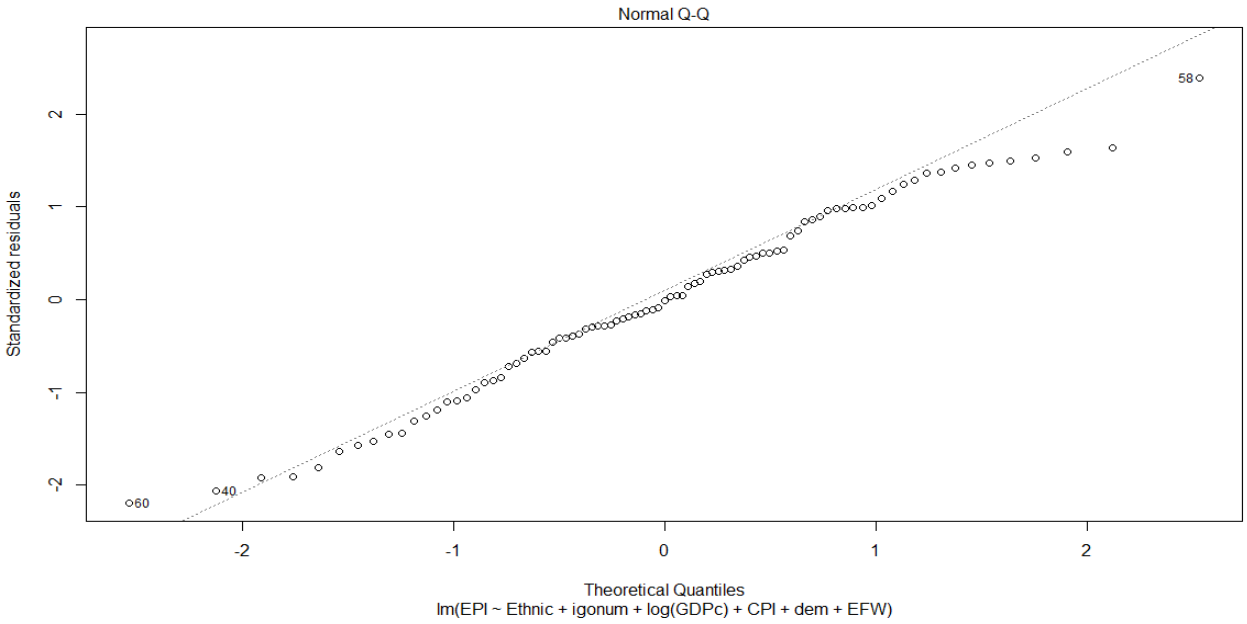
Nevertheless, the model shows the relationship that consistent with our theoretical assumptions. Both democracy and IGO membership have positive relationship with EPI. Democracies tend to have higher environmental performance, and countries with high level of international interaction also experience the same thing.

Morevoer, our model does not show any interaction effect between democracy and IGOnum variables as the second literature suggests. The test shows no statistical significance of that. The coefficient is -0.02 with t value of -0.15. The following pairs plot describes the relationships graphically.



The pair plot shows the existing pattern of natural log of GDPc and CPI to EPI. Our analysis on the residuals shows there is heterosdasticity issue, but it seems well-behaved.





In order to understand deeper the interaction between variables, we continue to make empirical test using other models, which are GLM models. In our Gaussian and logit models, we will change the dependent variable into green and non-green countries. Those are model of dichotomous dependent variable. The green countries are the countries that score above 70 in EPI. Here are the models mentioned.

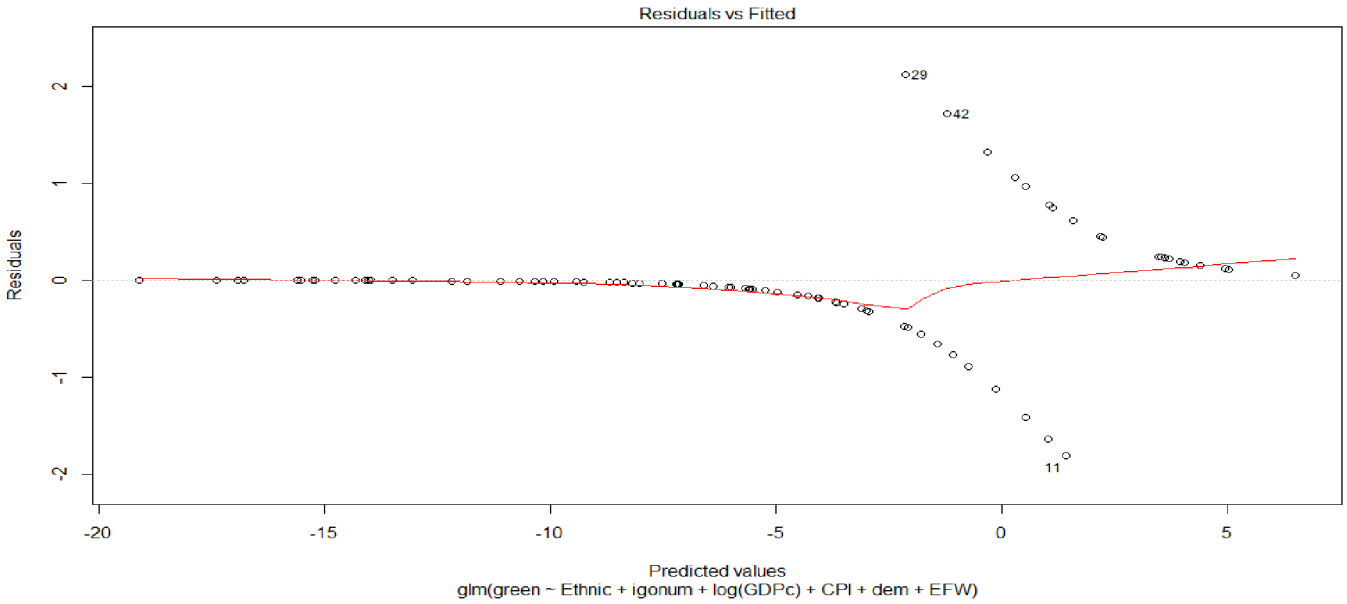
The GLM model of Gaussian family generated is:

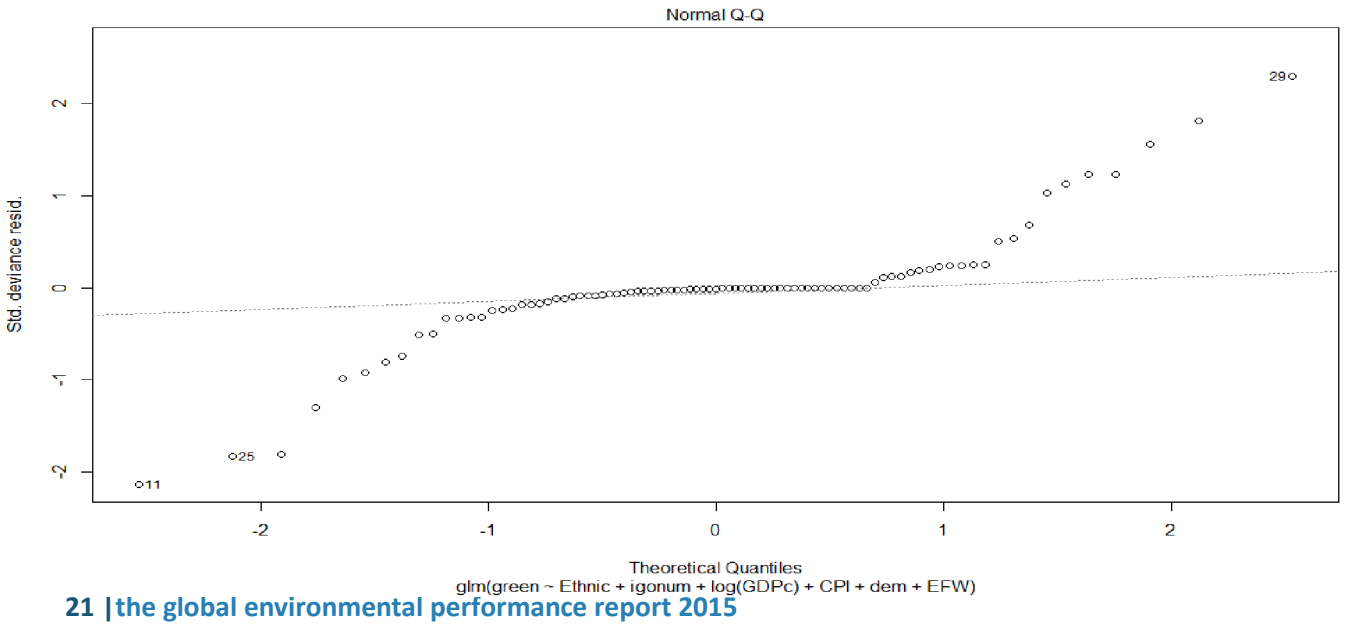
Green = - 21.39 - 2.8(Ethnic) + .04(IGOnum)
+ 7.16(lnGDPc) + .22(CPI) + .74(Democ) – .07 (EFW)

This model says the same relationship as mentioned on the previous model. LnGDPc and CPI are statistically significant in explaining the variation of EPI at <.001 level.

Furthermore, the logit model of dichotomous EPI variable shows only lnGDPc has statistical significance at 0.01 level (z value = 2.32) to our dependent variable. It has pseudo R^2 of .63. The logit model generated is:

Green = - 34.17 – 5.3(Ethnic) + .01(IGOnum)
+2.99(lnGDPc)+.02(CPI) + 1.68(Democ) + .32(EFW)





Our next model is a Poisson regression for a count-based dependent variable. It generates the model below:

Green = - 0.14 -1.19(Ethnic) + .0001(IGOnum)
+ 1.1(lnGDPc) - .004(CPI) + 1.03(Democ)
+ .21 (EFW)

The model shows how lnGDc is statistically significant at 0.01level (z value = 2.09) and it has 0.29 of pseudo R^2. The one that make this model different from our previous models is the relationship of CPI to EPI. Having cleaner governance leads to a decrease on environmental performance.

The last model is analyzing dependent variable measured as proportion, or so called binomial model. Our regression shows this generated model with pseudo R^2 of 0.63:

Green = - 34 -5.3(Ethnic) + .01(IGOnum)
+ 2.99(lnGDPc) + .02(CPI) + 1.67(Democ) + .32 (EFW)

Altogether, the following table shows the comparison of all models.

Table 3. Summary of Significance

	Model 1&2 (OLS)	***Model 3 (Logit)***	***Model 4 (Poisson)***	***Model 5 (binomial proportion)***
Economic freedom	-0.07	0.32	0.21	0.32
Corruption	0.22**	0.02	-0.004	0.02
Economic development	7.164***	2.99*	1.1*	2.99*
Ethnic diversity	-2.8	-5.3	-1.19	-5.3
Democracy	0.74	1.68	1.03	1.67
IGO membership	0.14	0.01	0.0001	0.01
R^2/pseudo R^2	0.83	0.63	0.29	0.63

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Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05
                ‘.’ 0.1 ‘ ’ 1
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In general, all models discussed before are consistent with our theoretical framework, which is wealth, democracy, and international interaction have positive relationship with environmental performance of countries. Variable of wealth, the natural log of GDPc, has statistical significance in all models. Unfortunately, we have not found any support for the statistical significance of IGO membership and Democracy to EPI. Nonetheless, this project can contribute to the previous study that using different measurement of environmental performance.

This cross-section analysis of environmental performance gives us broad tendency of it. The next part provides additional analysis to understand environmental performance in term of its depth. How is the relationship between variables across time for a specific country . In order to do that, we use a random case study of one developing country by using time-series analysis.

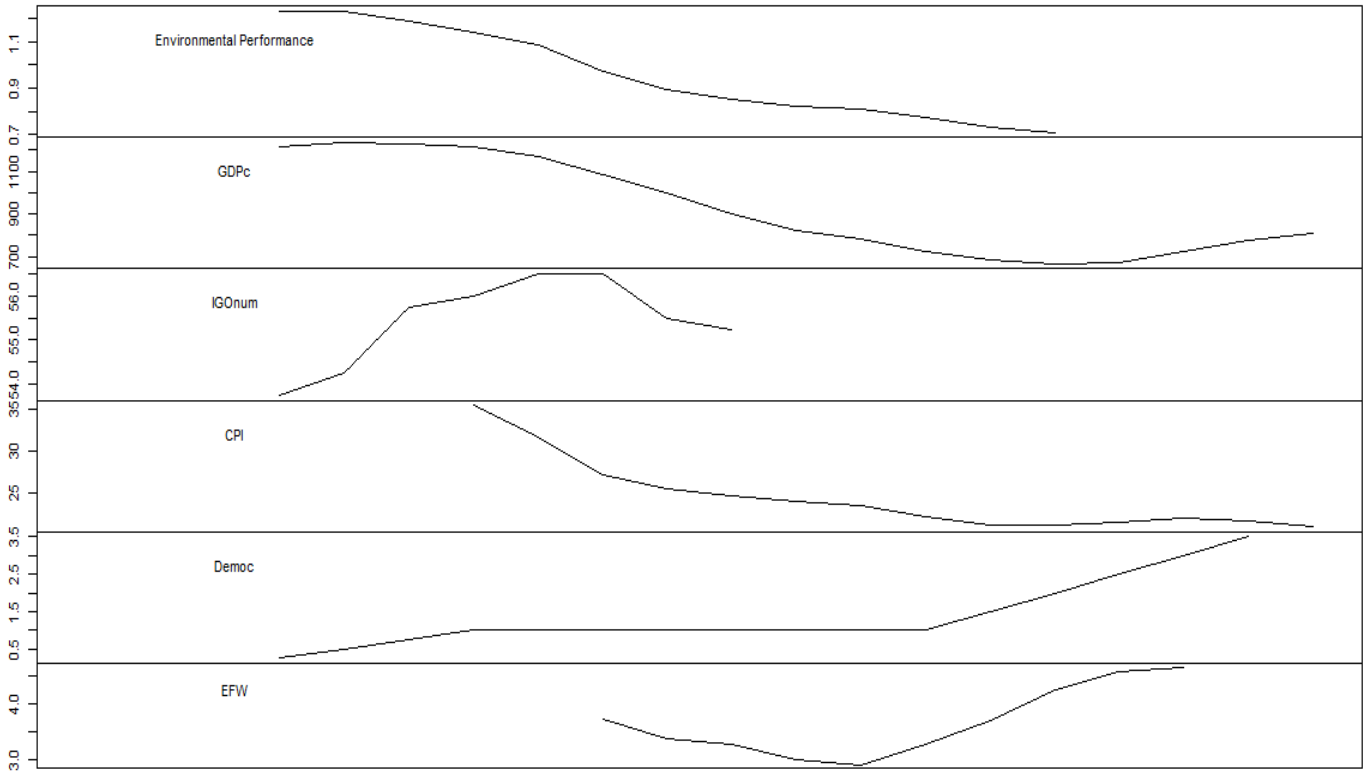
7 TIME-SERIES ANALYSIS OF ZIMBABWE

The 2014 EPI report mentions that countries of varying economic development have divergent climate emissions trajectories; these warrant different policy priorities. Wealthy countries produce the highest levels of climate emissions, but have for the most part been successful in reducing the carbon intensity of economic growth over the last decade. Denmark, for example, has made strong policy commitments to reduce emissions through increasing efficiency and renewable energy. Middle-income countries, such as Brazil, India, and China, are still growing economically and see the steepest increase in emissions over the last decade. As our cross section analysis consistently shows the importance of wealth, it is interesting to study the trend in the developing economies in environmental performances.

Environmental Performance Index (EPI) is a quite new measurement to represent the environmental policy of countries. Due to its novelty, there are not many data available. EPI was developed in 2006 and since then, it is being updated biennially. It is hard to use for a time-series analysis. Therefore, we need to shift to the more traditional measurement of environmental performance, which is

gas emission. Consequently, CO2 emission is used for our dependent variable, and the same independent variables as discussed in the previous part.

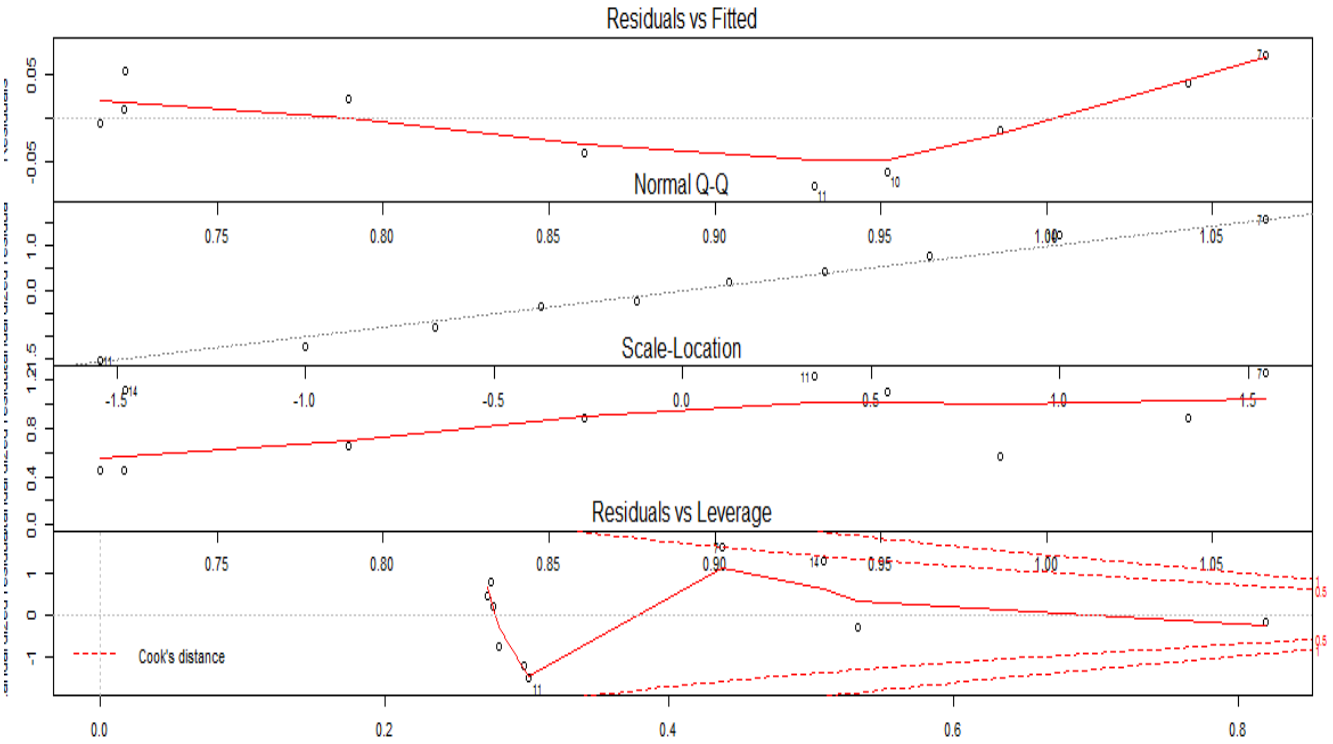
We study Zimbabwe for the period of 1995-2014. Basically, it is a random selection, but it is still an important case study. Zimbabwe has undergone several transformations related to the socio-economic aspects in this project. There are some missing data especially in term of IGO membership and economic freedom. Nevertheless, the following graph shows the development of each variable during the years of 1995 until 2014.



The visual interpretation shows that the environmental performance of Zimbabwe seems to be connected with GDP per capita, CPI and Democracy. The GDP per capita and CPI seem to have positive relationship. In this case, the higher GDPc and CPI, the higher emission Zimbabwe will be. In other words, it contradicts our previous analysis of how wealth leads to better environmental

performance. . In Zimbabwe case, the decrease of wealth leads to decrease of emission. Of course, it is important to note that in this time series analysis we use different measurement of environmental performance

Contrary to our visual interpretation, the robust analysis of Augmented Dickey-Fuller (ADF) test shows the series is stationary (there is no trend). Most of variables, except EFW, have p value >.1. Therefore, we cannot reject the null hypothesis that there is no relationship between dependent and independent variables. The following graph shows detail analysis of the residuals.



Besides that analysis, we develop simple linear model of time-series analysis. The model generated is

$$CO^2 = .08 + .0006(GDPc) + .008(CPI) - .002(Democ)$$

This model has adjusted R2 of .83 and showing that GDPc is significant at .05 level. In the case of Zimbabwe, wealth increase will

resulted in the increase of CO^2 emission. This reminds us with the EKC study mentioning a non-linear relationship between wealth and environmental input including CO2 indicator. All in all, this additional time series analysis provides an interesting insight to our main theme of environmental performance. Nonetheless, it is too early to draw conclusion from this limited data.

8 CONCLUSION

There is a need to understand the factors that drive countries to produce policy to protect their environment. This project studies the socio-economic factors of countries environmental performance. Using Yale's EPI as the proxy of environmental performance, we use regression analysis to test several hypotheses. We assume that the variables of wealth, political system and international interaction have strong relationship with our dependent variable of environmental performance.

The cross-sectional analysis strengthens our assumption of wealth as a powerful predictor of environmental performance. On the contrary, this project does not found strong statistical evidence to support the importance of democracy and IGO membership. Still, the result is consistent with our assumption of the nature of their relationships to the dependent variable.

Our additional analysis of time-series of Zimbabwe has not successfully presents the trend of the relationships. Using different proxy for our dependent variable, wealth variable has positive relationship with CO^2 emission. It re-states the finding of EKC study showing non-linear relationship between GDP per capita and environmental output. In the beginning of countries economic development, they tend to produce more emission (pollute more) until reach certain level of wealth, they start developing more environmentally friendly policy or development. Nevertheless, the limitation of time-series analysis in this project prevents us to conclude confidently on any time-series consequences.

9 BIBLIOGRAPHY

Church, Dennis. *The Economy Vs. The Environment: Is There a Conflict?* (presentation, Executive Training Program, Mountain View Chamber of Commerce, April 17, 1992) accessed from http://www.ecoiq.com/dc-products/prod_conflict.html.

Das, Jayoti, and Cassandra E. DiRienzo. "Is Ethnic Diversity Good for the Environment?A Cross-Country Analysis." *Journal of Environment & Development 19*, no. 1 (2010): 91-113.

Georgescu, M.A. &Cabeca J. C. "Environmental Protection Expenditure and Revenues in the EU, EFTA and candidate countries 2001-2006, " *Eurostat. Statistics in Focus*, no.31 (2010), accessed February 15, 2015. http://ec.europa.eu/eurostat.

Hammar, H and Löfgren, A. " Explaining adoption of end of pipe solutions and clean technologies -Determinants of firms' investments for reducing emissions to air in four sectors in Sweden", , Å., *Konjunkturinstitutet Working Paper* No. 102, 2007, 28 pp.

Keohane, R.O and Raustiala, K. "Toward a Post-Kyoto Climate Change Architecture: A Political Analysis," *The Harvard Project on International Climate Agreement, Discussion Paper 08-01,* July 2008.

Ruoff, Gabriele. "Grow Rich and Clean up Later? Joint Effects of Igo Membership and Democracy on Environmental Performance in Developing Countries." *Conference Papers -- International Studies Association (2009 Annual Meeting 2009*): 1-27.

Solomon,Uchechukwu. "A detailed look at the three disciplines, environmental ethics, law and education to determine which plays the most critical role in environmental enhancement and protection," *Environment, Development and Sustainability*, 2010. 12(6): p. 1069-1080.

10 APPENDIX : R CODES

Cross section analysis

```
>setwd()
>epi = read.csv("epi.csv",
        stringsAsFactors=F,
        na.strings = ":",
        header=T)
>e = read.csv("E.csv",
        stringsAsFactors=F,
        na.strings = ":",
        header=T)
>data1 = merge (epi, e, by.x = "Country", by.y = "Country")
>summary (data1)

>gdpc = read.csv("GDPC.csv",
        stringsAsFactors=F,
        na.strings = ":",
        header=T)

>cpi = read.csv("CPI.csv",
        stringsAsFactors=F,
        na.strings = ":",
        header=T)

>egov = read.csv("EGOV.csv",
        stringsAsFactors=F,
        na.strings = ":",
        header=T)
```

```
>efw = read.csv("EFW.csv",
              stringsAsFactors=F,
              na.strings = ":",
              header=T)

>democ = read.csv("democ.csv",
              stringsAsFactors=F,
              na.strings = ":",
              header=T)

>igonum = read.csv("igonum.csv",
               stringsAsFactors=F,
               na.strings = ":",
               header=T)

>data2 = merge (data1, gdpc, by.x = "Country", by.y = "Country.Name")
>data3 = merge (data2, efw, by.x = "Country", by.y = "Countries")
>data4 = merge (data3, cpi, by.x = "Country", by.y = "Country.name")
>data5 = merge (data4, democ, by.x = "Country", by.y = "Country")
>epidata = merge (data5, igonum, by.x ="Country", by.y = "country")

>epidata$dem =                    # Set dem value to TRUE
  ifelse(epidata$democ>7, T, F)    #   if democ > 7

>summary (epidata)
>epi = epidata$EPI
>sd(epi)
>efw = epidata$EFW
>sd(efw, na.rm=T)
>cpi = epidata$CPI
```

```
>sd(cpi)
>gdpc = epidata$GDPc
>sd(gdpc, na.rm=T)
>democ = epidata$democ
>sd(democ)
>ethnic = epidata$Ethnic
>sd(ethnic)
>igonum = epidata$igonum
>sd(igonum)
>attach (epidata)

>cor(epidata[-c(1,2)], use="pairwise.complete.obs")
>round(cor(epidata[-1], use="pairwise.complete.obs"),2)

>model1 <- lm(EPI ~ Ethnic + igonum + log(GDPc)+ CPI + dem + EFW)
>summary (model1)
>plot (model1)

>hist(epidata$GDPc)
>plot(density(epidata$GDPc))

>pairs(data=epidata, EPI ~
       Ethnic +igonum+ log(GDPc)+ CPI + dem + EFW,
     col=ifelse(
       epidata$democ>7,
       "blue","red"),
     pch=16)

>par(usr=c(0,1,0,1))
legend(x=.6, y=.05,
```

```
 pch=16,
      col=c("blue", "red"),
      xpd=T,
      legend = c("Democratic Countries",
                 "Non-Democratic Countries"))

>model1$model[abs(rstandard(model1))>2,]
>sort(rstandard(model1))

>drop1(model1, test="F")

>step(model1, test="F")

>model2 = glm(EPI ~
               Ethnic +igonum+ log(GDPc)+ CPI + dem + EFW,
             family=gaussian,
             data=epidata)
>summary(model2)
>plot (model2)

>model2a = glm(EPI              # Interacting igonum and democracy
              ~Ethnic+ log(GDPc)+ CPI + dem + EFW
              +igonum*dem,
              family=gaussian,     # Normal distribution
              data=epidata)

>summary(model2a)
>plot(model2a, ask=F)

>epidata$green =                  # Set green value to TRUE
```

```
> ifelse(epidata$EPI>70, T, F)    #   if epi > 70


>summary (epidata)



>model3 = glm(green ~
              Ethnic +igonum+ log(GDPc)+ CPI + dem + EFW,
            family=binomial(link="logit"),
            data=epidata)
>summary(model3)
>plot (model3)

#For the Pseudo R square
nullmodel3=glm(green~1,        # Set up glm model
                  family=binomial(link="logit"),       # link function -- binomial w/logit
                  na.action=na.omit, data=epidata)    # Omit missing values


>summary(nullmodel3)
# Three Pseudo R-squareds
# First based on AIC
>PR2.1 = 1-(model3$aic/nullmodel3$aic)
# Second McFadden pseudo R2
>PR2.2 = 1 -  logLik(model3)/logLik(nullmodel3)
# Third McFadden adjusted pseudo R2
>PR2.3 = 1 - (logLik(model3)-model3$rank)/logLik(nullmodel3)


>cat("AIC-Ratio Psuedo R2 = ", round(PR2.1,2),"\n",
  >  "McFadden pseudo R2 = ", round(PR2.2,2),"\n",
    >"McFadden adj. pseudo R2 = ", round(PR2.3,2),"\n")
```

```
>sumgreen = tapply(epidata$green,epidata$EPI,sum)
>greenepidata = data.frame(names(sumgreen),sumgreen)

>model4 = glm(sumgreen ~
              Ethnic +igonum+log(GDPc)+ CPI + dem + EFW,
            family=binomial,
            data=epidata)

>summary(model4)
>plot(model4, ask=F)

#For the Pseudo R square
>nullmodel4=glm(green~1,        # Set up glm model
              family=binomial(link="logit"),      # link function -- binomial w/logit
              na.action=na.omit, data=epidata)    # Omit missing values

>summary(nullmodel4)
# Three Pseudo R-squareds
# First based on AIC
>PR2.1 = 1-(model4$aic/nullmodel4$aic)
# Second McFadden pseudo R2
>PR2.2 = 1 -  logLik(model4)/logLik(nullmodel4)
# Third McFadden adjusted pseudo R2
>PR2.3 = 1 - (logLik(model4)-model4$rank)/logLik(nullmodel4)

>cat("AIC-Ratio Psuedo R2 = ", round(PR2.1,2),"\n",
  >  "McFadden pseudo R2 = ", round(PR2.2,2),"\n",
    >"McFadden adj. pseudo R2 = ", round(PR2.3,2),"\n")
```

```
>model5 = glm(green ~
      Ethnic +igonum+ log(GDPc)+ CPI + dem + EFW,
         family=poisson,
         data=epidata)

>summary(model5)
>plot (model5)
#For the Pseudo R square
>nullmodel5=glm(green~1,        # Set up glm model
            family=binomial(link="logit"),      # link function -- binomial w/logit
            na.action=na.omit, data=epidata)    # Omit missing values

>summary(nullmodel5)
# Three Pseudo R-squareds
# First based on AIC
>PR2.1 = 1-(model5$aic/nullmodel5$aic)
# Second McFadden pseudo R2
>PR2.2 = 1 -  logLik(model5)/logLik(nullmodel5)
# Third McFadden adjusted pseudo R2
>PR2.3 = 1 - (logLik(model5)-model5$rank)/logLik(nullmodel5)

>cat("AIC-Ratio Psuedo R2 = ", round(PR2.1,2),"\n",
  >  "McFadden pseudo R2 = ", round(PR2.2,2),"\n",
    >"McFadden adj. pseudo R2 = ", round(PR2.3,2),"\n")
```

```
                                                    xlab="", ylab="")          #  and
                                                no x or y labels
Time series

>install.packages("tseries")

>library(tseries)

>library(help="tseries")


>zimbabwe = read.csv("Zimbabwe.csv", header=TRUE)

>summary (zimbabwe)

>default.par = par()

>head(zimbabwe$year)


>zimbabwe$bCO2 = as.double(filter(zimbabwe$CO2, rep(1/4,4), sides=1))

>zimbabwe$bIGOnum = as.double(filter(zimbabwe$IGOnum, rep(1/4,4),

sides=1))

>zimbabwe$bGDPc = as.double(filter(zimbabwe$GDPc, rep(1/4,4), sides=1))

zimbabwe$bCPI = as.double(filter(zimbabwe$CPI, rep(1/4,4), sides=1))

zimbabwe$bDemoc = as.double(filter(zimbabwe$Democ, rep(1/4,4),

sides=1))

>zimbabwe$bEFW = as.double(filter(zimbabwe$EFW, rep(1/4,4), sides=1))


>layout(matrix(c(0,1,2,3,4,5,6,0),

          ncol=1),

     heights=c(.25,1,1,1,1,1,.8))

layout.show(6)

par(mai=c(0,.6,0,.30))


>plot(zimbabwe$year,zimbabwe$bCO2,          # Setup each plot as a line

plot

   type="l", xaxt="n",              #  with no x axis
```

```
                                                                    label="EFW")
    >par(usr=c(0,1,0,1))              # Set coordinates to (0,1) space
    text(x=.15,y=.75,                 # Overlay a label
      label="Environmental Performance")

    >plot(zimbabwe$year,zimbabwe$bGDPc, type="l", xaxt="n", xlab="", ylab="")
    par(usr=c(0,1,0,1))               # Set coordinates to (0,1) space
    text(x=.15,y=.75,                 # Overlay a label
      label="GDPc")

    >plot(zimbabwe$year,zimbabwe$bIGOnum,  type="l",  xaxt="n",  xlab="",
ylab="")
    par(usr=c(0,1,0,1))               # Set coordinates to (0,1) space
    text(x=.15,y=.75,                 # Overlay a label
      label="IGOnum")

    >plot(zimbabwe$year,zimbabwe$bCPI, type="l", xaxt="n", xlab="", ylab="")
    par(usr=c(0,1,0,1))               # Set coordinates to (0,1) space
    text(x=.15,y=.75,                 # Overlay a label
      label="CPI")

    >plot(zimbabwe$year,zimbabwe$bDemoc,  type="l",  xaxt="n",  xlab="",
ylab="")
    >par(usr=c(0,1,0,1))              # Set coordinates to (0,1) space
    text(x=.15,y=.75,                 # Overlay a label
      label="Democ")

    >plot(zimbabwe$year,zimbabwe$bEFW, type="l", xaxt="n", xlab="", ylab="")
    par(usr=c(0,1,0,1))               # Set coordinates to (0,1) space
    text(x=.15,y=.75,                 # Overlay a label
```

```
>adf.test(zimbabwe$bCO2[!is.na(zimbabwe$bCO2)])

>adf.test(zimbabwe$bGDPc[!is.na(zimbabwe$bGDPc)])

>adf.test(zimbabwe$bIGOnum[!is.na(zimbabwe$bIGOnum)])

>adf.test(zimbabwe$bCPI[!is.na(zimbabwe$bCPI)])

>adf.test(zimbabwe$bDemoc[!is.na(zimbabwe$bDemoc)])

>adf.test(zimbabwe$bEFW[!is.na(zimbabwe$bEFW)])


>zimbabwe$b1GDPc = c(NA,
            diff(zimbabwe$GDPc,lag=2))
>zimbabwe$bGDPc = as.double(
 > filter(zimbabwe$bGDPc,
        rep(1/4,4),
        sides=1))
>adf.test(zimbabwe$b1GDPc[!is.na(zimbabwe$b1GDPc)])


hist (zimbabwe$bCO2)


model1
=lm(zimbabwe$bCO2~zimbabwe$bGDPc+zimbabwe$CPI+zimbabwe$bDemoc)
summary (model1)


plot(model1, ask=F)
```