Democracy, Economic Growth and Global Carbon Dioxide Emission

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Abstract

The transmission process of the influence of a political institution on the environment-income nexus is multi-faceted and complex. We use panel data set on 147 countries for 23 years to investigate empirically the role democracy plays in the income-pollution nexus. Environmental interest groups can promote more awareness in the presence of democracy. Democratic governments are more responsive to the public than are non-democratic governments. Accumulation of civic and social right generated through historical experience is important in maintaining stable and responsive environmental policy. The finding of this paper is that not only the level of democracy but also the consistency in countries' political institution (whether a country maintains a steady score in freedom indicator) is influential in defining the tipping point of environmental Kuznets Curve.

1. Introduction

Environmentally healthy development is a crucial policy agenda for global leaders, today. Human society has been facing the great challenge regarding global warming issues. Political institutions dominate the policy agenda for each and every country. This paper has tried to explore the relationship between development indicator, environmental emission, and the state of the political institution taking consideration of the effects of industrialization.

Environmental Kuznets curve (EKC) hypothesis says that in the way of economic development countries not only contribute to environmental degradation by emitting various pollutants but also reduce the emission level with the grace of development. In the income emission panel, the curve shows the inverted U shape (Grossman and Krueger (1995)). Several factors are under consideration for this hypothesis. Among these are: in the way of development countries change the composition of national income. They progress toward industrialization as well as move to the service sector (Farzin and Bond (2006)). These dynamics helps to lower the emission level after a certain point. Technology is changing every day which contributes toward achieving Green Earth. Demand for environmental quality increases as people's income increases. The political institution is not out of the block when the national level and global level goal is

considered. This paper put efforts to investigate empirically the interaction between democracy, economic development, urbanization and environmental degradation.

The relationship between environmental quality and income does not form in isolation from government policy influences. Political institutions handle the strategic instruments related to the environmental quality (You et al. (2015)). This phenomenon is also argued by many other policy analyst and researchers. The empirical evidence regarding EKC hypothesis is mixed. The variation in findings among researchers is a result of the change in the sample used for analysis, the model and the method employed to estimate the relationship, and the control variables included in the model. Among many pollutants, created by human activities, carbon dioxide (CO2) is the primary greenhouse gas which is the major contributor to the environmental degradation. There is natural circulation of carbon among the atmosphere, soil, plants, and animals. So it is rational to say that carbon dioxide is naturally present in the ecosystem as part of the Earth's carbon cycle. Human activities are not only emitting the gas but also altering the natural carbon cycle. Carbon dioxide emissions come from a variety of human activities like combustion of fossil fuels (coal, natural gas, and oil) for energy and transportation, various industrial process and land use also dominate the carbon cycle. It is argued that C02 has an impact on a global scale, not local scale (Retrieved from https://www3.epa.gov). Taking into account of these various types of impact and degrees of contribution to the atmosphere, this paper opts to use CO2 as the only emission measure in the way of exploring the democracy-emission nexus.

The dynamics of democracy, carbon emission, and income relationship is complex. The transmission process of the effect of a political institution on the environment-income nexus is multi-faceted. Public awareness and environmental legislation are a product of political rights and freedom of information. Environmental interest groups can promote more awareness in the presence of democracy (Li and Reuveny (2006)). The autocratic system (No democracy) censors information flows, and its decision-making process is more unilateral than that of a democratic regime. Democratic governments are more responsive to the public than are non-democratic governments. Electoral accountability of representative government ensures the participation of social group in public policy making.

The Democratic government respects economic freedom and possesses the preference for market economies. They comply with the rule of law and are more likely to comply with environmental agreements which in turn improved the environmental qualities.

The structure of this paper is as follows: Section 2 reviews previous literature. This article takes into account of sample selection criteria as well as sample description in section 3. Section 4 illustrates the econometric model. Section 5 explores the empirical findings and interpretation of the results. The discussion about the finding takes place in section 6. Section 7 reports robustness checks. Concluding remarks take place into the last section.

2. Literature Review

It was the 67th annual meeting of American economic association in 1954 where Simon Kuznets expressed the relationship between per capita income and income distribution (Kijima et al. (2010)). This Kuznets curve hypothesis posits that income distribution is skewed toward higher income level when the income level is low, but the skewness is reduced as the per capita income increase and the income inequality decreases. This Kuznets curve hypothesis interested many researchers to test the feasibility to apply to environmental economics, and the income distribution has replaced by environmental degradation. This is known as environmental Kuznets curve (EKC) hypothesis. Grossman and Krueger (1995) is the most influential contributor among many.

2.1. Environmental Kuznets curve

Grossman and Krueger (1995) in a seminal paper have presented the relationship between income and the environmental degradation. Grossman and Krueger (1995) have argued that environmental quality initially deteriorated but in the way of development, initially the quality of environment declined but moves toward improved environment after a certain level of per capita income. This turning point differs across countries. They establish the turning point for most of the countries at $8000. They have taken into account of all dimensions of environmental quality (air quality and water quality). Grossman and Krueger (1995) have used the panel data and have used short form equations to estimate the model. They define a negatively sloped inverted U-shaped environmental Kuznets curve. After that, a large number of literature have re-examined

the EKC hypothesis. Considering the growing number, this paper focuses initially on recent empirical literature and theoretical findings regarding EKC. After that, a second group literature presented regarding their contribution to an effect of democracy on environment-emission nexus.

A meta-analysis can give a very good idea about a large number of literatures very quickly. Choumert et al. (2013) conduct a meta-analysis based on 69 studies and 547 regressions and investigate the reason for the difference in results related to EKC hypothesis using deforestation as an environmental degradation indicator. They found that the more the research, the more the probability of having EKC declined. They conclude that the selection of control variables have a significant impact on the likelihood of finding an EKC relationship. The inclusion of trade as a control variable negatively impacted on the probability of getting EKC about deforestation. They also argued that the channel of transmission of macro variables and environmental degradation diverted because of control variable like trade. This finding gives the researchers a good direction for the next research about EKC hypothesis.

The theoretical aspect of EKC hypothesis is explored by many researchers. Kijima et al. (2010) have focused on the theoretical aspect of EKC model. They adopt a static and dynamic aspect of classification among many different types of classification of EKC theoretical discussion. They found a plenty of researchers disagreed with the hypothesis. Some of them are also skeptical about the used data and methodology applied to define the EKC curve. Stern, D.I. (2010) Point out some fundamental econometric problems with the traditional method of estimating environmental Kuznets curve and propose some alternatives. To address the cross-sectional dependency and time effect problem, the between estimator is proposed. Stern also indicates that the time-dummies will not capture the time varying technological changes, and this may lead to the contemporaneous correlation between regressor and country effects and residual errors. Chow and Li (2014) attempt to investigate the major econometric problems arises in the way of testing EKC hypothesis. They use data from 132 countries for the period 1992 to 1994. They use the CO2 emissions from fuel combustion. They perform cross-sectional regression for each year using this panel data set and use the simple t-test to test the EKC hypothesis

The phenomenal change in the financial sector in the way of economic development gets attention from researchers. The flourishing environmental Kuznets Curve literature is also

growing again for some distinctive results related to EKC hypothesis. Pao and Tsai (2011) conduct an empirical analysis to address the impact of both financial development and economic growth on environmental degradation. They use the data for BRIC countries from 1980 to 2007. The panel cointegration technique is used for this panel dataset. The results are supportive of the EKC hypothesis. They find that CO2 emission is energy consumption elastic, FDI inelastic, and GDP elastic for a given level of GDP. These elasticities indicate the high responsiveness of environmental quality to change in energy consumption and output. But not directly to the change of foreign direct investment.

Researchers take endeavor to explore the effect of energy consumption, urbanization, trade openness, in addition to GDP and financial development on EKC. Al-Mulali et al. (2015) investigate the environmental Kuznets curve using the ecological footprint of a country. They explore the relation using 93 countries around the globe for a period 1980 to 2008. As the explanatory variable, they use energy consumption, urbanization, trade openness, in addition to GDP and financial development. They also categorize the cross-sectional data into low-income, lower middle income, upper middle income, and high-income countries and find that EKC is valid for upper middle income and high-income countries but not valid for low and lower middle-income group. They get this result using fixed effect and generalized method of moments (GMM).

There are some researchers those questioned the methodology used to test EKC hypothesis and propose the tipping band instead of tipping point to address proper policy instruments. Bernard et al. (2015) re-examine the EKC hypothesis and argue that there is a tipping band which is convenient to use for policy maker concerning EKC. They find EKC by using three control variables such as share of industry in GDP, number of kilogram of CO2 per kilogram of oil equivalent energy, and percentage of energy a country use that is derived from fossil fuel. Data for 114 countries spanning 1960 to 2007 are used for CO2 and SO2. Bernard et al. (2015) conclude that the identification of economically plausible tipping point is difficult and uncertain by analyzing the data using the parametric baseline case and a non-parametric spline-based alternative.

2.2. Democracy and EKC hypothesis

Existing literature about the effect of democracy on EKC is mixed. In one panel, researchers argued that democracy improves environmental quality; another group of researchers argues that political institution deteriorates environmental quality. There is also a third group those claim that democracy does not have a direct impact on environmental quality.

Li and Reuveny (2006) explore the democracy-environmental debate with empirical evidence focusing on the effect of political regime type on human activities that deteriorate the environmental quality. They use five human- induced environmental degradations, such as organic pollution in water, deforestation, land degradation, carbon dioxide (CO2) emissions, and nitrogen oxide (NOx) emissions. Data used for more than 105 (for some variable 143) countries. Per capita GDP, per capita GDP squared, trade openness and population density were used as control variables. Democracy is used as a continuous variable and also as a dichotomous variable. They find that democracy reduces environmental degradation, and these effects vary across the environmental indicators. This is happening through reducing human activities that directly degrade the environment.

Polity IV index is not the only available democracy indicator. It is also a matter of interest that how the result changes by using different indicators. By using Polity measure (Polity2) and Freedom House Political Rights Index and Civil Liberties Index as democracy indicator, You et al. (2015) revisit the EKC hypothesis to explore the effect of democracy and trade openness on it. They address this issue by applying quantile regression methods using data from a cross-section of countries over the time span from 1985 to 2005. To capture the economic and demographic structure of countries which is rationally expected to influence their pollution profile, three variables, trade openness, population size, and the share of industry in the country's GDP is included in the model. Trade openness is measured by the ratio of annual imports plus exports to GDP. Population size is the total population of a country. They find that the effect of democracy on CO2 emissions is heterogeneous across quantiles. Among the most emissions nations, greater democracy appears to reduce emissions, but more financial openness does not seem to reduce it. Political institutions affect the environmental pollution in different degrees considering existing intensity level of pollution of the countries.

Empirical analysis of EKC is influenced by sample selection. Only the developing country could explain the EKC Hypothesis. Mak and Lew (2011) explore the relationship between democracy and environmental quality using the data from a total of 141 developing countries from 1976 to 2003. CO2 emissions, water pollution emissions, and deforestation damage are used as measures of environmental qualities. Numerical ratings of Freedom House's for political rights and civil liberties which are based on detailed assessment of country situations and lower values indicating freer societies as freedom indicator. Urban population as a percentage of total population and population per square kilometer are added to the model in addition to the GDP per capita to address the possible effect of urbanization and population growth on the environment. They use Generalized Least Squares (GLS) with a fixed effect per country and year. They explore that democracy is conducive to environmental improvement. Depending on the measure of the environmental quality, the degree of improvement varies. These variations are also remarkable and not uniform across different sub-samples, which they use. They failed to conclude about any consistent relationship between democracy and the state of the environment.

Farzin and Bond (2006) hypothesize that democracy and its associated freedoms provide the channel through which individuals can exercise their preferences for environmental quality more efficiently than under an autocratic regime. The polity measure of Polity IV dataset plus ten as an explanatory variable indicating the political regime, with increasing values indicating greater levels of democratic freedom over both time and between nations is used. Empirical results support their hypothesis. Democracy influence positively to improve environmental quality. Farzin and Bond (2006) conclude that the qualities of political institutions and several indicators of societal preference interact with each other to create the inverted-U shape environmental Kuznets curve.

The effect of democracy on EKC could be influenced by some other variables like education, income, rural population, land area and control of corruption. The explanatory power of democracy compared to income in explaining environmental degradation is also a matter of interest for researchers. Buitenzorgy and Mol (2011) broaden the interpretation of EKC by using political development indicator (democracy index) and other explanatory variables in addition to economic development indicator (income level) to explain the income-emission nexus. They study the effect of education, income, rural population, land area and control of corruption on the

rate of deforestation, based on the average annual rate of change in forest covering 177 countries from 1990 to 2000. The primary independent variable, level of democracy, is chosen from the Polity index. The polity measure ranges from −10 (autocratic) to +10 (democratic). Buitenzorgy and Mol (2011) find the existence of an inverted U-shaped relationship between deforestation and democracy. Compared to non-democracies and mature democracies Countries, countries in democratic transition experience the highest deforestation rates. Democracy has larger explanatory power than income in explaining deforestation rates. They argue that emphasis should not only be on economic development but even more on democratization to reduce deforestation.

Economic development does not ensure distributional income equality in the early stage of development. Persistent income inequality could influence the EKC hypothesis. Policardo, L. (2015) investigates the relation between income inequality, economic development, environmental degradation, and political powers of the majority of the consumers of environmental goods. It is argued that democracy has mixed effect on environmental quality depending on the price and income effect on the demand for environmental goods. Policardo, L. (2015) concludes "assuming that society is composed of two classes of individuals with different levels of exposure to pollution, and thinking moreover that the decisive voter belongs to the most exposed class of individuals while the autocrat does not, democratization is beneficial for the environment, and the better the effect on the environment, the bigger the difference in wealth between the two decisive political actors." It is argued by some other researchers that this inequality has indirect negative effect on environmental quality and intern it helps to offset the effect of democracy on environmental quality. Romuald, K. S. (2011) examines the transmission channel of the effect of a democratic institution on environmental quality. Using data for 122 countries from 1960 to 2008 for two environmental quality indicator, Romuald, K. S. (2011) show that democratic institution have opposite effect on environmental quality which comes from a positive direct effect on environment quality and a negative indirect effect on investments and income inequality with the help of one-step GMM-System, two-step GMM-System one step, fixed effect estimators and the residuals generated regressor econometric model.

We are discussing the effect of democracy. The element of democracy could individually affect the analysis. In this regard, some literature investigates the effect of the elements of democracy

and other control variables on environmental pollution. Dasgupta et al. (2004) cast doubt on the conventional view of the relationship between economic growth and environmental quality using the air monitoring data for the period 1986-1999. Controlling for governance, vulnerability, population density, and pollution-intensive economic activity, as well as income per capita, Dasgupta et al. (2004), conclude about the sufficient effect of governance and geographic vulnerability on the crisis levels of air pollution in many developing-country cities.

Fredriksson and Neumayer (2013) argue that history of political institution affect the environmental quality of a country. In other words, the democratic capital stock is more influential than the current state of democracy for environmental quality. They explain this stock as an accumulation of civic and social right generated through historical experience. They use Climate Laws, Institutions, and Measures Index (CLIMI) as one of the dependent variables. Drosdowski, T. (2006) argued that economic growth played an ambiguous role in the environment-democracy relation. Political will, voters' preferences, and relative strength of organized interest played a vital role in the formation of EKC curve.

The previous literature explains EKC hypothesis from various point of view. Democracy, elements of democracy, the stock of democratic capital all influence the environmental quality.

3. Data

Existing literature about Democracy-pollution nexus is mixed depending on their sample section, methodology, control variables, and a measure of democracy. The choice of sample for this analysis is primarily dominated by the availability of reliable data. This paper uses data from 147 countries for a time span of 23 years from 1990 to 2012 with 3381 observations. This cross-section time-series data provides the distinct advantage of using panel data with increasing the degrees of freedom and reducing possible collinearity among the independent variables.

Data are drawn from three sources. Environmental emission data for carbon dioxide (CO2), socio-economic data for gross domestic product converted at purchasing power parity (GDP-PPP), gross domestic product in USD (GDP-USD), and population are drawn from World Resources Institute's CAIT Country GHG Emissions (1990-2012) dataset. Data for democracy indicator is collected from Freedom House's Freedom in the World Country Rating (1973 -

2014) dataset. Industry-GDP ratio data are obtained from World Development Institution. Total GDP-PPP and total GDP-USD are measured in million USD dollars. GDP-PPP converted at 2011 constant price, but GDP-USD converted at 2005 constant price. CO2 measured at million metric tons.

Initially, this paper intended to use all countries of the world, but data for all countries are not available. World Resource Institute publishes the sub-sectoral carbon emission from 1990. So the analysis started to work using data from 1990. Freedom house's data for Democracy is not available for each and every country for each year; this delimits the number of countries. To match the data for countries available in all data sources, the sample size is lowered to 147 countries. There is no missing data for GDP, CO2 emission, Freedom Index, but there are some missing data for industry-GDP variable.

Table 1 illustrates the summary statistics of the restricted sample. Total number of countries covered is 147 which represent 98% of total world GDP, about 93% of total global carbon dioxide emission, and 90% of total world population. Luxembourg was the second highest per capita CO2 contributor among the 147 countries in 1990. Figure 1 depicts the per capita CO2 emission and per capita GDP profile of Luxembourg. It is found that Trinidad and Tobago and Bahrain secure the highest and second highest position regarding per capita CO2 in 2012 among the 147 countries respectively. Chad contributed the lowest amount of per capita CO2 in 1990 and 2012. Figure 2, figure 3, and figure 4 depict the per capita CO2 emission and per capita GDP profile of above Trinidad and Tobago, Bahrain and Chad respectively. USA, China, India, and Brazil also contribute a significant amount of CO2 in the carbon cycle. Figure 5, figure 6, Figure 7, and figure 8 illustrate the per capita CO2 emission and per capita GDP profile of above four countries respectively. Now, it is time to explain all the manipulated and used variables in details.

The democracy indicator is compiled using the numerical value of Freedom House's Political Rights Index and Civil Liberties Index. Both of them assign a numerical value to each country on a scale of 1 to 7, where 1 indicates the highest degree of freedom and 7 the lowest degree of freedom. They also categorize countries depending on combined average ratings for Political Rights and Civil Liberties. Free (F), Partly Free (PF) and Not Free (NF) are labeled depending

on numeric values between 1.0 and 2.5, 3.0 and 5.0, and 5.5 and 7.0, respectively. All the labels are a relative term not in absolute sense. The free designation does not mean that a country enjoys perfect freedom or lacks serious problems. This labeling does not take account of the consistency of an individual county's democratic status over the whole period. It only considers the stage of democracy at a single point in time. This Freedom Index is used as “Freedom Index without consistency” in this analysis.

This paper reverses the Political Rights Index and Civil Liberties Index in terms of numerical value. Subtracting each value from 8, the highest and lowest levels of democracy are represented by 7 and 1 in both indices, respectively. A simple sum of these two indices is used as a proxy for the aggregate democracy level and named “Total Freedom Index” as well as treated as a continuous variable in this analysis.

Democracy indicator is also used as a categorical variable. The democracy indicator shows that some countries are consistent in their category all over the period. For example, 50 countries hold full free democratic status for the whole time span from 1990 to 2012. It is considered entire period if they maintain it at least for 22 years out of 23 years. On the other hand, many countries changed their status throughout the whole period. These countries, in the latter category, are labeled as inconsistent country. Some of these inconsistent countries upgraded their democracy level to partly free or full free level from their previous lower level of the democracy index. There is another group those move down to partly free or not free level. Surprisingly, some countries are not stable on their path to democracy. Those experience political instability in the sense of moving up and down. As a derived categorical variable, this democracy index is labeled "democracy index with consistency". This new democracy index is categorized into six different levels and labeled as “consistently full free”, “consistently partly free”, and “consistently not free” “Improved”, “Deteriorated”, and “Fluctuated”. The first three groups of countries are considered as consistent over the periods in their democracy stage, and the latter three are inconsistent in their democracy level for the whole period.

This paper takes consideration of three different types of democracy index, such as “Total Freedom Index", "Freedom Index without consistency”, and “democracy index with consistency”. It is also mentionable that democracy, freedom, and political institution are also

interchangeably in this analysis. Table 2 illustrates the share of GDP, CO2, and Population of 6 groups of countries compared to the total sample. "Consistently full free" countries represent 17% of the population, 47% GDP-PPP, and 37% carbon dioxide emission of the total sample. On the other hand, "consistently not free" countries represent 26% of the population, 21% GDP-PPP, and 35% carbon dioxide emission of the total sample. It is also mentionable that "Fluctuated" group consists of 34 countries which are double of the number of countries of "consistently not free" group and represent 24% of the population, 14% GDP-PPP, and 8% carbon dioxide emission of the total sample. The statistics are intuitive by itself.

4. Econometric model

The Environmental Kuznets Curve (EKC) hypothesis implies an inverted U-shape relationship between per capita income and per capita emission. So, there is a functional form of this hypothesis which is as follows:

$$E_{it} = f(Y_{it}, Z_{it}, F_i, F_t, u_{it})$$

Where, E_{it}, be the emissions per capita in country *i* and year *t*, Y_{it} be the country's income, Z_{it} is the vector of control of other variables which may influence the formation of EKC curve, F_i is the cross sectional effect, F_t is the time effect, and μ_{it} is the disturbance term of the model. Considering the income emission relation, researchers prefer to use a quadratic form of equation with a positive coefficient of per capita income and a negative coefficient of squared per capita income. For the empirical model, we follow Kijima et al. (2010) and Bernard et al. (2015). The basic EKC in equation form is as follows:

$$E_{it} = \beta_1 + \beta_2 Y_{it} + \beta_3 (Y_{it})^2 + \beta_4 Z_{it} + \mu_{it}$$

The square of income is used to get the quadratic form of equation keeping in mind the curvature shape of EKC. This is a standard formula, as used by (for example) Kijima et al. (2010). Some researchers use the cubed of income to derive the n-shape curve. The tipping point is found by taking the first order derivative of the above equation, and it corresponds to

$$\delta = -\beta_2 / 2\beta_3$$

For the computational and methodological benefit, it is preferred to use log of the variables and by this way, coefficients can easily say the elasticity effects of any change. As employed by Bernard et al. (2015), The model become

$$lnE_{it} = \beta_1 + \beta_2 lnY_{it} + \beta_3 (lnY_{it})^2 + \beta_4 Z_{it} + \mu_{it}$$

The dependent variable of interest of this paper is environmental emission which is represented by per capita carbon dioxide emission (CO2). Per capita GDP is used as the explanatory variable. The basic model of this setting, only including income and emission, considering no other control variables, (we follow the model specification of Bernard et al. (2015) but drop all of the control variables except GDP) the quadratic form of model is primarily defined by

$$lnCO2_{it} = \beta_1 + \beta_2 lnGDP_{it} + \beta_3 (lnGDP_{it})^2 + \mu_{it}$$

To capture the structural change in economy, the industry variable Industry-GDP ratio (IND) is added to the model (Bernard et al. (2015)). The basic model of EKC hypothesis is as follows:

$$lnCO2_{it} = \beta_1 + \beta_2 lnGDP_{it} + \beta_3 (lnGDP_{it})^2 + \beta_4 lnIND_{it} + \mu_{it}$$

The democracy variable, level of democracy (DEM) is used as the control variable to capture the structural change in the political institution of the country. The final model becomes

$$lnCO2_{it} = \beta_1 + \beta_2 lnGDP_{it} + \beta_3 (lnGDP_{it})^2 + \beta_4 lnIND_{it} + \beta_5 DEM_{it} + \mu_{it}$$

Let, $lnCO2_{it}$ be the log of per capita emissions in country *i* and year *t*, $lnGDP_{it}$ be the log of the country's per capita GDP at purchasing power parity, $lnIND_{it}$ be the log of industry to GDP ratio, DEM_{it} be the level of democracy of the country. Then the tipping point corresponds to

$$\delta = \exp(-\beta_2/2\beta_3).$$

Using five dummies for six categories of democracy status, the model becomes

$$lnCO2_{it} = \beta_1 + \beta_2 lnGDP_{it} + \beta_3 (lnGDP_{it})^2 + \beta_4 lnIND_{it} + \beta_5 FRDEM_i + \beta_6 PRDEM_i + \beta_7 IMPDEM_i + \beta_8 DETDEM_i + \beta_9 FLUCDEM_i + \mu_{it}$$

Let, $FRDEM_i$ be the "consistently full free" countries, $PRDEM_i$ be the "consistently partly free" countries, $IMPDEM_i$ be the "Improved" countries which are improving their democracy level over time, $DETDEM_i$ be the "Deteriorated" countries which are deteriorating their democracy level over time, $FLUCDEM_i$ be the "Fluctuated" countries which have fluctuation in their democracy level over time. The group of "consistently not free" countries is used as a reference group under this model. This paper estimates last three models under different specifications. For all the models, the tipping points correspond to $\delta = \exp(-\beta_2/2\beta_3)$. Getting the model specification and the restricted sample of data, methodological aspect is imperative to discuss.

Having larger number of cross-sectional unit (n=147) than the number of periods (T=23), the focus of econometric analysis of this micro panel dataset is on how to control for individual heterogeneity (i.e., differences between individual cross-sectional units). As it will be seen, the implicit underlying assumption, in this case, is that we have a random sample of cross-sectional units, and the derivation of asymptotic properties of estimators in this context relies on large n.

We also note that all of the cross-sectional units are observed for the same period. The data set is a balanced panel data, and the problems associated with unbalanced data are eliminated. This panel data set gives the advantage of increased degrees of freedom and the reduced multicollinearity between the explanatory variables. Taking the advantages of micro panel data, this literature estimated fixed effects, random effects, pooled regression, and cluster country models for all specifications. Fixed effects and random effects models differ regarding their assumption about the properties of the individual specific effect. It is assumed that the unobserved heterogeneity is correlated with the other explanatory variables of the model in case of fixed effect model. Unlike fixed effect model, the random effect model assumes that the unobserved heterogeneity is uncorrelated with the other explanatory variables in the model.

This paper estimates the fixed effect model. This model gives the same results as the OLS estimation results of a model where all the cross-sectional units are represented as a dummy variable. By this feature, the fixed effect model is defined as the least squares dummy variables (LSDV) model. This one-way fixed effect model is extended to the two-way fixed effect models by adding time dummies to the model. The significant limitation of this model is that it cannot include the time-invariant explanatory variables. In our case, when the democracy is used as a

categorical variable and represented by the dummies, the fixed effect is zero. Considering the limitation of fixed model, we also resort to the random effect model. For the underlying assumption, this model is also referred to the variance components model. The feasible generalized least square (FGLS) estimation is carried to get the random effects. For all the specifications, if we find positive GDP coefficient and negative GDP square coefficient, collectively, these will indicate an inverted U-shaped curve which supports the Environmental Kuznets Curve hypothesis.

The estimation results under fixed effects, random effects, pooled regression, and cluster country models are compared by conducting various diagnostic tests to select relatively reliable result. It is very commonly to carry a standard F test to check whether the fixed effects are equal or not to that of the pooled regression model. For the purpose of this analysis, the restricted model is the pooled regression model, while the unrestricted model is the fixed effects model. The LM test of Breusch and Pagan (1980) is carried to compare the random effects model versus the pooled regression model. Many researchers prefer the random effect to the fixed effect model because time-invariant explanatory variables can be included in the model. It is also important to remember that the random effects estimator is inefficient if any of the explanatory variables of the model is correlated with the individual effect. Taking into account the issue above, we carry out the Hausman test for each pair of model fixed and random effect. If we reject the null hypothesis that the difference in coefficients is not systematic, we adopt the fixed effect model. For the most of our comparisons, standard Hausman test does not provide conclusive results. So we go further to use modified Hausman test.

5. **Results**

This paper takes endeavor to test the EKC hypothesis for CO2. The fundamental relation is tested between per capita income and per capita carbon dioxide emission. Then the control variable industry to GDP ratio is included in the model. Furthermore, the explanatory variable democracy added to the model as continuous variable as well as categorical variable. The panel data is used for this analysis.

Table 3 illustrates four regression results. Under the fixed effects and random effects regressions, without and with the industry-GDP control variable, positive GDP coefficient and negative GDP square coefficient collectively indicate an inverted U-shaped curve which supports the Environmental Kuznets Curve hypothesis. The estimated coefficients are statistically significant at 1% level of significant. We were concern about the omitted variable bias at the beginning of the foundation of the model. It is argued that urbanization, as well as industrialization, is the major contributor to the CO2 emission. To account for this, we include the Industry-GDP ratio to capture this structural change of an economy. Table 3 illustrates that the inclusion of Industry-GDP ratio in the model does not alter the magnitude of the coefficients of GDP and GDP square much. The coefficient of Industry-GDP ratio is statistically significant at 1% level of significant. Under the fixed effects model, Tipping point without industry effect found to be $87,898, but it increased to $112,719 with the addition of this variable. Under the random effects model, the addition of industry variable also shifts the tipping point from $191,657 to $299725. The addition of this variable increases the turning point significantly. The Hausman test supports the fixed effect panel regression for this basic model over the random effects model.

Some researchers argue that the political institution also involves with policy making and implementation which affects the environmental quality. The Democracy Index from Freedom House is added to the model to reflect the impact of the quality of political institution on environmental emission. Table 4 shows the four regression results under different scenarios. In this table, categorical Freedom Index is plugged in and the effect of the addition of industry variable is also presented. Consistently not free status is used as a reference and others categories, such as fully free, partly free, improved, deteriorated, fluctuated is used as a dummy variable. For all the specifications, the determinants of EKC hypothesis are present here at the 1% statistical significance level. The panel regression in the fixed effect model does not take into account the time-invariant effect of democracy dummies. The coefficients of the variables remain same for both the model before and after the inclusion of democracy dummies and the tipping points also not changed under this model.

Table 5 compares the complete model under four different econometric methodologies. Under the random effects model, the variation in the magnitude of coefficients indicates the effect of democracy in the EKC relation. The results show that full democracy and improvement in

democracy have a positive effect on CO2 emissions. Democratic countries contribute more to carbon dioxide emission. These results are statistically significant at 1% level. On the other hand, the coefficient of deteriorated democracy is negatively related to carbon emission at 5% significance level. Partly free and fluctuated dummy shows a negative impact on carbon emission, but they are not statistically significant. The tipping point is $199,899.

The pooled regression estimates are not all significant. Consistently full free, consistently partly free, and improving countries have a positive statistically significant impact on carbon emission. The cluster country regression does not change the coefficients. It only affects the standard errors. None of the coefficients of democracy dummies is significant under this model. But the tipping points are same in pooled and cluster country regression model, and it is $1,224,272. This tipping point is much higher than that of under fixed or random effects model.

The LM test of Breusch and Pagan (1980) prefers the random effects model to the pooled regression model. By carrying out a standard F test, it is decided that the fixed effects model are more reliable to the pooled regression model. On the other hand, the Hausman test supports the fixed effects model over random effects model. So, it is rational to say under above mentioned four methodologies and different specifications; the tipping point is $111,270. But the problem with this is that the fixed effect model in this setting does not say anything about individual effects of dummies. Now it is better to go for the different settings where Freedom Index is used as a continuous variable.

Table 6 illustrates the effects of inclusion of democracy indicator as a continuous variable. Table 6 represent the fixed effect regression results where the democracy index is used as a continuous variable and derived from Freedom House data. We run four regressions for this category. The first model (column 2) considers all countries together; the second model column 3 considers only those countries that are fully free. Third and fourth take account of the partly free and not free countries, respectively. One important point that should be mentioned, the categorisation here does not take consideration of consistency of a country's democracy level over period of times. The democracy status in this setting indicates the situation at any point in time irrespective of particular country. The whole sample range, the coefficient of total Freedom Index is positive and statistically significant at 10% significant level. The magnitude of the effect is not high. 1

unit improve in the index only contributes 0.6% increase in CO2 emission, holding the EKC relation valid. The result inspired to delve into details about the effect of democracy on subsamples. Restricting the sample for fully democratic countries, we find an insignificant positive effect. Restricting the sample further for less democratic (partly free) countries, we do not have any significant results. Though the effect is transformed into negative, the magnitude of effect is also subtle. The sub-sample of not free countries shows impressive results. The coefficient of total Freedom Index in negatively related to CO2 in this models and this statistically significant result also get improved regarding magnitude compares to the last model. The tipping point for the whole sample range found to be $112,719, but it plummeted to $51,619 for countries that have full freedom in any given period. On the contrary countries with no freedom reported a tipping point of $71,430 which implies that we have a tipping point at lower level of per capita GDP for countries with full freedom compared to no freedom. But the whole sample results in a higher tipping point because of the unusual large tipping point for partly free countries. The last three results under fixed effect model show that as we move from democracy to non-democracy, the environmental emission level also decreased. The deterioration of democratic political institutions contributes to improved environmental quality. This hypothesis contradicts conventional wisdom about the environment. Now we will move to another dimension of econometric analysis of the above four settings.

Table 7 illustrates the results of random effect models, but all the model specifications are same as the table 4. In the case of overall sample, democracy index positively affect the CO2 emission but only at 10% significant level. The results show the coefficient of total Freedom Index in negatively related to CO2 in the models where the condition is all countries are not free, and it is statistically significant at 1% level of significance. The tipping point for the whole sample range found to be $300,171, but it plummeted to $56,502 for countries that have full freedom in any given period. On the contrary, countries with no freedom reported a tipping point of $400,075 which implies that we have a tipping point at the lower level of per capita GDP for countries with full freedom compared to no freedom. This phenomenon is supported by fixed effects model also. For both the methodologies, partly free countries showed irrational tipping points. It is necessary to use another available model to look it to the problem.

Table 8 compares the results of addition of continuous democracy index in four different settings like fixed effects model, random effects model, pooled regression model, and cluster country model. Except the cluster country model, the coefficient of democracy index is statistically significant at 10% level. Under pooled regression the effect is negative but under remaining three settings the effect is positive.

Until now the model has performed better under fixed or random effect compared to the pooled or cluster country model. Now it is intuitively important to find out the tipping points in the core model conditioning on Freedom Index. This Freedom Index is defined by Freedom House, and they categorize in three different categories. Table 9 and Table 10 represent the results under the scenario where the Freedom Index is not included in the model as a variable, but it is used as a condition and compared to the whole model. The tipping point for the entire sample range found to be $111,270, but it plummeted to $54,265 for countries that have full freedom in any given period. On the contrary countries with no freedom reported a tipping point of $88,231 which implies that we have a tipping point at lower level of per capita GDP for countries with full liberty at any point in time compared to countries with no freedom even when we are using democracy as a condition. This finding is also valid under random effects model. The change in tipping point is high for countries having no freedom status at any point in time compared to full free countries in case of random effect.

The history of the political institution and its stability might affect the environmental Kuznets curve. Using table 5 and 6, this paper concluded the fixed effect model is better to describe the democracy effect on environmental emission. But for the individual effect of democracy dummies, the fixed effect does not say anything. Table 11 shows that consistency in any democratic stage has some influential effect on the tipping point. To find the effect of consistency of democratic status, this paper controls the analysis using six democracy statuses as control and derives the fixed and random effects individually. Table 11 and 12 illustrate this finding for the fixed and random effects individually. The differing coefficients and tipping points for each democracy status confirm the effects of consistency. A tipping point of $45,305 is reported for consistently fully free countries under the fixed regression. But the tipping point for consistently fully free countries under the random regression is $55,293. This finding implied

that the history of the political institution and its stability affects the environmental Kuznets curve.

6. Discussion

This paper estimated fixed effects, random effects, pooled regression, and cluster country models for all specifications using data on 147 countries from 1990 to 2012. The main intuition behind this analysis is to check the environmental Kuznets curve hypothesis and find the effect of democracy on its turning points.

Each model gives different results regarding the tipping point. Every methodological consideration provides some intuitive results that are shown by fifteen (15) separate tables. Various diagnostic tests like standard F test, the LM test of Breusch and Pagan (1980), the Hausman test as well as Hausman test reject some of the estimation results. Data limitations also reduce the number of reliable results. The intuitive results are appeared by segregating cross-sectional unit in the category of consistency and inconsistency. Democratic capital stock influences the level of environmental emission (Fredriksson and Neumayer (2013)). They explain this stock as an accumulation of civic and social right generated through historical experience.

The finding of this paper is that not only the level of democracy but also consistency in countries political institution is influential in defining the tipping point of that county. The results that are found in this empirical analysis may not be the solely contributed by the democracy, but the effect is inevitable.

Public awareness and environmental legislation are a product of political rights and freedom of information. Environmental interest groups can promote more awareness in the presence of democracy. The autocratic system (No democracy) censors information flows, and its decision-making process is more unilateral than that of a democratic system. Democratic governments are more responsive to the public than are non-democratic governments. Electoral accountability of representative government ensures the participation of social groups in public policy making. These are supported by this paper as it finds a lower tipping point of $45,304 for the countries

which are consistently free compared to the tipping point of ($54265) for the countries which are free at any point in time over 23 years.

At the end of the discussion, it should be acknowledged that the used models in this paper are not the only ideal one to talk about the environment-democracy nexus. Econometric model, data limitation is considerable in these settings. The used environmental emission indicator in this paper is only CO2 including the land use and forestry effect. The sub-sectoral contribution of CO2 emission to the environment, other emissions, deforestation and many other contributors are affecting the income-emission nexus. Improving towards full democracy and deviating from total freedom both have multi-dimensional effects on policy agenda, economic structure, bargaining power of social groups, and the perception and capability of countries. Some countries also are enjoying the free riding in the environmental sector. Natural disasters are not an ignorable contributor to the environment- income nexus. Considering all the above limitation that is also prevailing in much other environmental literature, the findings of this paper, political stability and consistency in a particular regime has an effect on environmental Kuznets curve, is intuitive. The results found in this empirical analysis may not be the solely contributed by the democracy, but the outcome is inevitable.

7. Robustness

We believe that the model settings, specification, and dataset are rich enough to support our results. Empirical results and discussion in section 5 and 6 confirm the robustness of our results. To address the potential remaining concern, in this section, we present further robustness checks. Table 13, 14, and 15 report results for robustness.

This paper again uses six democracy statuses as control but carry out the pooled regression. Table 13 shows that consistency in any democratic stage has some influential effect on the tipping point. The tipping points $55,293 is the same as in column 2 of Table 12. We replace GDP-PPP by GDP-USD and carry out the same regression under fixed effect mode using six democracy statuses as a control. Table 14 illustrates the results of fixed effect models, but the model specifications are as like as table 4. In this case, we also replace GDP-PPP by GDP-USD. In table 14, the differing coefficients and tipping points for each democracy status confirm the

effects of consistency. Comparing results from table 14 and 15, we can conclude that consistency in countries political institution is influential in defining the tipping point of that county. This argument is also true when we replace "C02 emission without the land and forest use" by "CO2 emission, including land and forest use" in the dependent variable. Changing the measurement of CO2 emission and GDP, this paper explores the same finding. So, it is logical to say that our results are robust.

8. Conclusion:

The transmission process of the influence of a political institution on the environment-income nexus is multi-faceted and complex. We use panel data set in 147 countries for 23 years to investigate empirically the role democracy plays in the income-pollution nexus. Our results suggest that not only the level of democracy but also the consistency in countries' political institution (whether a country maintains a steady score in freedom indicator) is influential in defining the tipping point of environmental Kuznets Curve. Public awareness and environmental legislation are a product of political rights and freedom of information. Environmental interest groups can promote more awareness in the presence of democracy. Democratic governments are more responsive to the public than are non-democratic governments. Accumulation of civic and social right generated through historical experience is important in maintaining stable and responsive environmental policy. Improving towards full democracy and deviating from full democracy both have multi-dimensional effects on policy agenda, economic structure, bargaining power of social groups, and the capability of countries. The result of this paper also is not out of methodological limitations. Considering all the above limitation that is also prevailing in much other environmental literature, the finding of this paper, political stability and consistency in a particular regime have an effect on environmental Kuznets curve, is intuitive. The tipping point is at a lower level of per capita GDP for countries with consistently full democracy compared to countries with full democracy at any point in time.

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Appendix A: Tables

Table 1: Summary Statistics

	Carbon Emission per Capita (Including Land-use Change and Forestry)	Carbon Emission per Capita (Excluding Land-use Change and Forestry)	GDP-PPP per Capita	GDP-USD per Capita	Industry-GDP Ratio	Total Population
Mean	4.36	5.25	14,129.34	9,135.56	29.30	39,100,000
Median	1.99	3.72	7,698.69	2,590.19	28.39	8,624,280
Std. Dev.	5.44	5.94	16,850.09	14,204.53	11.06	139,000,000
Minimum	0.01	-13.10	434.34	142.97	4.99	61,906
Maximum	32.87	32.39	115,747.70	86,126.26	74.11	1,350,000,000
Range	32.86	45.49	115,313.40	85,983.29	69.12	1,350,000,000
Observations	3,381	3,328	3,381	3,381	3,194	3,381
Countries	147	147	147	147	147	147

Notes: Carbon Emission per Capita is measured at metric ton unit. GDP-PPP per Capita is measured at 2011 constant price. GDP-USD per Capita is measured at 2005 constant price. Industry-GDP Ratio is measured by industrial output at USD divided by GDP-PPP (2005).

Table 2: Democracy categories and their share compared to total sample

	Number of countries	Carbon Emission 1	Carbon Emission 2	GDP-PPP	GDP-USD	population
Consistently Full Free	50	37%	32%	47%	72%	17%
Consistently Partly Free	19	3%	4%	4%	3%	5%
Consistently Not Free	17	35%	32%	21%	11%	26%
Improved	9	8%	7%	6%	3%	5%
Deteriorated	18	8%	8%	9%	4%	23%
Fluctuated	34	8%	16%	14%	7%	24%
Total sample	147	100%	100%	100%	100%	100%

Notes: Carbon Emission 1 (Including Land-Use Change and Forestry). Carbon Emission 2 (Excluding Land-Use Change and Forestry). Data compared for the year 2012.

Table 3: Effects of Industry-GDP ratio

	Model1fe	Model1re	Model1ife	Model1ire
Log GDP	2.55***	2.53***	2.31***	2.28***
	(.182)	(.179)	(.181)	(.179)
Squared Log GDP	-.112***	-.104***	-.0994***	-.0904***
	(.0104)	(.0102)	(.0103)	(.0101)
Industry-GDP	-	-	.231***	.247***
			(.0243)	(.0248)
Constant	-13.2***	-13.6***	-12.8***	-13.3***
	(.792)	(.784)	(.781)	(.773)
R-squared	0.258	-	0.279	-
Observations	3194	3194	3194	3194
Tipping point	87,898	191,657	111,270	299,725

Notes: The dependent variable is log per capita CO2 emission. Standard errors in parentheses. Data Sources: World Resource Institute, World Bank, Freedom House. Asterisks: * significant at 10% ** significant at 5% *** significant at 1%.

Table 4: Effects of democracy dummies 1

	model2fe	model2re	model2ife	model2ire
Log GDP	2.55***	2.54***	2.31***	2.28***
	(.182)	(.179)	(.181)	(.178)
Squared Log GDP	-.112***	-.105***	-.0994***	-.0923***
	(.0104)	(.0102)	(.0103)	(.0101)
Industry-GDP	-	-	.231***	.251***
			(.0243)	(.0247)
Con. Full Free	0	.481***	0	.572***
	(.)	(.177)	(.)	(.174)
Con. Partly Free	0	-.116	0	-.0353
	(.)	(.206)	(.)	(.202)
Improved	0	.677***	0	.675***
	(.)	(.255)	(.)	(.25)
Deteriorated	0	-.536**	0	-.469**
	(.)	(.211)	(.)	(.207)
Fluctuated	0	-.233	0	-.198
	(.)	(.185)	(.)	(.181)
Constant	-13.2***	-13.6***	-12.8***	-13.3***
	(.792)	(.787)	(.781)	(.776)
R-squared	0.258	-	0.279	-
Observations	3194	3194	3194	3194
Tipping points	87,898	179,017	111,270	199,899

Notes: The dependent variable is log per capita CO2 emission. Standard errors in parentheses. Data Sources: World Resource Institute, World Bank, Freedom House. Asterisks: * significant at 10% ** significant at 5% *** significant at 1%.

Table 5: Effects of democracy dummies 2

	model3p	model3clu	model2ife	model2ire
Log GDP	3.14***	3.14***	2.31***	2.28***
	(.139)	(.483)	(.181)	(.178)
Squared Log GDP	-.112***	-.112***	-.0994***	-.0923***
	(.00778)	(.0274)	(.0103)	(.0101)
Industry-GDP	.464***	.464***	.231***	.251***
	(.0354)	(.141)	(.0243)	(.0247)
Con. Full Free	.144***	.144	0	.572***
	(.0434)	(.225)	(.)	(.174)
Con. Partly Free	.125***	.125	0	-.0353
	(.0466)	(.265)	(.)	(.202)
Improved	.584***	.584	0	.675***
	(.0565)	(.361)	(.)	(.25)
Deteriorated	-.0129	-.0129	0	-.469**
	(.0465)	(.259)	(.)	(.207)
Fluctuated	.0426	.0426	0	-.198
	(.0413)	(.237)	(.)	(.181)
Constant	-20***	-20***	-12.8***	-13.3***
	(.585)	(2.11)	(.781)	(.776)
R-squared	0.857	0.857	0.279	-
Observations	3194	3194	3194	3194
Tipping point	1,224,272	1,224,272	111,270	199,899

Notes: The dependent variable is log per capita CO2 emission. Standard errors in parentheses. Data Sources: World Resource Institute, World Bank, Freedom House. Asterisks: * significant at 10% ** significant at 5% *** significant at 1%.

Table 6: Effects of continuous democracy varaible1

	model4fe	model4fe1	model4fe2	model4fe3
Log GDP	2.28***	3.95***	1.06***	2.28***
	(.182)	(.339)	(.342)	(.453)
Squared Log GDP	-.098***	-.182***	-.0238	-.102***
	(.0104)	(.0178)	(.0203)	(.0267)
Log Industry-GDP	.233***	.289***	.257***	.252***
	(.0243)	(.0342)	(.041)	(.06)
Total Freedom Index	.00597*	.00498	-.00061	-.0287**
	(.00333)	(.00692)	(.0054)	(.0133)
Constant	-12.7***	-20.7***	-8.2***	-12.6***
	(.783)	(1.58)	(1.42)	(1.91)
R-squared	0.280	0.308	0.290	0.274
Observations	3194	1359	1132	703
Tipping point	112,719	51,619	4,690,980,986	71,430

Notes: The dependent variable is log per capita CO2 emission. Standard errors in parentheses. Data Sources: World Resource Institute, World Bank, Freedom House. Asterisks: * significant at 10% ** significant at 5% *** significant at 1%.

Table 7: Effects of continuous democracy varaible2

	model5re	model5re1	model5re2	model5re3
Log GDP	2.25***	4.53***	1.23***	2.18***
	(.179)	(.305)	(.337)	(.422)
Squared Log GDP	-.0892***	-.207***	-.0273	-.0845***
	(.0102)	(.0162)	(.02)	(.0247)
Log Industry-GDP	.25***	.299***	.282***	.281***
	(.0249)	(.0345)	(.0416)	(.0622)
Total Freedom Index	.00563*	.00368	-.00197	-.0369***
	(.00336)	(.00704)	(.00552)	(.0136)
Constant	-13.2***	-24.1***	-9.31***	-13.1***
	(.775)	(1.4)	(1.4)	(1.78)
R-squared	-	-	-	-
Observations	3194	1359	1132	703
Tipping point	300,171	56,502	6,075,150,062	400,075

Notes: The dependent variable is log per capita CO2 emission. Standard errors in parentheses. Data Sources: World Resource Institute, World Bank, Freedom House. Asterisks: * significant at 10% ** significant at 5% *** significant at 1%.

Table 8: Effects of continuous democracy variable

	model6p	model6clu	model4fe	model5re
Log GDP	3.45***	2.25***	2.28***	2.25***
	(.137)	(.543)	(.182)	(.179)
Squared Log GDP	-.128***	-.0892***	-.098***	-.0892***
	(.00763)	(.0305)	(.0104)	(.0102)
Log Industry-GDP	.447***	.25**	.233***	.25***
	(.035)	(.0971)	(.0243)	(.0249)
Total Freedom Index	-.00665*	.00563	.00597*	.00563*
	(.00366)	(.00905)	(.00333)	(.00336)
Constant	-21.3***	-13.2***	-12.7***	-13.2***
	(.577)	(2.37)	(.783)	(.775)
R-squared	0.851	-	0.280	-
Observations	3194	3194	3194	3194
Tipping point	712,519	300,171	112,719	300,171

Notes: The dependent variable is log per capita CO2 emission. Standard errors in parentheses. Data Sources: World Resource Institute, World Bank, Freedom House. Asterisks: * significant at 10% ** significant at 5% *** significant at 1%.

Table 9: Effects of different level of democracy(conditional)1

	model1ife	model1iffe1	model1iffe2	model1iffe3
Log GDP	2.31***	3.99***	1.06***	2.15***
	(.181)	(.335)	(.341)	(.45)
Squared Log GDP	-.0994***	-.183***	-.0238	-.0944***
	(.0103)	(.0176)	(.0203)	(.0265)
Log Industry-GDP	.231***	.287***	.257***	.25***
	(.0243)	(.0341)	(.0409)	(.0602)
Constant	-12.8***	-20.9***	-8.2***	-12***
	(.781)	(1.57)	(1.42)	(1.9)
R-squared	0.279	0.307	0.290	0.268
Observations	3194	1359	1132	703
Tipping point	111,270	54,265	4,690,980,986	88,231

Notes: The dependent variable is log per capita CO2 emission. Standard errors in parentheses. Data Sources: World Resource Institute, World Bank, Freedom House. Asterisks: * significant at 10% ** significant at 5% *** significant at 1%.

Table 10: Effects of different level of democracy(conditional)2

	model1ire	model1ifre1	model1ifre2	model1ifre3
Log GDP	2.28***	4.55***	1.23***	2.04***
	(.179)	(.303)	(.337)	(.42)
Squared Log GDP	-.0904***	-.208***	-.0273	-.0765***
	(.0101)	(.0161)	(.02)	(.0246)
Log Industry-GDP	.247***	.298***	.283***	.281***
	(.0248)	(.0344)	(.0415)	(.0626)
Constant	-13.3***	-24.2***	-9.32***	-12.6***
	(.773)	(1.39)	(1.4)	(1.78)
R-squared				
Observations	3194	1359	1132	703
Tipping point	299,725	56,247	6,075,150,062	617,438

Notes: The dependent variable is log per capita CO2 emission. Standard errors in parentheses. Data Sources: World Resource Institute, World Bank, Freedom House. Asterisks: * significant at 10% ** significant at 5% *** significant at 1%.

Table 11: Effects of different level of democracy(6 categories)1

	model9frfe	model9prfe	model9noffe	model9detfe	model9impfe	model9flucfe
Log GDP	4.46***	.562	.81	2.38**	1.17***	3.06***
	(.449)	(.665)	(.534)	(.949)	(.419)	(.45)
Squared Log GDP	-.208***	-.00313	.00193	-.117**	-.0205	-.148***
	(.0233)	(.0383)	(.0325)	(.0527)	(.0256)	(.0262)
Log Industry-GDP	.307***	.485***	.501***	.594***	.0337	-.055
	(.042)	(.0741)	(.0646)	(.169)	(.06)	(.0462)
Constant	-23***	-5.95**	-8.74***	-12.8***	-8.89***	-15.1***
	(2.12)	(2.85)	(2.16)	(4.31)	(1.7)	(1.92)
R-squared	0.257	0.270	0.550	0.200	0.384	0.201
Observations	1031	444	340	201	413	765
Tipping point	45,304	-	-	26,133	-	30,879

Notes: The dependent variable is log per capita CO2 emission. Standard errors in parentheses. Data Sources: World Resource Institute, World Bank, Freedom House. Asterisks: * significant at 10% ** significant at 5% *** significant at 1%.

Table 12: Effects of different level of democracy(6 categories)2

	model9frre	model9prre	model9nofre	model9detre	model9impre	model9flucre
Log GDP	4.39***	.589	.712	2.35**	1.3***	3.13***
	(.424)	(.645)	(.473)	(.949)	(.425)	(.45)
Squared Log GDP	-.201***	-.00243	.0104	-.114**	-.0207	-.141***
	(.0222)	(.0371)	(.0282)	(.0527)	(.026)	(.0263)
Log Industry-GDP	.333***	.511***	.532***	.555***	.0353	-.0536
	(.042)	(.0739)	(.0654)	(.17)	(.0616)	(.0484)
Constant	-23.2***	-6.33**	-8.65***	-12.6***	-9.89***	-16.1***
	(1.99)	(2.77)	(1.96)	(4.31)	(1.73)	(1.92)
R-squared	-	-	-	-	-	-
Observations	1031	444	340	201	413	765
Tipping point	55,293	-	-	29,942	-	66,124

Notes: The dependent variable is log per capita CO2 emission. Standard errors in parentheses. Data Sources: World Resource Institute, World Bank, Freedom House. Asterisks: * significant at 10% ** significant at 5% *** significant at 1%.

Table 13: Effects of different level of democracy (Robustness1)

	rpmodel9frfe	rpmodel9prfe	rpmodel9noffe	rpmodel9detfe	rpmodel9impfe	rpmodel9flucfe
Log GDP	4.39***	2.12***	4.78***	-6.08***	.426	1.19***
	(.424)	(.569)	(.396)	(1.66)	(.5)	(.348)
Squared Log GDP	-.201***	-.0686**	-.214***	.408***	.0645**	.00809
	(.0222)	(.0311)	(.0215)	(.0952)	(.0306)	(.0206)
Log Industry-GDP	.333***	.872***	1.56***	-1.35***	.403***	.404***
	(.042)	(.127)	(.0972)	(.25)	(.104)	(.0629)
Constant	-23.2***	-15.7***	-30.2***	27.6***	-9.66***	-12***
	(1.99)	(2.37)	(1.73)	(7.13)	(1.89)	(1.42)
R-squared		0.721	0.893	0.456	0.907	0.855
Observations	1031	444	340	201	413	765
Tipping point	55,293	5,136,565	70,843	1,722	-	-

Notes: The dependent variable is log per capita CO2 emission. Standard errors in parentheses. Data Sources: World Resource Institute, World Bank, Freedom House. Asterisks: * significant at 10% ** significant at 5% *** significant at 1%.

Table 14: Effects of continuous democracy variable (Robustness 2)

	rmodel4fe	rmodel4fe1	rmodel4fe2	rmodel4fe3
Log GDP (USD)	1.55***	2.14***	1.1***	1.74***
	-0.124	-0.212	-0.261	-0.363
Squared Log GDP(USD)	-.0647***	-.0937***	-.0303*	-.083***
	-0.00803	-0.012	-0.0181	-0.0254
Log Industry-GDP	.229***	.301***	.255***	.234***
	-0.0246	-0.0349	-0.0409	-0.0601
Total Freedom Index	.00689**	0.00751	-0.000362	-.0288**
	-0.00334	-0.00702	-0.00539	-0.0134
Constant	-8.42***	-11.3***	-7.3***	-8.65***
	-0.458	-0.909	-0.929	-1.26
R-squared	0.274	0.285	0.291	0.269
Observations	3194	1359	1132	703
Tipping point	159,271	91,074	-	35,665

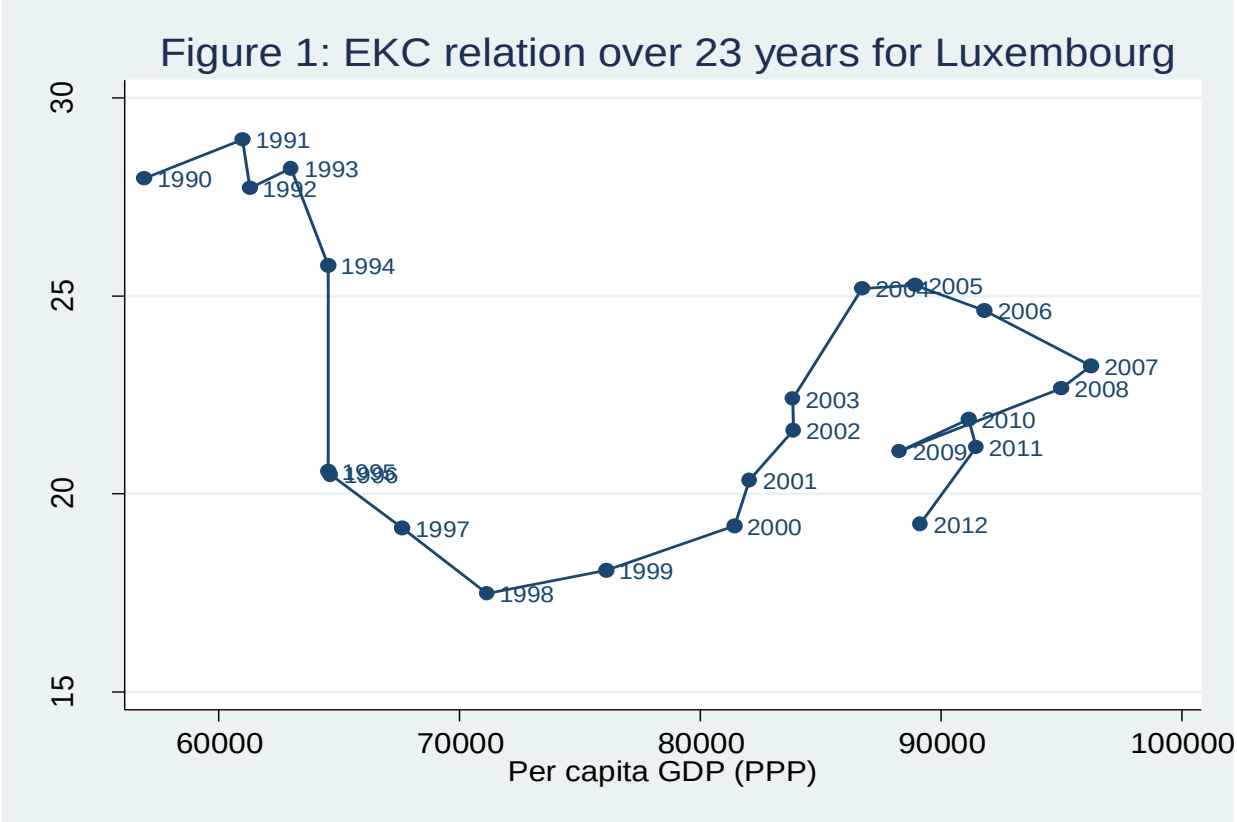
Notes: The dependent variable is log per capita CO2 emission. GDP calculated at USD and in 2005 constant price. Standard errors in parentheses. Data Sources: World Resource Institute, World Bank, Freedom House. Asterisks: * significant at 10% ** significant at 5% *** significant at 1%.

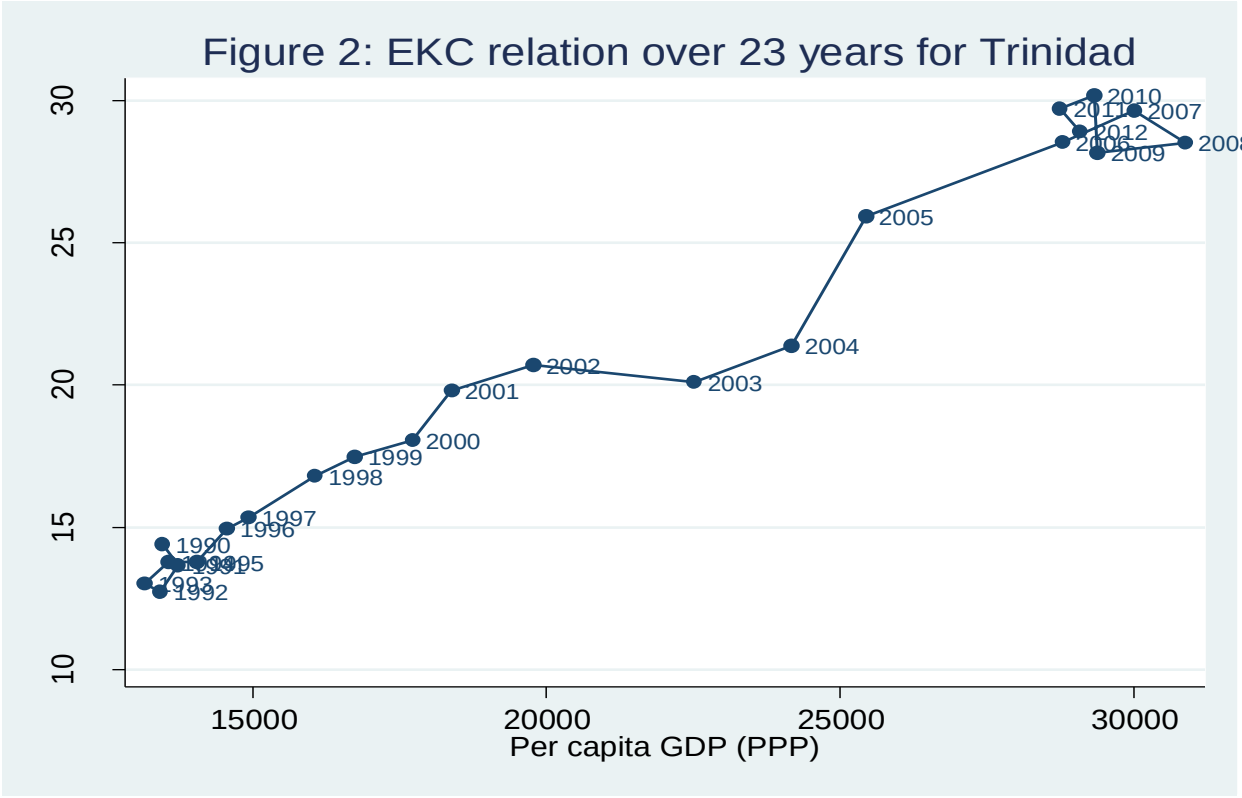
Table 15: Effects of different level of democracy (Robustness 3)

	rmodel9frfe	rmodel9prfe	rmodel9noffe	rmodel9detfe	rmodel9impfe	rmodel9flucfe
Log GDP (USD)	2.32***	.748	1.19***	1.44**	.957***	1.47***
	(.282)	(.487)	(.406)	(.718)	(.335)	(.318)
Squared Log GDP(USD)	-.104***	-.016	-.0252	-.0757	-.00838	-.0648***
	(.0156)	(.0322)	(.0295)	(.047)	(.0237)	(.0218)
Log Industry-GDP	.337***	.481***	.5***	.57***	.0339	-.0584
	(.0425)	(.074)	(.0645)	(.17)	(.0602)	(.0469)
Constant	-12.1***	-6.03***	-8.88***	-7.33***	-7.03***	-7.09***
	(1.24)	(1.81)	(1.35)	(2.75)	(1.17)	(1.15)
R-squared	0.231	0.270	0.551	0.191	0.383	0.176
Observations	1031	444	340	201	413	765
Tipping point	69,832	14,178,605,351	17,954,580,693	13,511	-	84,338

Notes: The dependent variable is log per capita CO2 emission. Standard errors in parentheses. Data Sources: World Resource Institute, World Bank, Freedom House. Asterisks: * significant at 10% ** significant at 5% *** significant at 1%.

Appendix B: Graphs





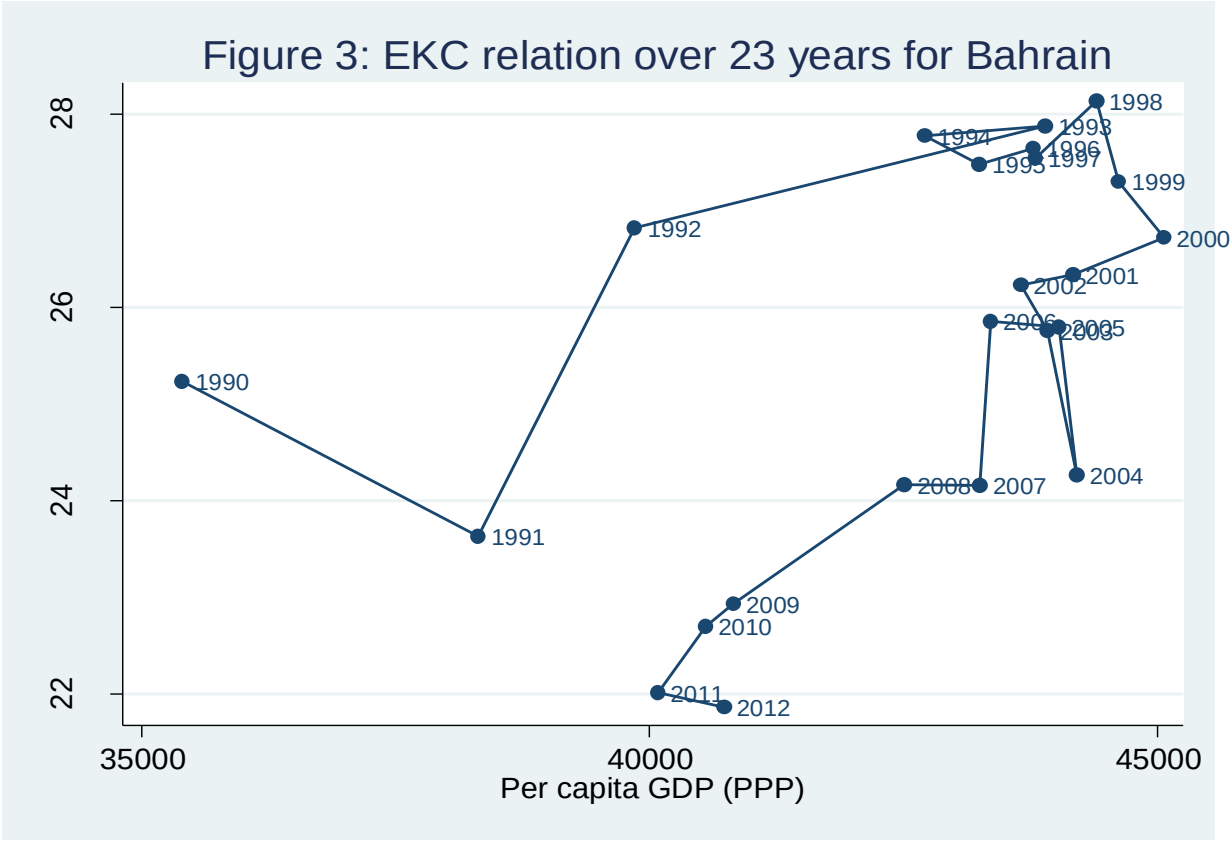


Figure 3: EKC relation over 23 years for Bahrain
28
26
24
22
1998
1994
1993
1996
1995
1997
1999
1992
2000
2001
2002
2006
2005
2003
1990
2004
2008
2007
1991
2009
2010
2011
2012
35000
40000
45000
Per capita GDP (PPP)

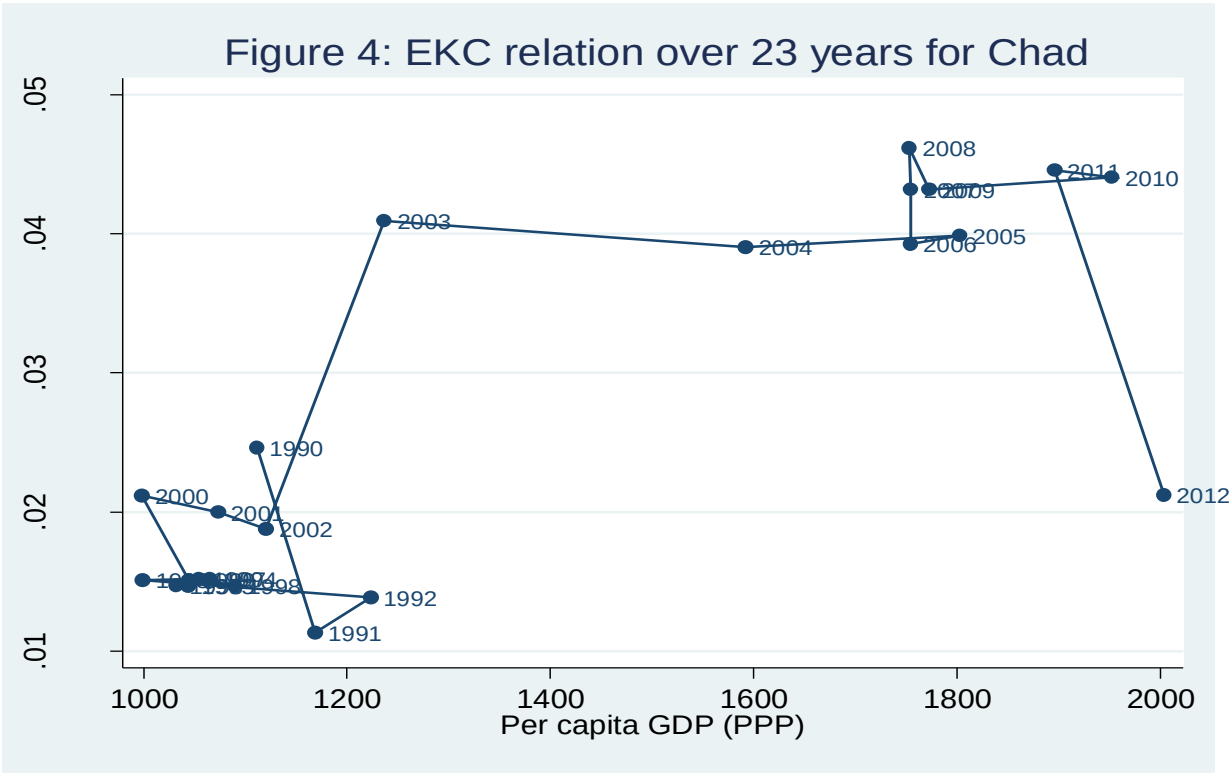


Figure 4: EKC relation over 23 years for Chad
.05
.04
.03
.02
.01
2008
2011
2010
2003
2004
2005
2006
1990
2012
2000
2001
2002
1992
1991
1000
1200
1400
1600
1800
2000
Per capita GDP (PPP)

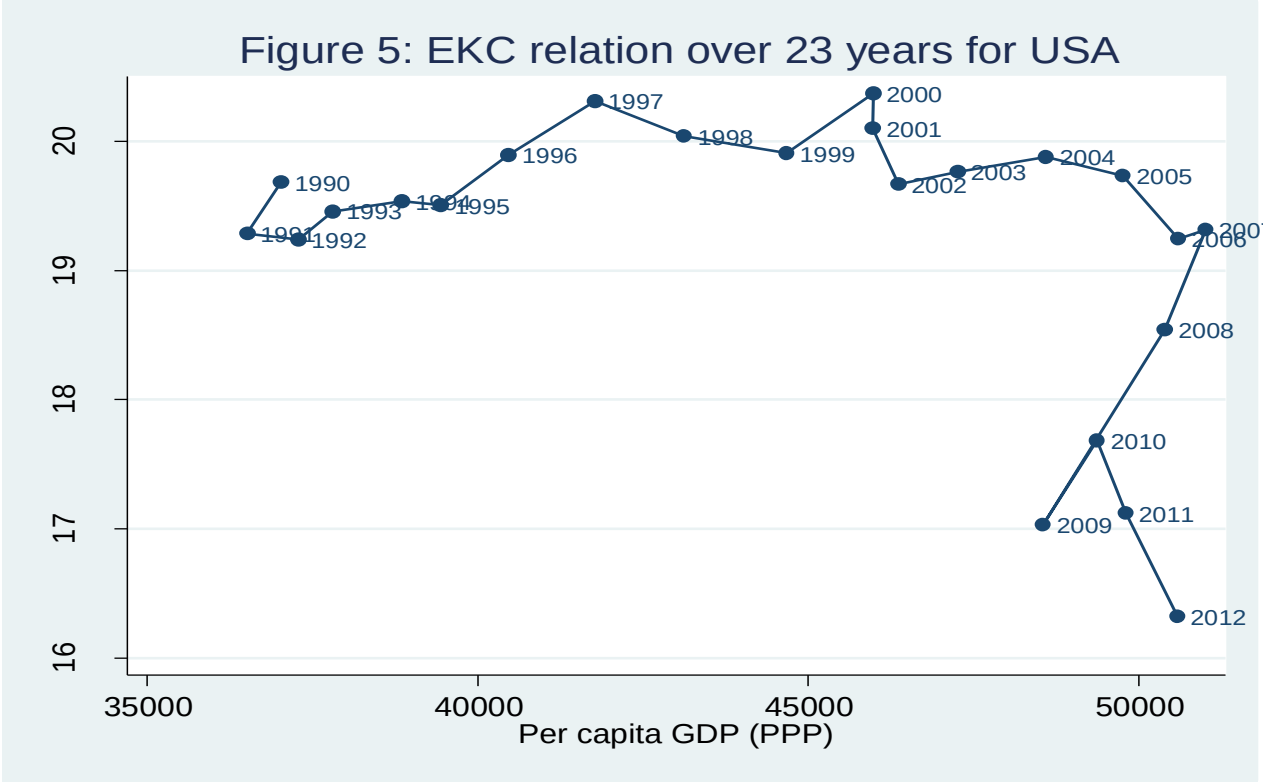


Figure 5: EKC relation over 23 years for USA
20
19
18
17
16
35000
40000
45000
50000
Per capita GDP (PPP)
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

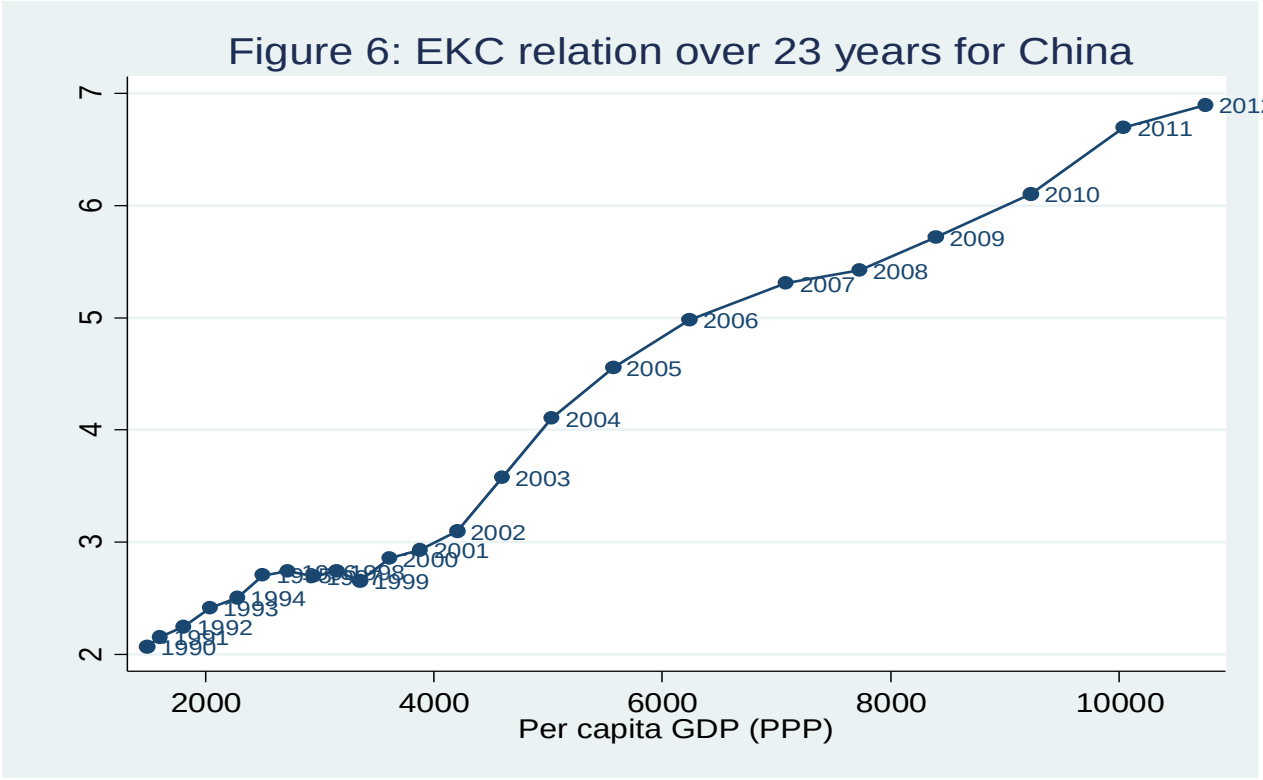


Figure 6: EKC relation over 23 years for China
7
6
5
4
3
2
2000
4000
6000
8000
10000
Per capita GDP (PPP)
1990
1991
1992
1993
1994
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

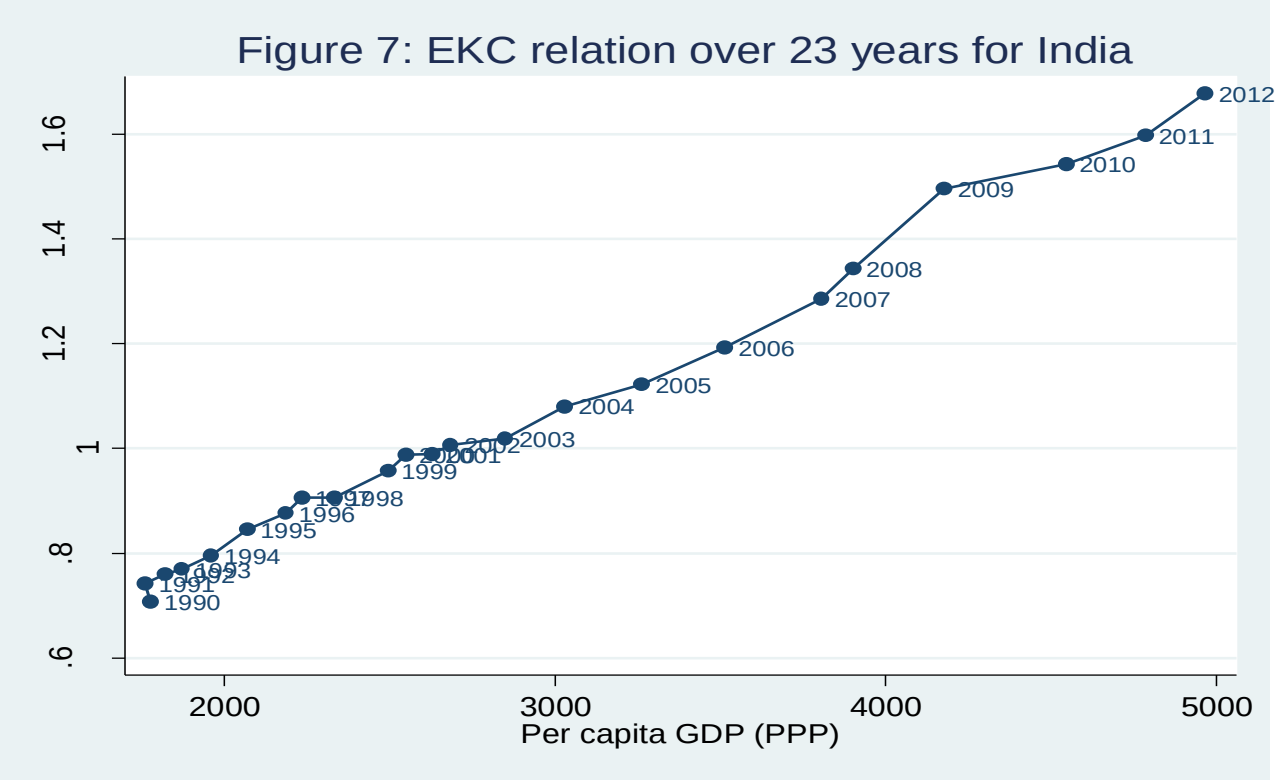


Figure 7: EKC relation over 23 years for India
.6
.8
1
1.2
1.4
1.6
2000
3000
4000
5000
Per capita GDP (PPP)
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002
2001
1999
1998
1996
1995
1994
1991
1990

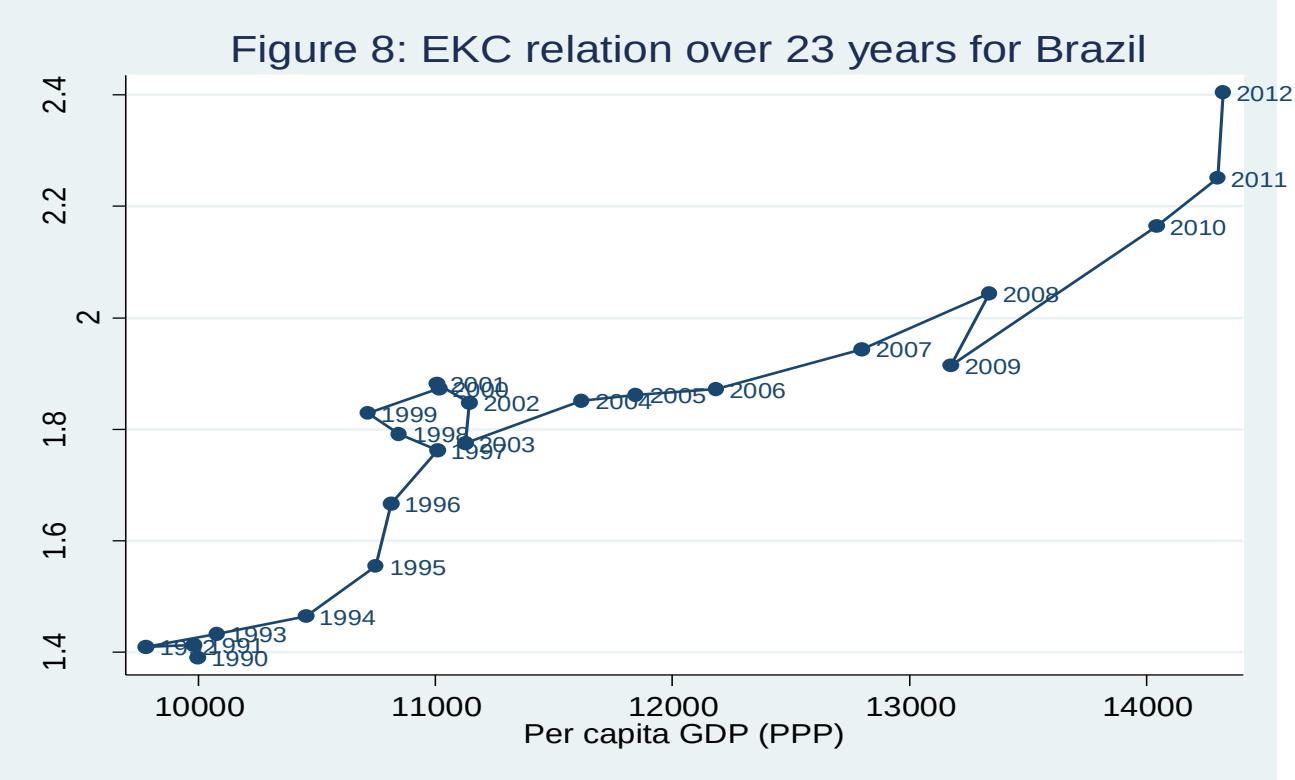


Figure 8: EKC relation over 23 years for Brazil
1.4
1.6
1.8
2
2.2
2.4
10000
11000
12000
13000
14000
Per capita GDP (PPP)
2012
2011
2010
2008
2007
2009
2006
2005
2004
2002
2001
1999
1998
1997
1996
1995
1994
1993
1991
1990

Figure 9: EKC of inconsistently full free countries in FE model

Figure 10: EKC of inconsistently full free countries in RE model

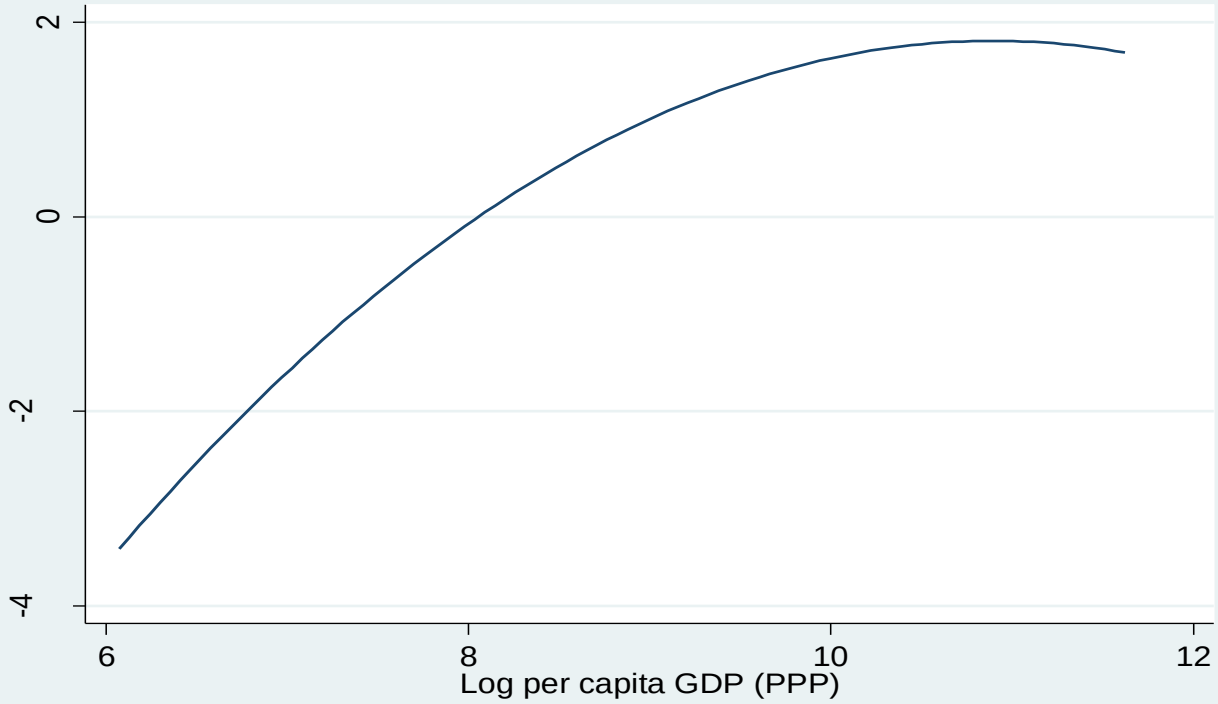


Figure 11: EKC of consistently full free countries in FE model

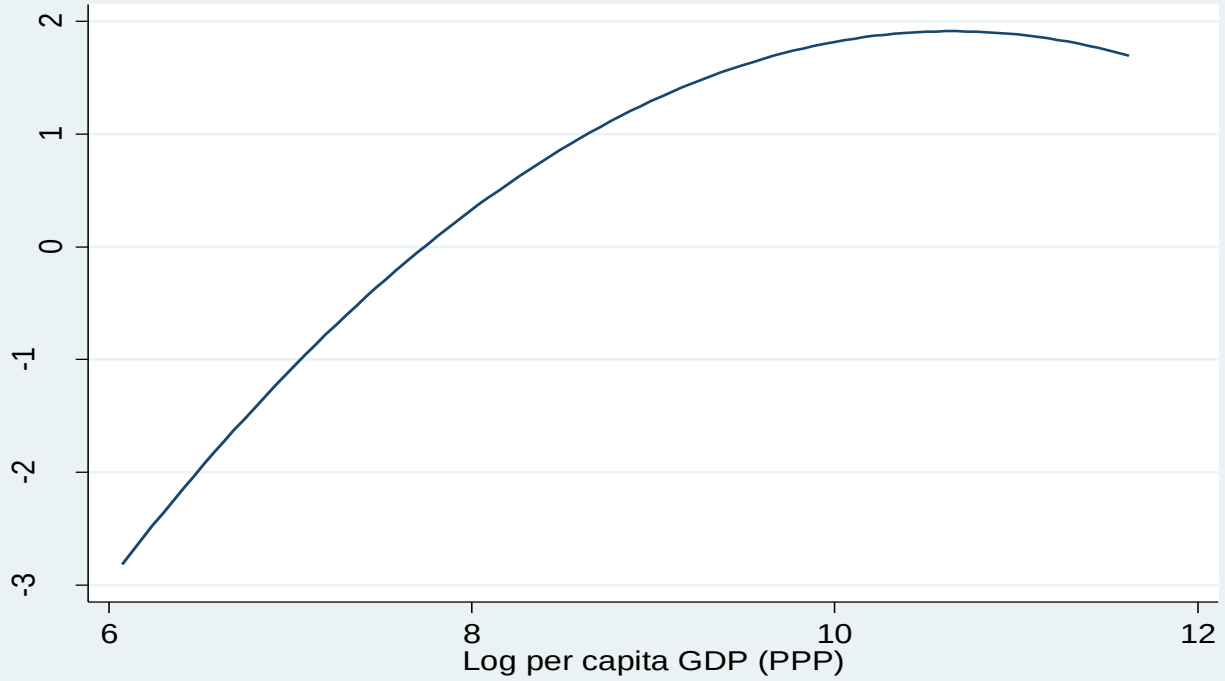
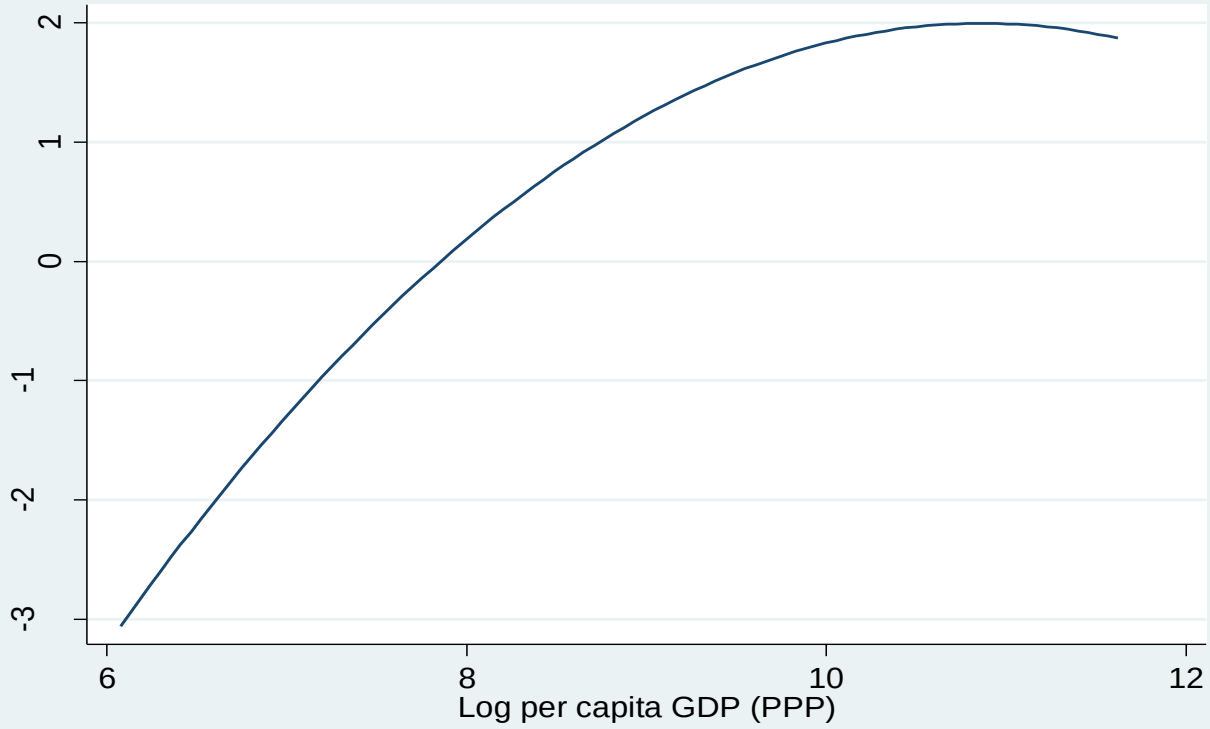


Figure 12: EKC of consistently full free countries in RE model



Appendix C: Country List

Total number of countries 147

List of Consistently full free countries (50)

Australia, Austria, Bahamas, Belgium, Belize, Benin, Botswana, Bulgaria, Canada, Cape Verde, Chile, Costa Rica, Cyprus, Denmark, Dominica, Finland, France, Germany, Greece, Grenada, Hungary, Iceland, Ireland, Italy, Japan, Kiribati, Latvia, Lithuania, Luxembourg, Malta, Mauritius, Mongolia, Namibia, Netherlands, New Zealand, Norway, Poland, Portugal, Saint Lucia, Solomon Islands, South Korea, Spain, Sweden, Switzerland, United Kingdom, United States, Uruguay, Vanuatu.

List of Consistently partly free countries (19)

Albania, Armenia, Colombia, Comoros, Fiji, Georgia, Guatemala, Macedonia, Madagascar, Malaysia, Moldova, Morocco, Nicaragua, Paraguay, Singapore, Sri Lanka, Tonga, Turkey, Ukraine,

List of Consistently not free countries (17)

Angola, Brunei, Cameroon, Chad, China, Cuba, Iran, Laos, Oman, Rwanda, Saudi Arabia, Sudan, Tajikistan, Turkmenistan, United Arab Emirates, Vietnam.

List of improved countries (9)

Algeria, Belarus, Egypt, Jordan, Kazakhstan, Russia, Swaziland, Uzbekistan, Zimbabwe.

List of deteriorated countries (18)

Burkina Faso, Burundi, Central African Republic, El Salvador, Ghana, Guyana, India, Kenya, Lesotho, Mali, Mozambique, Niger, Panama, Peru, Romania, Seychelles, South Africa, Suriname.

List of fluctuated countries (34)

Antigua & Barbuda, Azerbaijan, Bahrain, Bangladesh, Bhutan, Bolivia, Brazil, Cote d'Ivoire, Djibouti, Dominican Republic, Ecuador, Guinea, Honduras, Indonesia, Kyrgyzstan, Lebanon, Malawi, Mauritania, Mexico, Nepal, Nigeria, Pakistan, Papua New Guinea, Philippines, Senegal, Sierra Leone, Tanzania, Thailand, Togo, Trinidad & Tobago, Tunisia, Uganda, Venezuela, Yemen, Zambia