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DO DEMOCRATIC GOVERNMENTS IMPROVE ENVIRONMENTAL QUALITY?

By

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Thesis

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Do democratic governments improve environmental quality?

Chairperson: Katrina L. Mullan

My research question is whether democratic countries improve the environment. This research question is important because many nowadays people are more than ever concerned about environmental quality, and researchers have produced mixed results of democratic governments' effects on the environment. As an attempt to contribute to this area of research, I implement three different types of heterogeneity in the relationships between democratic countries and environmental quality. These three different types of heterogeneity include different environmental outcomes, separate components of democracy, and countries with different income levels. By using these three different types of heterogeneity, I may better understand the mechanisms through which democratic countries affect the environment.

Although previous studies using countries around the world report that democratic governments usually improve environmental quality, I find that democratic countries have an insignificant effect on the environment when I include 145 countries at the same time. However, I find that democratic governments sometimes have effects (usually positive) on environmental quality when I implement the three different types of heterogeneity into my analyses.

When different environmental outcomes are considered, democratic countries reduce or have an insignificant effect on carbon reductions, increase or have an insignificant effect on protected areas. When individual components of democracy are considered, executive constraints are found to be the most informative component of democracy. Finally, when the countries with different income groups are considered, democracy in low-income countries reduces carbon emissions, and in high-income countries reduces carbon emissions and increases the size of protected areas.

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1. Introduction

Do democratic governments improve environmental quality? Al Gore, the 2007 Nobel Peace Prize winner, said that “an essential prerequisite for saving the environment is the spread of democratic government to more nations of the world.”¹ The spread of democracy may be important because democratic governments may affect good environment.

Although democratic countries may affect environmental quality, research addressing this topic has produced mixed results: some researchers find that political institutions improve², worsen³, or have no effect on the environment.⁴ These mixed results exhibited in the literature could be attributable to a number of factors: different estimation methods or control variables; different environmental outcomes; or alternatively, it may be that different components of democracy have different impacts or that the relationship differs in countries with different characteristics (e.g., income levels). I contribute to this existing body of literature by using different types of environmental quality, different component variables constituting democracy, and countries with different income groups to understand the potential heterogeneity in the relationship between institutions and the environment.

What are political institutions? The Nobel prize-winning institutional economist Douglass North (1990, 3) states that “institutions are the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction.” Although institutions are usually categorized into two types, formal and informal, I consider political institutions as belonging to formal institutions.

¹ (Gore 1992, 179).

² (Barrett and Graddy 2000; Congleton 1992; Fredriksson and Neumayer 2013; Gallagher and Thacker 2008; Hosseini and Kaneko 2013; Li and Reuveny 2006; Mak and Lew 2011; Midlarsky 1998; Neumayer 2002; Pellegrini and Gerlagh 2006; Yoon 2014).

³ (Barrett and Graddy 2000; Congleton 1992; Hosseini and Kaneko 2013; Mak and Lew 2011; Midlarsky 1998).

⁴ Most of the papers supporting that democratic countries improve or worsen environmental quality report at least one or more insignificant results associated with democratic governments, but emphasize the directions if they seem to be relatively consistent.

While various factors introduced in the previous paragraph might account for the mixed results, institutions, the key explanatory variable of this paper, have been mostly represented by variables from the Polity IV Project dataset by the Center for Systematic Peace. The Polity IV Project scores the authority characteristics of states in the world. The Polity IV Project: Dataset Users' Manual states that the Polity IV dataset is "the most widely used resource for monitoring regime change and studying the effects of regime authority." Using measures from this widely-used dataset, I hope to understand the relationships between political institutions and environmental quality.

To understand the relationships between institutions and the environment, I treat democracy and autocracy as separate political institutions. Treating democracy and autocracy separately rather than as opposite ends of the same spectrum will give me new information. The structure of democracy can be represented by a separation of power among a large number of people whereas that of autocracy can be represented by a separation of power among a small number of people.

Although some researchers have already incorporated autocracy in their analyses (Li and Reuveny 2006; Neumayer 2002), most studies have excluded explicit effects of autocracy on environmental quality. Therefore, I examine two very different political structures to understand the relationships between political institutions and the environment.

As part of separating political institutions into democracy and autocracy, I offer a fresh perspective by incorporating three different types of composite indicators: *revised combined Polity score*, *institutionalized democracy*, and *institutionalized autocracy*. The first two represent democracy and the last one represents autocracy. Using these three composite indicators helps discover the mechanisms through which institutions affect environmental quality by identifying which aspects of political institutions are important. These composite indicators are named and managed through the Polity IV Project (Polity IV 2012).

I differentiate this paper from the earlier studies by incorporating separate components of democracy in assessing the relationships between institutions and environmental quality. I implement four different component variables: *competitiveness of executive recruitment*, *openness of executive recruitment*, *executive constraints*, and *competitiveness of political participation*.

A country receives the highest score for *competitiveness of executive recruitment* if the country's chief executive such as a council, a cabinet, a king, a premier and a president is selected by a competitive election involving two or more parties. A country receives the highest score for *openness of executive recruitment* if the country's chief executive is selected by (1) a competitive election involving two or more parties, (2) an elite designation, or (3) a pre-arrangement between a competitive election and an elite designation. A country receives the highest score for *executive constraints* if the country's accountability group such as legislatures, a ruling party, or a council of nobles has more or equal power than a country's chief executive. A country receives the highest score for *competitiveness of political participation* if the country's ruling party competitively or voluntarily shifts the central power to a competing party. These variables form *institutionalized democracy* which is one of the aforementioned three composite indicators. Using these four component variables in addition to *institutionalized democracy* helps understand the sources of potential heterogeneity between political institutions and environmental quality by identifying which aspects of democracy are important.

I also use three different measures of environmental outcomes. The environment is very important because it can be directly related to people's health, and the good environment may reflect how educated or wealthy a country is. The more numbers of media attention to environmental quality issues have made people more concerned than ever. Furthermore, more people are conscious about environmental issues through easier access to knowledge

accumulated by researchers. Although environmental quality can be measured in many ways, I incorporate environmental outcomes corresponding to global air pollutants, land quality and natural resources, and sustainable development policies. These environmental quality features are driven by different processes, so institutions may affect them differently. Using these comprehensive environmental outcomes, I hope to understand the relationships between political institutions and the environment.

Finally, I extend previous work in this field by analyzing the relationships between institutions and environmental quality for countries with different income levels. Assessing the effects of political institutions on the environment for countries with different income groups is important because even countries with better institutions may engage in activities degrading environmental quality if doing so is likely to make them richer. A *New York Times* columnist, Gardiner Harris (2014), writes about the Indian government's unwillingness to improve the environment, even when its citizens' health suffers:

‘Suffering widespread respiratory and skin disorders, residents accuse the government of allowing fires to burn and allowing pollution to poison them as a way of pushing people off land needed for India’s coal rush. “The government wants more coal, but they are throwing their own people away to get it,” said Ashok Agarwal of the Save Jharia Coal Field Committee, a citizens’ group.’

What is so ironic about this current event is that democratic countries may not lead to improved environmental quality for a poor country where economic growth is a higher priority. The Indian government rates as highly democratic, with an average *institutionalized democracy* score of $\approx +8.79$ from 1992 to 2010 on a scale of 0 (just democratic) to +10 (strongly democratic). This example suggests that the impacts of political institutions on the environment may differ for countries with different levels of income. Therefore, using countries with different income groups helps discover the mechanisms through which institutions affect environmental quality.

I contribute to the existing body of literature by using various measures of environmental quality, component variables constituting democracy, and countries with different income groups in understanding the relationships between political institutions and the environment. Few studies researched the relationships between institutions and environmental quality in this detail. These detailed analyses will help understand the relationships between political institutions and the environment. This paper is organized as follows: Section 2 reviews previous studies and provides several research hypotheses, Section 3 describes the data, Section 4 addresses estimation methodologies, Section 5 describes the results, Section 6 discusses the results, and finally Section 7 concludes.

2. Literature review and research hypotheses

Recent studies in environmental economics often focus on factors that may have determinant effects on environmental quality. One of these factors is considered to be a country's level of democracy and this factor is investigated in this paper.

Early studies used cross-sectional data and found that democratic governments often improve the environment. More recent papers use panel data due to the advancement of technology, the increase in collection of data for economic and political analyses, and the increase in awareness of environmental quality.

Panel data have advantages over cross-sectional data in having the option to control for time-invariant country characteristics that may be correlated with both political institutions and the environment. Furthermore, panel data also have an advantage in providing a greater number of observations. Studies using panel data find that democratic countries usually improve environmental quality, even though the results of these papers are not fully consistent with one another.⁵

⁵ (Barrett and Graddy 2000; Congleton 1992; Fredriksson and Neumayer 2013; Gallagher and Thacker 2008; Hosseini and Kaneko 2013; Li and Reuveny 2006; Midlarsky 1998; Neumayer 2002; Yoon 2014).

Existing literature suggests four key mechanisms through which democratic governments may produce better or worse environment than autocratic governments: (1) democratic governments aim to satisfy the majority while autocratic governments aim to satisfy the elites, and these populations may have different preferences⁶; (2) democratic governments are less likely to effectively enact policies than autocratic governments⁷; and (3) democratic governments are more likely to participate in global environmental treaties than autocratic governments.⁸ I will introduce these mechanisms in the order as they appear above. Furthermore, I will provide some possible hypotheses at the end of each mechanism. The discussion section of this paper will assess whether these hypotheses hold. Table 1 shows the three mechanisms and the four corresponding hypotheses.

The first mechanism proposed in the existing literature is that democratic governments aim to satisfy the majority while autocratic governments aim to satisfy the elites, and these populations may have different preferences. In other words, democratic governments act in the interests of the majority and autocratic governments in the interests of the elites. In democracy, a government must act in the interests of majority because there is a large winning coalition (De Mesquita et al. 1999). Although democratic countries act in the interests of the majority, autocratic countries, an institution that is opposite to democracy for this paper, act in the interests of the elites. The elites in autocracy may not like environmental regulation if it lowers production and consumption because this reduces the elite's benefits (Congleton 1992). In contrast, under democracy, a greater number of people in both the

⁶ (Barrett and Graddy 2000; Congleton 1992; De Mesquita et al. 1999; Grossman and Krueger 1995; Hosseini and Kaneko 2013; Kotov and Nikitina 1995; Li and Reuveny 2006; Mak and Lew 2011; Midlarsky 1998; Neumayer 2002; Payne 1995; Schultz and Crockett 1990).

⁷ (Gallagher and Thacker 2008; Hardin 1968; Li and Reuveny 2006; Mak and Lew 2011; Pellegrini and Gerlagh 2006; Yoon 2014).

⁸ (Barrett and Graddy 2000; Congleton 1992; Hosseini and Kaneko 2013; Li and Reuveny 2006; Mak and Lew 2011; Payne 1995).

winning coalition and the electorate may be concerned if only a few people receive benefits from looser environmental regulations (Congleton 1992).

Since the preferences of the majority are prioritized in a democracy to a greater degree than in an autocracy, an environmental regulation benefitting many people while hurting only a few is more likely to be enacted. For example, Li and Reuveny (2006), and Midlarsky (1998) find that democratic countries improve land quality and natural resources. Since democratic governments value the preferences of majority over minority, democratic countries have the potential to improve land quality and natural resources benefitting the majority. For the same reasons, Barrett and Graddy (2000), Li and Reuveny (2006), and Mak and Lew (2011) find that democratic governments improve water quality.

Conversely, autocratic countries may worsen environmental quality if its leaders receive fewer benefits from having environmental regulations. Li and Reuveny (2006) find that autocratic countries worsen water quality by increasing the ratio of organic pollution levels in water to the amount of internal renewable water resources. These researchers also find that autocratic governments worsen land quality and natural resources by decreasing the percentage share of the forested area within the total land area; increasing average annual deforestation rates per decade; and increasing the share of severely and very severely degraded land out of the total land area. Furthermore, Neumayer (2002) finds that less democratic countries worsen land quality and natural resources by decreasing the percentage of land area under protection. Autocratic governments may worsen environmental quality since the chance of enacting an environmental regulation, if it reduces benefits received by autocratic leaders, is very low.

A caveat to this argument is that since democratic countries act in the interests of the majority, democratic governments may refrain from improving the environment if the majority of voters lose economically from certain environmental policies (Hosseini and

Kaneko 2013). Midlarsky (1998) finds that democratic countries worsen land quality and natural resources by increasing the annual deforestation percentage and average soil degradation by water. He argues that for countries where logging or other related activities are the main sources of income, environmental regulations protecting forests are likely to be rejected by the countries' citizens. These countries are usually poor. This means the relationships between political institutions and environmental quality may differ among high- and low-income countries. Furthermore, demand for better environment is higher in rich countries (Grossman and Krueger 1995). Consequently, in low-income countries, democratic governments may worsen land quality and natural resources.

Democratic countries may not be able to improve global environmental quality in a timely manner because democracy is national or local in character, whereas the environment is global in character, as stated by Hosseini and Kaneko (2013) in their literature review. Since democratic governments work in the interest of its own country, they want to improve environmental outcomes that are externalities from a national point of view and only consider national costs to benefits. Congleton (1992) finds that democratic countries worsen global air quality by increasing net methane and chlorofluorocarbons (CFCs). Finally, Midlarsky (1998) finds that democratic governments worsen global air quality by increasing CO₂ emissions per capita. Since democratic countries have local characteristics and usually focus on environmental quality within the borders of their countries, democratic governments may worsen global air quality between countries.

Similarly, although autocratic countries may worsen environmental quality, research specifically addressing autocracy suggests that autocratic governments may improve the environment in some cases. Although Mak and Lew (2011) do not specifically measure the impacts of autocracy in their analyses, they find that democratic countries worsen land quality and natural resources by increasing deforestation damage. The researchers explain

their findings by acknowledging that autocratic governments may manage land quality and natural resources better than democratic countries if protecting forests provides benefits to the autocratic governments. Barrett and Graddy (2000) find that using certain measures of democracy and certain environmental outcomes, low civil freedom dummy, one of their variables representing low level of democracy, improves water quality. Since autocratic countries may improve the environment if doing so gives the country's elites benefits, autocratic governments may improve environmental quality.

The first mechanism is that democratic governments aim to satisfy the majority while autocratic governments aim to satisfy the elites, and these populations may have different preferences. The existing studies addressing this first mechanism suggest that democratic and autocratic governments may improve or worsen the environment depending on the specific preferences of the majority and the elites in a given country. The majority of citizens in a democracy are likely to care about environmental quality directly related to people's health. However, the majority may vote against regulations because of the trade-off with economic activity if environmental issues do not directly affect the majority's health and well-being. Using the same argument, the majority is expected to be more supportive of regulations that have local benefits rather than global benefits. Therefore, a possible hypothesis associated with this first mechanism that democratic governments aim to satisfy the majority while autocratic governments aim to satisfy the elites, and these populations may have different preferences is as follows.

H1a: More democratic governments improve environmental outcomes directly affecting local health, while have no effect on or worsen environmental quality indirectly affecting local health.

There is one more reason why I hypothesize that democratic governments lead to better environment directly related to people's health. More access to information and rights

related to environmental quality helps the majority in democracy be more aware of environmental issues. Democratic citizens have more access to the free press and other forms of information regarding the environment (Payne 1995; Schultz and Crockett 1990).

Democratic countries allow freedom of speech and organization among its citizens who then assemble and appeal to their governments about environmental issues (Kotov and Nikitina 1995; Payne 1995). In addition, democratic governments may be held accountable for their ignorance of environmental quality if a noticeable environmental degradation takes place (Payne 1995). Since exchange of ideas regularly takes place in democratic countries, good ideas are shared. However, this mechanism will only apply if the majority are in favor of environmental regulations.

Citizens of low- (high-) income countries care about both development and the environment, but trading economic development for environmental improvement is relatively more (less) costly. Environmental Kuznets Curve (EKC) literature (e.g., Grossman and Krueger 1995) finds that high-income countries have more demand for environmental regulations because high-income countries have achieved some level of economic development and want to reduce environmental degradation. Therefore, another hypothesis reflecting these differences in the costs of setting up environmental regulations and demands for better environment is as follows.

H1b: Democratic governments lead to better environmental quality in high-income countries, while lead to lower environmental quality in low-income countries.

The second mechanism suggested in the existing studies is that democratic governments are less likely to effectively enact policies than autocratic governments. Before sharing papers claiming that democratic countries are less effective in enacting policies, I will first share studies suggesting that democratic governments may be more effective in enacting policies. Since democracy is a strong formal institution that establishes a consistent

foundation for enacting policies improving the environment (Gallagher and Thacker 2008), democratic governments may improve sustainable development policies. Li and Reuveny (2006) find that democratic countries improve sustainable development policies by decreasing a composite index measuring environmental pollution stress. Pellegrini and Gerlagh (2006) find that democratic governments improve sustainable development policies by increasing an environmental protection stringency index and decreasing an environmental regulatory regime index. Finally, Yoon (2014) finds that democratic countries improve sustainable development policies by increasing an environmental performance index score and an ecosystem vitality category score.

Although democratic governments may improve environmental quality, some studies suggest that democratic countries may worsen environmental outcomes in both short run and long run. If the environment is considered a common good, unconstrained individuals or interest groups are more likely to overuse natural resources and ignore the damage of their actions on environmental quality (Hardin 1968). While this study seems to be a little bit older than other papers cited in this paper, it is so seminal that many scholars still incorporate it: irresponsible over-usage of natural resources by people who do not care about others is more likely to worsen the environment. Mak and Lew (2011) find that democratic governments worsen land quality and natural resources by increasing deforestation damage.

In order to examine the ability of a government to enact policy, I focus on the extent to which a government is constrained from taking actions. Measures of democracy consist of separate components, not all of which affect policy implementation. Therefore, I consider *executive constraints*, which is one of the four component variables constituting *institutionalized democracy*. The other three component variables are *competitiveness of executive recruitment*, *openness of executive recruitment*, and *competitiveness of political participation*. Detailed descriptions about the variables are provided in the data descriptions

section of this paper. A government with strong *executive constraints* may have less freedom to implement environmental regulations relative to a government with weak *executive constraints*, or implementation may occur more slowly. However, other component variables are not likely to have the same types of effects. Therefore, a possible hypothesis associated with this second mechanism that democratic governments are less likely to effectively enact policies than autocratic governments is as follows.

H2: Greater *executive constraints* lead to worse environmental quality. More democratic countries, measured as other component variables (e.g., *competitiveness of political recruitment*), have no effect on environmental quality.

Finally, the third mechanism suggested in the existing literature is that democratic governments are more likely to participate in global environmental treaties than autocratic governments. Democratic countries may improve environmental quality because democratic governments are more likely to participate in international treaties improving the environment (Payne 1995). Since democratic countries are more likely to participate in global environmental treaties, they are more likely to model other successful countries also participating in the treaties. Therefore, democratic countries may improve global air quality. Barrett and Graddy (2000), Hosseini and Kaneko (2013), Li and Reuveny (2006), and Mak and Lew (2011) find that democratic governments improve global air quality. Finally, Congleton (1992) finds that democratic countries improve global air quality by decreasing net methane per GNP.

Under this mechanism, the degree of democracy does not affect local environmental quality. However, more democratic governments improve global environmental outcomes. A possible hypothesis associated with this third mechanism that democratic governments are more likely to participate in global environmental treaties than autocratic governments is as follows.

H3: Democratic governments lead to better global environmental quality, while have no effect on local environmental quality.

Research reveals mixed impacts of democratic and autocratic governments on environmental quality. The past studies focused on relationships between income and the environment. After learning that democratic countries may have determinant impacts on environmental quality, researchers have carefully designed models that may explain the relationships between democratic governments and the environment. More recent papers use more and better data, and more sophisticated estimation methods than earlier studies due to the advancement in a field of economics and technology. More recent papers⁹ seem to produce results suggesting that democratic countries usually improve environmental quality. However, this is not true in all cases. In addition, theoretical mechanisms suggested in literature do not give a single clear prediction about directions of relationships.

Since the results have been mixed, this suggests that the relationships are more complex than so far assumed. I will examine some potential sources of heterogeneity in the relationship in order to better understand the underlying mechanisms. Therefore, my contribution is that since the hypotheses suggest different relationships in different context, I will investigate how the relationships between democratic countries and the environment varies by different types of environmental outcomes, types of components constituting democracy, and types of countries with different income levels.

3. Data descriptions

The entire dataset for this paper consists of an unbalanced panel of 145 countries between 1992 and 2010. The dataset is unbalanced because there are different numbers of

⁹ (Barrett and Graddy 2000; Fredriksson and Neumayer 2013; Gallagher and Thacker 2008; Hosseini and Kaneko 2013; Li and Reuveny 2006; Mak and Lew 2011; Neumayer 2002; Pellegrini and Gerlagh 2006; Yoon 2014).

observations for different countries in different time periods. For example, Solomon Islands has a number of observation of 1, which is the minimum number of observation for the entire time span for a country. Conversely, some countries¹⁰ have a number of observations of 19, which is the maximum number of observations for the entire time periods for a country. Therefore, the range of number of observations is the difference between the maximum and the minimum, and is 18 for the entire time span. The total number of observations is 1,899.

The way I calculated my sample size is different from that of Li and Reuveny (2006), who did not make the number of observations the same for different estimations. In other words, their reported results for CO₂ per capita and organic water pollutants per km³ are from different countries. The sample size for CO₂ per capita is 3,833 and that for organic water pollutants per km³ is 1,344. Since the samples were not from the same countries, their estimation results would have been influenced by countries that belonged or did not belong to the estimations. In order to isolate differences due to types of environmental outcomes from differences due to sample composition, my sample is restricted to 1,899 observations by excluding all the explanatory and response variables that do not have observations. The same set of countries is also incorporated.

Since different categories of outcomes might be affected differently by political institutions, I use three different environmental outcomes representing environmental pollution and environmental quality as response variables. These three environmental outcomes reflect global air pollution (*CO₂ emissions*); measures of land and natural resources quality (*terrestrial protected areas*); and sustainable development policies quality (*improved water sources*).

¹⁰ Australia, Austria, Bulgaria, Finland Guinea, Japan, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Namibia, the Netherlands, New Zealand, Senegal, Spain, and Tunisia.

Table 2 shows the bottom twelve countries and Table 3 shows the top twelve countries for each variable to give an indication of where the variation is occurring. The value for each variable used to rank the countries is an average value of the variable between 1992 and 2010. For example, column 1 of Table 2 represents *CO₂ emissions (kt)_i*. The variable, *CO₂ emissions (kt)_{i,t}*, represents global air pollution. *CO₂ emissions* result from the burning of fossil fuels and the manufacturing of cement, among other things. The subscript *i* represents a country. Since countries are sorted in an ascending order, countries appearing on top in Table 2 are the ones with the lowest *CO₂ emissions*.

The subscript *t* attached to the variable represents a time period *t*. The data also include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. Table 4 contains descriptive statistics of all the variables. The mean and standard deviation for *CO₂ emissions* are 167,662 kilotons and 612,992 kilotons, respectively. *CO₂ emissions*' standard deviation to mean ratio exceeds a constant one which suggests that their standard deviation is larger than their mean. This shows that *CO₂ emissions* have a high variability. Countries having large *land area* in general have high *CO₂ emissions*, while those having small *land area* have low *CO₂ emissions*. The values for *CO₂ emissions* are not size adjusted. The data for *CO₂ emissions* and all other environmental outcomes are from World Bank Group (2012).

The variable, *terrestrial protected areas (% of total land area)_{i,t}*, represents land quality and natural resources quality. *Terrestrial protected areas* are totally or partially protected areas of at least 1,000 hectares that are designated by national authorities as scientific reserves with limited public access and other uses. The mean and standard deviation for *terrestrial protected areas* are 11.93% and 9.322%. Countries having large *land area* in general have high *terrestrial protected areas*, while those having small *land area* have low *terrestrial protected areas*.

Finally, the variable, *improved water sources (% of population with access)_{i,t}*, represents sustainable development policies. It reflects the percentage of the population using an improved drinking water sources including piped water on premises (piped household water connections located inside the users' dwelling, plot or yard) and other sources. The mean and standard deviation for *improved water sources* are 83.81% and 18.10%. Countries having high population density, which is calculated by *total population* divided by *land area*, in general have high *improved water sources*, while those having small population density have low *improved water sources*.

The aforementioned relationships among *land area*, population density, *CO₂ emissions*, *terrestrial protected areas*, and *improved water sources* do not necessarily imply causality, but attempt to give some indications of other characteristics beside income that may be correlated with environmental quality.

The key explanatory variables for this paper are institutions. I am interested in institutions of democracy and autocracy which are two opposite political institutions. By separating democracy and autocracy, I may discover the mechanisms through which institutions affect the environment by identifying which aspects of political institutions are important. The variable, *revised combined Polity score_{i,t-1}*, represents the two different institutions. The variable ranges from -10 to +10, a country with a closer score to -10 means it is more autocratic and a country with a closer score to +10 means it is more democratic. This variable is a modified version of the Polity variable for time-series analyses. It applies a treatment filling in scaled Polity scores for observations that occur during political interregnums and transitions, which would otherwise be treated as missing values. These data and the other political institutional measures are from Polity IV (2012). The countries with the lowest average value of *revised combined Polity score* are Qatar, Saudi Arabia, Swaziland, Uzbekistan and Oman. The countries with the highest average value of *revised*

combined Polity score are Switzerland, the United Kingdom, the Netherlands, Finland and Hungary.

The variable, *institutionalized autocracy*_{*i,t-1*}, reflects autocracy which is an institution favoring a fewer number of people in a ruling party and is contrasted with democracy for this paper. It is an eleven-point scale (0 to +10) measure constructed by adding the scores received for *competitiveness of executive recruitment*, *openness of executive recruitment*, *executive constraints*, *competitiveness of political participation*, and *regulation of participation* using pre-determined weights.

The variable, *institutionalized democracy*_{*i,t-1*}, represents democracy. It is an eleven-point scale (0 to +10) measure constructed by adding the scores received for *competitiveness of executive recruitment*, *openness of executive recruitment*, *executive constraints*, and *competitiveness of political participation* using pre-determined weights. The Polity IV Project calls these three measures of political institutions “three composite indicators.”

Although *institutionalized autocracy* and *institutionalized democracy* look like they share the same component variables, *institutionalized autocracy* is composed of one extra component variable, *regulation of participation*, which does not belong to the four component variables constituting *institutionalized democracy*. More importantly, although the names of the component variables are the same, the way they are calculated is totally different. For example, *executive constraints* of *institutionalized autocracy* have the following criteria: (1) unlimited authority, (2) intermediate category, and (3) slight to moderate limitations. The criteria are numbered by the Polity IV Project. A country’s *executive constraints* receive a point of +3, +2, and +1 respectively if the country meets (1), (2), and (3), respectively. Conversely, the criteria for *executive constraints* of *institutionalized democracy* are: (7) executive parity or subordination, (6) intermediate category, (5) substantial limitations, and (4) intermediate category. If a country meets these criteria, the

country's *executive constraints* receive a point of +4, +3, +2, and +1, respectively. Therefore, since the way that the component variables constituting *institutionalized autocracy* and *institutionalized democracy* is different, these two composite indicators individually measure autocracy and democracy.

The variable, *competitiveness of executive recruitment*, refers to a selection of chief executives through popular elections matching two or more viable parties or candidates. The variable, *openness of executive recruitment*, refers to the extent to which all the politically active population has an opportunity, in principle, to attain the position through a regularized process. The variable, *executive constraints*, refers to the extent of institutionalized constraints imposed by accountability groups on the decision-making powers of chief executives, whether individuals or collectivities. Finally, the variable, *competitiveness of political participation*, refers to the extent to which alternative preferences for policy and leadership can be pursued in the political arena. These four component variables form *institutionalized democracy* which is one of the aforementioned three composite indicators. These four component variables are also obtained from Polity IV (2012).

In summary, the Polity IV Project data consist of the five component variables (*competitiveness of executive recruitment*, *openness of executive recruitment*, *executive constraints*, *competitiveness of political participation*, and *regulation of participation*). These component variables are coded along an ordinal scale reflecting assumptions about their relative weight. The weighted scores are summed to produce *institutionalized autocracy* and *institutionalized democracy* (*regulation of participation*, the fifth component variable, is excluded in this specific calculation). Finally, by subtracting *institutionalized autocracy* from *institutionalized democracy*, the variable *revised combined Polity score* is obtained.

Although most studies include a variable for democracy and only a few studies include a variable for autocracy, in addition to “three composite indicators,” I offer a fresh

perspective by incorporating “four component variables”: *competitiveness of executive recruitment*_{*i,t-1*}, *openness of executive recruitment*_{*i,t-1*}, *executive constraints*_{*i,t-1*}, and *competitiveness of political participation*_{*i,t-1*}. Using these four component variables in addition to *institutionalized democracy* helps find sources of heterogeneity in explaining the relationship between institutions and environmental quality by identifying which aspects of democracy are important.

Institutionalized democracy and the four component variables forming *institutionalized democracy* have low standard deviation to mean ratio. The mean and standard deviation for *institutionalized democracy* are 5.687 and 3.968. The mean and standard deviation for *competitiveness of executive recruitment* are 2.096 and 1.071. The mean and standard deviation for *openness of executive recruitment* are 3.428 and 1.309. The mean and standard deviation for *executive constraints* are 5.003 and 2.038. The mean and standard deviation for *competitiveness of political participation* are 3.49 and 1.321.

Since *institutionalized democracy* and the four component variables forming *institutionalized democracy* do not vary as much, *institutionalized autocracy* appears to drive much of the variation in *revised combined Polity score*. The mean and standard deviation for *institutionalized autocracy* are 1.854 and 2.79. The mean and standard deviation for *revised combined Polity score* are 3.82 and 6.522.

Before I introduce my set of control variables besides the key explanatory variables, some arguments related to the validity of the Polity IV Project measures are provided as follows. Although many researchers attempt to develop measures representing political institutions, a set of the most widely used measures is by the Polity IV Project (Polity IV 2012). Some alternative measures of political institutions include those of Alvarez et al. (1996); Arat (1991); Bollen (1980, 1991, 1993); Coppedge and Reinicke (1991); Freedom House (2000); Gasiorowski (1996); Hadenius (1992); and Vanhanen (2000). These measures

represent political institutions, particularly democracy. They tend to be based on effectiveness, fairness, freedom, and openness of elections; executive selections; legislative selections; party competitiveness; and freedom of organization. In their article, Munck and Verkuilen (2002) list the strengths and weaknesses of all of these aforementioned political institution measures.

Although it is conceded that these political institution measures provide many useful insights, some scholars are concerned with these measures. Bowman, Lehoucq, and Mahoney (2005) analyze the Central American countries to find that the principal, long-term cross-national scales of democracy including Gasiorowski (1996), Polity IV (2012), and Vanhanen (2000) are often inaccurate. Although these three measures are considered most popular and share high correlations based on their raw values, the researchers find that these measures are obtained by referring to less reliable secondary sources.

The researchers examine a few countries whose democracy measures may be contestable. One of the countries is Costa Rica. The Polity IV Project scores Costa Rica as strongly democratic for every year between 1900 and 1999. These researchers believe that these scores are incorrect because they are based on less reliable secondary sources (e.g., President Oscar Arias' speech during an event in 1989 celebrating the centennial of Costa Rican democracy). To mitigate issues with less reliable sources, these researchers suggest reading Spanish-language secondary sources, the US diplomatic correspondence, government documents, local newspaper, and interviewing local experts and eyewitnesses (Bowman 2002, Lehoucq 1992, Lehoucq and Molina 2002). By engaging in these types of activities themselves, the researchers find that 16 coups against the central government occurred in Costa Rica by the opposition as a response to incumbents trying to impose their successors five times on the presidency between 1900 and 1955 (Lehoucq 1996). These researchers also find that the minister of defense, Federico Tinoco, overthrew his predecessor, Alfredo

González, who became the president in 1914 as a result of an extraconstitutional compromise. González did not even participate in an election campaign during the hotly debated 1913 general elections (Murillo Jiménez 1981).

Using more examples including the cases with El Salvador and Nicaragua, the researchers acknowledge that the Vanhanen (2000) democracy index best measures the effects of the US occupation and the quality of elections out of all three democracy measures. However, the researchers also state that more reliable sources than the ones used by Vanhanen (2000) should be considered, and list many historically important events that may influence democracy measures of these countries.

Although Bowman, Lehoucq, and Mahoney (2005) recommend political institution measures from Vanhanen (2000), one of the most widely used measures for political institutions are from the Polity IV Project and many scholars implement them in their analyses (e.g., Fredriksson and Neumayer 2013; Gallagher and Thacker 2008; Li and Reuveny 2003; 2006). However, many studies use these measures without explicitly justifying their reasons. This may potentially be attributable to a well-established tradition of using these measures in academic research, and lack of information provided by the Polity IV Project regarding their theoretical arguments and weighting schemes when calculating the variables (Munck and Verkuilen 2002).

The Polity IV Project analysts are the ones assigning a score for each country on each scale. According to the Polity IV Project website, these analysts monitor “real-time events to make tentative assessments of the trajectories of unfolding political dynamics and their effect on the essential qualities of governing institutions, or patterns of authority.” Therefore, these analysts score the countries by monitoring real-time events from numerous sources, while these sources usually are not provided. One of a very few relevant statements found in the Polity IV Project: Dataset Users’ Manual states that “multiple historical sources

were used for each country, along with reference to a variety of standard sources. The first step was to identify historical and social science works for each country, then to compile from them a basic political chronology. Periods of substantial change were identified in this process and then examined in detail to determine whether events met the specified criteria for changes in and of polities. The same sources provided information for the coding of authority characteristics.” Therefore, the Polity IV Project analysts indeed refer to relevant sources, but these sources are not necessarily reported in the Manual probably due to too many volumes and limited writing spaces. Finally, the Polity IV Project website states that these analysts regularly re-examine recent annual Polity records during each annual update, re-examine historical cases because users and country experts raise questions about the data, and may refine the data based on new information or the correction of errors in the records. Therefore, the Polity IV Project analysts are aware of the fact that their data are not always correct, and attempt to make many corrections to improve their data.

Some scholars report problems associated with the Polity IV Project data. Munck and Verkuilen (2002) state that the Polity IV Project’s five component variables are weighted differently by using different scales and assigning a different number of points for each component variable. The researchers claim that although weighted scores provide a legitimate way of acknowledging the greater or lesser theoretical importance of different component variables, the Polity IV Project has no justification for the weighting scheme. Therefore, these researchers claim that the Polity IV Project analysts use subjective pre-determined scores without providing specific information on how the weighting scheme works for each component for each country. The researchers also claim that this operation is not based on theoretical justification and the Polity IV Project has conceptual logic problems. These researchers argue that the Polity IV Project data include pairs of redundant component

variables, which lead to a fair amount of double counting that is never acknowledged or explained.

Although Munck and Verkuilen (2002) share concerns with the Polity IV Project data, these researchers describe some objective strengths of the Polity IV Project data. As opposed to other political institution measures, the Polity IV data clearly identify the component variables; provide specific coding rules in a fair amount of detail; use multiple codes; do good jobs in the recording and publicizing of the coding rules, the coding process, and the disaggregated data. Furthermore, the researchers acknowledge that since the Polity IV Project data are publicly available, independent scholars may tailor the data for their own use.

Although the Polity IV Project data do not necessarily share information on what kind of theoretical arguments are incorporated and use subjective judgments on their weighting schemes, some other scholars praise the measures' advantages. Gerring et al. (2005) acknowledge that the measures usually offer extensive country coverage (all sovereign polities except microstates) and good historical coverage. Furthermore, the measures help consider both the degree and the duration of democracy in any given country-year. These researchers argue that, compared to other measures of democracy, the Polity IV Project measures are on average better. Confirming that the measures correlate highly with other democracy measures, the researchers state that there is no reason to suspect systematic errors in the Polity IV Project measures. However, the researchers acknowledge that democracy measures from the Polity IV Project may be prone to errors, and the construction of the measures is very complex.

Many papers tried to establish measures capturing democracy¹¹, but Bowman, Lehoucq, and Mahoney (2005) claim that many of these attempt to generate measures based

¹¹ (Alvarez et al. 1996; Arat 1991; Bollen 1980, 1991, 1993; Coppedge and Reinicke 1991; Freedom House 2000; Gasiorowski 1996; Hadenius 1992; Vanhanen 2000).

on less reliable sources. However, due to the aforementioned strengths, data availability, and a wide-implementation, I use political institution measures from the Polity IV Project in my paper. Although the measures are appreciated by academic communities and sometimes do a good job capturing the characteristics of democracy, users of the Polity IV Project should not believe that the measures are perfect and use them with caution.

In addition to the key explanatory variables, I use a number of control variables. The control variables included are the ones that may vary with both political institutions and the environment. If they are not included, the estimations would produce biased impacts of institutions on environmental quality.

Some of the control variables that are widely used by other studies include types of economic development measures of countries.¹² The variable, *GDP per capita (constant 2005 US \$)*_{*i,t-1*}, represents economic development of countries. Since past studies find that environmental degradation against income is represented as an inverted U shape (Grossman and Krueger 1995), *GDP per capita* and its squared term are used to reflect economic development of the countries. This inverted U relationship is called an Environmental Kuznets Curve (EKC). As an economy produces more output, its income or GDP per capita increases. However, as income increases, environmental degradation increases due to more waste coming from more intensive production processes. However, this degradation stops at a location called the turning point because more people recognize the importance of environmental quality (Grossman and Krueger 1995). Therefore, degradation decreases as income passes the turning point, and cleaner production technology and fewer resources are used. Data are in constant 2005 US dollars. The mean and standard deviation for *GDP per*

¹² (Barrett and Graddy 2000; Congleton 1992; Fredriksson and Neumayer 2013; Gallagher and Thacker 2008; Hosseini and Kaneko 2013; Li and Reuveny 2006; Mak and Lew 2011; Midlarsky 1998; Neumayer 2002; Pellegrini and Gerlagh 2006; Yoon 2014).

capita are \$9,847 and \$14,636. The ratio of *GDP per capita* exceeds a constant one. The data for *GDP per capita* and all other control variables are from World Bank Group (2012).

Another important set of control variables that are widely used by other studies include the size of nations.¹³ Two measures represent the size of nations. They are the variables *total population*_{*i,t-1*}, and *land area (km²)*_{*i,t-1*}. *Total population* is a mid-year estimate and this figure counts all residents regardless of legal status or citizenship except for refugees not permanently settled in the country of asylum. *Land area* is a country's total area, excluding area under inland water bodies and other zones. I hypothesize that as *total population* increases, *CO₂ emissions* increase due to more people consuming and producing goods. Furthermore, I hypothesize that as *total population* increases, *terrestrial protected areas* decrease due to more people using agricultural land for food and industry. The mean and standard deviation for *total population* are approximately 40 million and 133 million. *Total population* has the highest standard deviation to mean ratio out of all control variables. The mean and standard deviation for *land area* are approximately 808,583 km² and 2 million km².

Another variable, *urban population (% of total)*_{*i,t-1*}, is a measure of the structure of the economy. *Urban population* refers to people living in urban areas as defined by national statistical offices. The mean and standard deviation for *urban population* are 55.08% and 22.51%.

I use two other control variables. The first variable reflects economic activities, and the second variable represents social activities. The variable, *trade (% of GDP)*_{*i,t-1*}, reflects economic activities. *Trade* is the sum of exports and imports of goods and services measured as a share of gross domestic product. Brunnermeier and Levinson (2004) give an example of

¹³ (Barrett and Graddy 2000; Congleton 1992; Hosseini and Kaneko 2013; Li and Reuveny 2006; Mak and Lew 2011; Midlarsky 1998; Neumayer 2002).

trade that may affect the environment. The researchers state that environmental quality of a country increases as a country trades environmentally clean goods such as compostable products. The researchers also state that these countries are obligated to have more stringent environmental regulations imposed by some international treaties that the countries have signed. Furthermore, the researchers argue that *trade* may improve economic development of countries, which then may improve the environment by decreasing environmental pollution. This is a similar justification used to explain the EKC. The mean and standard deviation for *trade* are 79.61% and 41.17%.

The second control variable reflecting social activities is the variable *primary education enrollment rate*_{*i,t-1*}. This is obtained by dividing the total number of students enrolled in public and private primary education institutions by population of age between 0 and 14. Li and Reuveny (2006) claim that national structural variables (e.g., education) may affect environmental degradation. The mean and standard deviation for *primary education enrollment rate* are approximately 36.2% and 8.92%. The descriptive statistics in Table 5 suggest that environmental outcomes, and economic activities vary more than political institutions do.

Figures 1 and 2 display environmental outcomes across countries and over time, respectively. The data for Figure 1 are the average values for each country, while those for Figure 2 are the average values for each time period. Since both *terrestrial protected areas* and *improved water sources* are in percentage, proportion of *CO₂ emissions* instead of actual *CO₂ emissions* is used for easier comparisons. Proportion of *CO₂ emissions* is calculated by dividing the actual *CO₂ emissions* by the maximum *CO₂ emissions* value.

Figure 1 plots environmental quality against *institutionalized democracy*. Although the countries' names are not labeled for visual convenience, *improved water sources* show the steepest slope, which suggests that more democratic countries are associated with high

improved water sources. The slopes of other two environmental outcomes are not as steep. Therefore, *improved water sources* vary the most across countries.

Figure 2 plots environmental quality against time represented by year. Unlike Figure 1, where *improved water sources* have the steepest slope, proportion of *CO₂ emissions* has the steepest slope. This seems to suggest that more recent time periods are associated with high *CO₂ emissions*. The slopes of other two environmental outcomes are not as steep. Therefore, *CO₂ emissions* vary the most across the time span. Tables 5 and 6 show the correlations of the response variables and explanatory variables, respectively.

4. Methodologies

The majority of recent studies on this topic use panel data. Consequently, the estimation methods switched from a simple estimation method of ordinary least squares (OLS)¹⁴ to more advanced estimation methods, including two-way fixed effects estimation¹⁵, a random effects estimation¹⁶, and generalized least squares.¹⁷

I, similarly, conduct panel data analyses. I use a two-way fixed effects model to control for unobserved heterogeneity in country characteristics as well as general trends over time. Equation (1.1) below helps describe a two-way fixed effects estimation.

$$(1.1) \quad \text{Environmental quality}_{i,t} = \beta_0 + \beta_1 \text{Political institutions}_{i,t-1} + \text{CONTROL VARIABLES}\Omega + \varepsilon_{i,t},$$

where $\varepsilon_{i,t} = \alpha_i + u_{it}$.

In a two-way fixed effects model in Equation (1.1), α_i is an unobserved heterogeneity capturing all unobserved characteristics staying constant over time and

¹⁴(Congleton 1992; Midlarsky 1998; Neumayer 2002; Pellegrini and Gerlagh 2006).

¹⁵(Barrett and Graddy 2000; Gallagher and Thacker 2008; Hosseini and Kaneko 2013; Li and Reuveny 2006; Yoon 2014).

¹⁶(Barrett and Graddy 2000; Hosseini and Kaneko 2013).

¹⁷(Mak and Lew 2011; Yoon 2014).

affecting *Environmental quality*_{*i,t*}, which consists of *CO₂ emissions*_{*i,t*}, *terrestrial protected areas*_{*i,t*}, and *improved water sources*_{*i,t*}.

*Political institutions*_{*i,t-1*} consists of *revised combined Polity score*_{*i,t-1*}, *institutionalized autocracy*_{*i,t-1*}, *institutionalized democracy*_{*i,t-1*}, *competitiveness of executive recruitment*_{*i,t-1*}, *openness of executive recruitment*_{*i,t-1*}, *executive constraints*_{*i,t-1*}, and *competitiveness of political participation*_{*i,t-1*}.

CONTROL VARIABLES is a vector of control variables and is multiplied by a coefficient vector Ω . **CONTROL VARIABLES** consists of *GDP per capita*_{*i,t-1*}, its squared term, *total population*_{*i,t-1*}, *urban population*_{*i,t-1*}, *land area*_{*i,t-1*}, *trade*_{*i,t-1*}, *primary education enrollment rate*_{*i,t-1*}, and **YEAR DUMMIES**, which is a vector of year dummies.

Some unobserved characteristics that vary across countries (α_i) include global/local biophysical attributes (e.g., atmospheric integrity, existing damage, and climate). These unobserved characteristics may affect environmental quality (Li and Reuveny 2006). Cultural factors may affect care for the environment. Historical focus on certain types of policies may also affect environmental quality. Furthermore, other measures such as geographical features, demographic features of the population (age, race, and etc.), and historical differences (e.g., attitudes) toward the environment are also included in α_i .¹⁸ Although these characteristics may not always be constant, they are considered approximately constant because they change very slowly over time.

The fixed effect, α_i , may be correlated with political institutions because it may help shape certain institutions. Therefore, my estimated results may be biased if I fail to control for the unobserved heterogeneity, α_i .

¹⁸ (Wooldridge 2008, 460).

Consequently, I implement a two-way fixed effects estimation using time-demeaned variables to remove the unobserved heterogeneity from Equation (1.1). A pooled OLS estimator that is based on the time-demeaned variables is called the fixed effects estimator.¹⁹ A pooled OLS is different from a regular OLS by having year dummies. The fixed effects transformation successfully removes any explanatory variable that is constant over time for all countries.²⁰ Therefore, my estimation would eliminate bias due to correlations of the fixed effect, α_i , with variables measuring institutions.

Although a two-way fixed effects estimation helps produce more reliable results, there is a cost. Since a two-way fixed effects model only captures variation within countries over time instead of variation between countries, a two-way fixed effects model uses less variation. Therefore, since much variation in the response variables is not explained by other right-hand-side (RHS) variables, especially by the political institutions, I may not be able to find many statistically significant results.

The error, u_{it} , in Equation (1.1) is an idiosyncratic error. It represents unobserved characteristics changing over time, affecting *Environmental quality* _{i,t} and *Political institutions* _{$i,t-1$} . Although I may not be able to fully remove an idiosyncratic error, u_{it} , I include control variables to reduce the effects of an idiosyncratic error, u_{it} . The control variables include *GDP per capita*, its squared term, *total population*, *urban population*, *land area*, *trade*, *primary education enrollment rate*, and **YEAR DUMMIES**. However, this approach may not fully control some other remaining unobserved characteristics varying over time, which will bias the results.

Even after controlling the effects of an idiosyncratic error, u_{it} , a simultaneity problem may be an issue. If I use explanatory variables in a given year with response

¹⁹ (Wooldridge 2008, 485).

²⁰ (Wooldridge 2008, 485).

variables in the same year, there may be a problem of simultaneity: I may not be able to tell whether it is institutions influencing environmental quality or it is the environment influencing political institutions. As Fredriksson and Neumayer (2013) provide as a justification for their use of instrumental variable (IV) estimation, countries with poor environmental quality may demand more democracy. Therefore, the environment may influence institutions. Furthermore, a simultaneity problem is not only relevant to the response variables and the key explanatory variables but also to the control variables: degradation in land quality may reduce agricultural economy's exports, or an increase in exports resulting from high production may worsen environmental quality. To reduce this effect, I lag all the RHS variables by one year. Other studies (e.g., Oneal and Russett 1999; Li and Reuveny 2003; 2006) also follow this approach.

Since there are issues of heteroskedasticity, I implement the Huber-White robust standard errors (White 1982) to control for possible heteroskedasticity issues, which represent a state where the variance of an idiosyncratic error, u_{it} , is not constant. Furthermore, there is another issue of serial correlations. However, the year dummies capturing the temporal dynamics in the panel data in my two-way fixed effects estimation already control for possible serial correlation issues (Li and Reuveny 2006), which represent a state where there are correlations between idiosyncratic errors, u_{it} , in different time periods.

Instead of using a one-tailed test, I use a two-tailed test. A one-tailed test assesses whether a positive effect of democratic governments on environmental quality has the same magnitude as a negative effect of democratic countries on the environment. A two-tailed test assesses whether there is an effect of democratic governments on environmental quality against a null hypothesis that there is no effect of democratic countries on the environment. Many other studies follow this latter approach (e.g., Morrow, Siverson, and Tabares 1998; Oneal and Russett 1999; Li and Reuveny 2003; 2006).

Finally, if I find different relationships between democratic governments and environmental quality by using all countries at the same time, I may not be able to get valid estimates for countries with different income levels. Therefore, I also interact institutions and countries with four different income groups (low-, lower middle-, upper middle-, and high-income).

5. Empirical results

Table 7 displays the effects of the three composite indicators of political institutions on three different environmental outcomes. Columns 1 through 3 show the results on *CO₂ emissions*. Columns 4 through 6 show the results on *terrestrial protected areas*. Columns 7 through 9 show the results on *improved water sources*. All the samples for Tables 7 through 10 were taken from 1992 to 2010 in 145 countries.

In columns 1 through 3, democratic governments have an insignificant effect on *CO₂ emissions*, and autocratic countries are not significantly associated with *CO₂ emissions*. In columns 4 through 6, autocratic governments are positively associated with *terrestrial protected areas*. Democratic countries do not significantly affect *terrestrial protected areas*. In columns 7 through 9, there appears to be no impact of democratic governments on provision of *improved water sources*. Autocratic countries have an insignificant impact on *improved water sources*.

Among the control variables, an increase in *GDP per capita* has a positive but diminishing effect on *CO₂ emissions*, even though the squared term of *GDP per capita* is insignificant. *CO₂ emissions* are also higher for countries with larger populations. The control variables are insignificantly associated with *terrestrial protected areas*. Finally, an increase in *GDP per capita* has a negative but increasing effect on *improved water sources*. *Improved water sources* are also higher for countries with larger populations, and higher levels of education.

Given the lack of an overall relationship between the composite indicators of institutions and environmental quality, I examine the impacts of four individual component variables of democracy. Table 8 displays the effects of the four component variables on three different environmental outcomes. Columns 1 through 4 show the results on *CO₂ emissions*. Columns 5 through 8 show the results on *terrestrial protected areas*. Columns 9 through 12 show the results on *improved water sources*. Since the signs and significance of coefficients for the control variables are very similar to those reported in Table 7, Tables 8 through 10 include the control variables in regressions, but do not report their coefficients to help focus on the impacts of the political institutions.

In columns 1 through 4, all components of democracy do not significantly affect *CO₂ emissions*. In columns 5 through 8, I observe no significant effect of all components of democracy besides a positive effect of *competitiveness of political participation* on *terrestrial protected areas*. In columns 9 through 12, all components of democracy do not significantly affect *improved water sources*.

Not a single component of democracy has effects on environmental outcomes besides *competitiveness of political participation*. It is interesting to observe that both *institutionalized autocracy* and *competitiveness of political participation* have a positive effect on *terrestrial protected areas* given that the Polity IV Project states that countries scoring high on *institutionalized autocracy* oppress *competitiveness of political participation*.

Although *institutionalized autocracy* and *competitiveness of political participation* have a significantly positive effect on *terrestrial protected areas*, political institutions in general do not seem to affect environmental quality. Little variation in institutions over time may be one of several reasons why there is a lack of significance.

However, even if there is not one overall effect of political institutions on the environment, it is possible that there may be effects that vary by context: there are different

effects on different environmental quality, the distinct components of democracy affect the environment in different ways, and the relationship between democratic governments and environmental outcomes varies in countries with different income groups. The previous insignificant effects of institutions on environmental quality may be due to a failure to account for these differences. Therefore, I will use interaction terms to separately identify the impacts of political institutions for different income levels rather than estimating a single effect for all countries. This reasoning is also supported by Mak and Lew (2011) and is further discussed in the discussion section of this paper. Therefore, I include interaction terms between institutions and countries with different income groups (e.g., *executive constraints* × *low-income country dummy*). This approach is different from the one used by Mak and Lew (2011) who just use sub-samples of countries with different income levels.

Table 9 displays the marginal effects of the three composite indicators at four different income groups on three different environmental outcomes. Columns 1 through 3 show the results on *CO₂ emissions*. Columns 4 through 6 show the results on *terrestrial protected areas*. Columns 7 through 9 show the results on *improved water sources*. When the effects of political institutions on environmental quality are estimated separately for countries with different income levels, the relationships between democratic countries and environmental outcomes differ in sign, statistical significance and magnitude.

Since Tables 9 and 10 report marginal effects, interpretations on the coefficients are different from those for Tables 7 and 8. In columns 1 through 3 (see Table 9), *revised combined Polity score* and *institutionalized democracy* reduce *CO₂ emissions* in low-, and high-income countries. There is no significant effect in lower middle- and upper middle-income countries.

In columns 4 through 6, *institutionalized autocracy* increases *terrestrial protected areas* in lower middle-income countries, while the results on *revised combined Polity score*

and *institutionalized democracy* suggest that democratic governments increase *terrestrial protected areas* in high-income countries. There is no significant effect in low- and upper middle-income countries. The results jointly show that democratic countries increase *terrestrial protected areas* in high-income countries. In columns 7 through 9, democratic governments do not significantly affect provision of *improved water sources* in any of the income groups.

Table 10 displays the marginal effects of the four component variables at four different income groups on three different environmental outcomes. Columns 1 through 4 show the results on *CO₂ emissions*. Columns 5 through 8 show the results on *terrestrial protected areas*. Columns 9 through 12 show the results on *improved water sources*.

Where there is a relationship observed between democratic countries and environmental quality, it appears to be mainly driven by *executive constraints*. *Executive constraints* reduce *CO₂ emissions* in low- and high-income countries, while the results on *executive constraints* suggest that democratic countries increase *terrestrial protected areas* in high-income countries. *Executive constraints* reduce *improved water sources* in low-income countries. There is no significant effect in lower middle- and upper middle-income countries. The results jointly show that *executive constraints* reduce *CO₂ emissions* in low- and high-income countries, and increase *terrestrial protected areas* in high-income countries.

The other three measures are largely not significant. Some exceptions are that *openness of executive recruitment* in low-income countries reduces *CO₂ emissions*. *Competitiveness of political participation* in high-income countries increases *terrestrial protected areas*. Furthermore, *openness of executive recruitment* in upper middle-income countries increases *improved water sources*.

6. Discussion

The key finding of this paper is that some aspects of democracy improve some aspects of environmental quality in some countries. For example, out of the four component variables, executive constraints have the greatest number of effects on the environment compared to other aspects of democracy followed by openness of executive recruitment, competitiveness of political participation, and competitiveness of executive recruitment. Out of the three environmental outcomes, democratic governments have the greatest number of effects on CO₂ emissions followed by terrestrial protected areas and improved water sources. There appear to be generally positive effects on environmental quality in low- and high-income countries, and positive or insignificant effects in middle-income countries.

Although the existing literature seems to suggest that democratic governments usually improve environmental quality, my findings suggest that political institutions, whether they are measured as democracy, autocracy, or component variables of democracy, do not have significant overall effects on the environment if I use all 145 countries at the same time. These findings are displayed in Tables 7 and 8, and indicate that the relationships between democratic governments and environmental quality are more complex than the existing literature suggests. Studies that generally show an effect usually share similar methodologies as mine, but cover earlier time periods and do not necessarily include control variables capturing education. The relationships do vary by context however, there are different impacts on environmental outcomes, the separate components of democracy influence the environment in different ways, and the relationship between democratic countries and environmental quality varies in countries with different income levels.

In Tables 7 and 8, democratic governments have no overall significant effect on the environment even though two of the three different types of heterogeneity in the relationships between democratic countries and environmental quality (different environmental quality and

different components of democracy) are implemented. I attribute this insignificance to a failure of incorporating another and probably more informative type of heterogeneity, countries with different income groups. Implementing this last type of heterogeneity with the former two produces much more informative results. These results are provided in Tables 9 and 10.

The discussion below refers to Table 9. Democracy in low-income countries reduces carbon emissions. My results suggest that as opposed to less democratic, low-income countries, it is more democratic, low-income countries that reduce carbon emissions even though the existing studies (e.g., Grossman and Krueger 1995) states that people in low-income countries usually develop more interests in economic development. One other possible reasons is that more contemporary low-income countries do not necessarily follow the footsteps by the other traditional low-income countries. The more contemporary low-income countries learn from the mistakes by the other traditional low-income countries and develop interests in saving the environment. Democratic countries having positive impacts on carbon reductions help support a view that democracy in low-income countries improves the environment even though low-income countries are usually thought to be primarily interested in economic development.

I find that autocracy in lower middle-income countries improves the size of protected areas. This finding seems to be supportive of the idea by Mak and Lew (2011), who argue that autocratic countries will better manage land quality and natural resources if doing so provides the elites more benefits. This result seems to be deriving the positive association between autocratic governments and protected areas reported in Table 7.

Democracy in high-income countries has the most significant impacts, and all of them are associated with improvement in carbon reductions and protected areas. Although the existing papers (e.g., Grossman and Krueger 1995) state that people in high-income countries

usually develop more interests in improving the environment, my results suggest that it is democratic, high-income countries that reduces carbon emissions and increases the size of protected areas. Since high-income countries are usually known to be more interested in improvements in environmental quality, democratic countries having positive impacts on carbon reductions and protected areas help support a view that democracy in high-income countries improves the environment.

I find that democratic governments have an insignificant effect on access to clean drinking water. One possible reason for the absence of a relationship between democratic countries and access to improved water sources is that most countries have achieved high levels of access to clean drinking water regardless of how democratic they are. Descriptive statistics in Table 4 show that the mean of access to improved water sources between 1992 and 2010 is 83.81%. This suggests that roughly 83.81% of the population around the world has access to clean drinking water. Since access to improved water sources are directly related to people's health, countries might have prioritized development of access to clean drinking water more than other environmental quality, regardless of their institutions. Therefore, access to improved water sources may not be a good response variable to check whether democratic and autocratic governments may influence the environment. The three composite indicators still have an insignificant effect on clean drinking water sources even if I only compare the results among low-income countries.

More meaningful results are also found when the analyses incorporate components of democracy. Executive constraints in low- and high-income countries improve carbon reductions (see Table 10), and executive constraints in high-income countries increase the size of protected areas. This seems to suggest that although accountability groups have more or equal power than a chief executive, agreements on policies related to environmental quality that are global in nature may be more easily achieved than expected in low- and high-

income countries. Since the coefficients of executive constraints share the same signs and have a larger magnitude than those of democratic countries, this component of democracy seems to be deriving the previous results of revised combined Polity score and institutionalized democracy observed in Table 9.

Except in a few cases (openness of executive recruitment in low- and upper middle-income countries; and competitiveness of political participation in high-income countries), all other components of democracy beside executive constraints have an insignificant effect on the environment. In general, these other components of democracy do not necessarily represent time it takes to process decisions related to environmental quality. However, these components besides executive constraints are more about ways chief executives get selected and shifts of power between a ruling party and a competing power. Hence, competitiveness of executive recruitment, openness of executive recruitment, and competitiveness of political participation have less direct impacts on environmental quality as opposed to executive constraints. Therefore, these other components of democracy usually have an insignificant effect on the environment.

Since an overall discussion on the empirical findings has been provided, I now compare the results with my hypotheses developed in the literature review and research hypotheses section. As democratic governments are expected to act in the interest of the majority to a greater extent than autocratic governments, the impacts of democratic countries were predicted to be positive for environmental outcomes directly affecting local health and in high-income countries. The relationship was hypothesized to be insignificant or negative for environmental quality indirectly affecting local health and negative for democracy in low-income countries. Access to improved water sources are considered to have direct health impacts, while carbon reductions and protected areas are indirect.

Democracy in high-income countries reduces carbon emissions, increases the size of

protected areas, but has an insignificant impact on access to clean drinking water. This partially agrees with the hypothesis that democracy in high-income countries has a positive impact on the environment. However, this disagrees with the hypothesis that democratic governments have an insignificant or a negative impact on environmental quality indirectly affecting local health. Democracy in low-income countries reduces carbon emissions. This disagrees with the hypothesis that democracy in low-income countries has a negative impact on environmental quality. Finally, the results show that democratic countries have an insignificant effect on access to improved water sources. This disagrees with the hypothesis that democratic governments have a positive impact on environmental quality directly affecting local health. Overall, democratic processes have no significance on environmental outcomes directly affecting local health, while democracy in high-income countries improves the environment.

Since democratic governments are associated with high executive constraints and thus a chief executive's decisions may be rejected by accountability groups, the impacts of executive constraints were predicted to be negative for environmental quality. The results show that executive constraints in low- and high-income countries reduce carbon emissions and increase the size of protected areas. These findings disagree with the hypothesis. Executive constraints in low-income countries are associated with less access to clean drinking water. This partially agrees with the hypothesis. Overall, executive constraints improve the environment.

Since democratic governments are expected to participate more in global environmental treaties, the impacts of democratic governments were predicted to be positive for global environmental quality. The relationship was hypothesized to be insignificant for a local environmental outcome. Access to improved water sources is considered to be local environmental quality, while carbon reductions and protected areas are global.

The results show that democratic countries have an insignificant effect on local environmental outcome agreeing with the hypothesis that democratic governments have an

insignificant effect on local environmental quality. Democracy in low-income countries reduces carbon emissions, and democracy in high-income countries reduces carbon emissions and increases protected areas. This partially agrees with the hypothesis that democratic governments have a positive effect on global environmental quality. Overall, democracy in low- and high-income countries improves the environment.

The hypotheses and the results in general support a view that there is no single/straightforward impact of democratic countries on environmental quality. However, the relationships vary by context: there are different effects on different environmental outcomes, the individual components of democracy influence the environment in different paths, and the relationships between democratic governments and environmental quality vary in countries with different income groups.

Once these three different types of heterogeneity in the relationships between democratic governments and environmental quality are considered, the idea of democratic countries improving the environment because it acts in the interests of majority partially seems to work. Democracy in high-income countries reduces carbon emissions and increases the size of protected areas. The idea of more executive constraints worsening environmental quality because agreements on policies between a chief executive and accountability groups having more or equal power than a chief executive is more difficult does not seem to hold. Executive constraints in low- and high-income countries reduce carbon emissions and increase protected areas. Finally, the idea that democratic countries improving global environmental quality because democratic countries have higher participation rates in global environmental treaties seems to hold. Democracy in low- and high-income countries reduces carbon emissions, and democracy in high-income countries increase the size of protected areas.

7. Conclusion

Some aspects of democracy improve some aspects of environmental quality in some countries. The key findings of this paper are as follows: Out of four different components of democracy, executive constraints have the most number of effects on environmental quality. Democratic governments have the most number of effects on CO₂ emissions. Finally, middle-income countries have an insignificant or positive effect on the environment, while low- and high-income countries usually have a positive impact on environmental quality.

I consider democratic governments and environmental quality in this paper. In general, democratic countries seem to have an insignificant effect on the environment when all 145 countries are used at the same time. However, when I include different types of environmental outcomes, components of democracy, and countries with different income levels, democratic governments sometimes have effects (usually positive) on environmental quality. I implement these three different types of heterogeneity in the relationships between democratic countries and environmental quality to better understand the sources of potential heterogeneity.

When considering different environmental outcomes, based on Table 9, I find that democratic governments either reduce or have no effect on carbon emissions, increase or have no effect on the size of protected areas, and have no effect on access to clean drinking water. When separate components of democracy are used, I find that executive constraints are the most important component variable. Finally, when countries with different income groups are considered, democracy in low-income countries reduces carbon emissions, and in high-income countries it reduces carbon emissions and increases protected areas. However, democracy in middle-income countries has an insignificant effect on the environment.

Since the existing studies find that democratic countries usually improve environmental quality, its policy implications are that countries should become more democratic to improve the local and global environment. However, my findings suggest that

becoming democratic does not always lead to improved environmental quality, and there are many other factors to consider when improvement of the environment is a main concern.

Democracy in low- and high-income countries reduce carbon emissions, democracy in high-income countries improve protected areas, while democracy in middle-income countries have an insignificant effect on environmental quality. Therefore, a policy implication is that democratic governments improve the environment if the majority prefers improvements in environmental quality.

Executive constraints in low- and high-income countries improve carbon reductions and the size of protected areas, while executive constraints in middle-income countries have an insignificant effect on the environment. A policy implication is that an agreement on environmental quality is feasible even if there is a high level of executive constraints.

Finally, democratic governments improve global environmental outcomes because democratic countries participate more in global environmental treaties. A policy implication is that other countries should support democracy because it helps improve the environment.

My results seem to be quite different from the existing studies, which find that democratic governments usually improve environmental quality using all the countries at the same time. Although my research shares similarity with many existing papers in using panel data and a two-way fixed effects estimation, I differ from the existing studies by including more explanatory variables that may affect political institutions and the environment. Existing papers do not necessarily have as many important control variables as mine does. Although existing studies mostly have *GDP per capita*, its squared term and some variables related to populations, my set of controls differ from the existing papers by including *total population*, *land areas*, and *urban population* all at the same time. Furthermore, I include *trade* and *primary education enrollment rate*. By including another economic variable and an education variable that not many studies have included, my results reduce issues related to

omitted variables and provide more detailed insights on the relationships between democratic governments and environmental quality.

The effects of democratic countries may operate through these additional control variables. In other words, if democratic governments increase trade or education, and these are the mechanisms through which democratic countries improve the environment, the effect will be removed by including them as controls. Therefore, an inclusion of these control variables may be one possible reason for less significance for democratic governments on environmental quality.

In addition to including more relevant control variables, the results differ from prior papers by incorporating three different environmental outcomes capturing comprehensive environmental quality. Although some previous studies are interested in the relationship between political institutions and the environment, some papers only include one or two environmental outcomes. Therefore, by implementing a broader set of environmental outcomes, my results better explain the relationships between democratic countries and environmental quality. These relationships are complex and not easily explained by just one or two environmental outcomes. For example, assume there is another researcher studying sulphur dioxide (SO₂), deforestation, and fecal coliforms. The first two environmental outcomes represent local environmental quality and the latter one represents environmental outcome affecting local health. By having these different types of environmental quality, the researcher may better understand the sources of potential heterogeneity in the relationships between democratic governments and the environment.

As more control variables and environmental outcomes are implemented, I also differentiate my work from the existing studies by incorporating components of democracy. Since there are many factors constituting democracy, it is important to look for which factor plays an important role in explaining the relationships between democratic countries and

environmental quality. Assessing the component variables of democracy specifically is a very unique approach and doing so provides useful results. Let us again consider the case of the hypothetical researcher. Since SO₂ and deforestation may be considered as local environmental quality and fecal coliform as environmental quality affecting local health, the researcher would be less likely to find some significant results without considering separate components of democracy as my results do with access to improved water sources. Therefore, this researcher should consider using individual components of democracy to better understand the mechanisms through which democratic countries affect the environment.

Finally, by comparing countries with different income levels, it is possible to learn the differences between democratic and autocratic governments in countries with different income groups. Although most studies include variables that are related to *GDP per capita*, the papers do not usually consider countries with different income levels separately. Assume again the case of the hypothetical researcher. As the results with openness of executive recruitment in upper middle-income countries, and executive constraints in low-income countries show, more significant relationships are expected if we consider countries with different income groups. Therefore, by including countries with different income levels, we may better understand the sources of potential heterogeneity in the relationships between democratic governments and environmental quality.

For future research, more environmental outcomes should be included. Although finding more environmental outcomes may be challenging, having more environmental outcomes especially those that are in the interests of the public may produce more meaningful results. Research based on this wider range of environmental outcomes will help understand the relationships between democratic countries and the environment. Many people may incorrectly estimate the importance of democratic governments on environmental quality if

only a few environmental outcomes are implemented. According to my analyses, as opposed to local environmental quality, democracy in low- and high-income countries improves global environmental outcomes.

Since different components of democracy provide useful information, research assessing democratic countries should consider implementing these components. As opposed to competitiveness of executive recruitment, openness of executive recruitment, and competitiveness of political participation, executive constraints in low- and high-income countries improve global environmental outcomes. Since executive constraints provide more consistent and significant results, future research may focus on the reasons why executive constraints affect the environment, while the other components do not.

Finally, as opposed to the results without countries with different income levels, the results with countries with different income groups suggest that democratic governments sometimes influence (usually positively) environmental quality. Therefore, research assessing democratic countries and the environment should consider estimating separate effects for countries with different income levels. According to my analyses, democracy in low- and high-income countries provides more significant results than that from middle-income countries.

Furthermore, it would be beneficial to consider countries with different geographical regions. This approach would help policy makers and researchers learn about an effect of democratic governments on environmental quality in specific regions.

Figure 1. Environmental outcomes across countries.

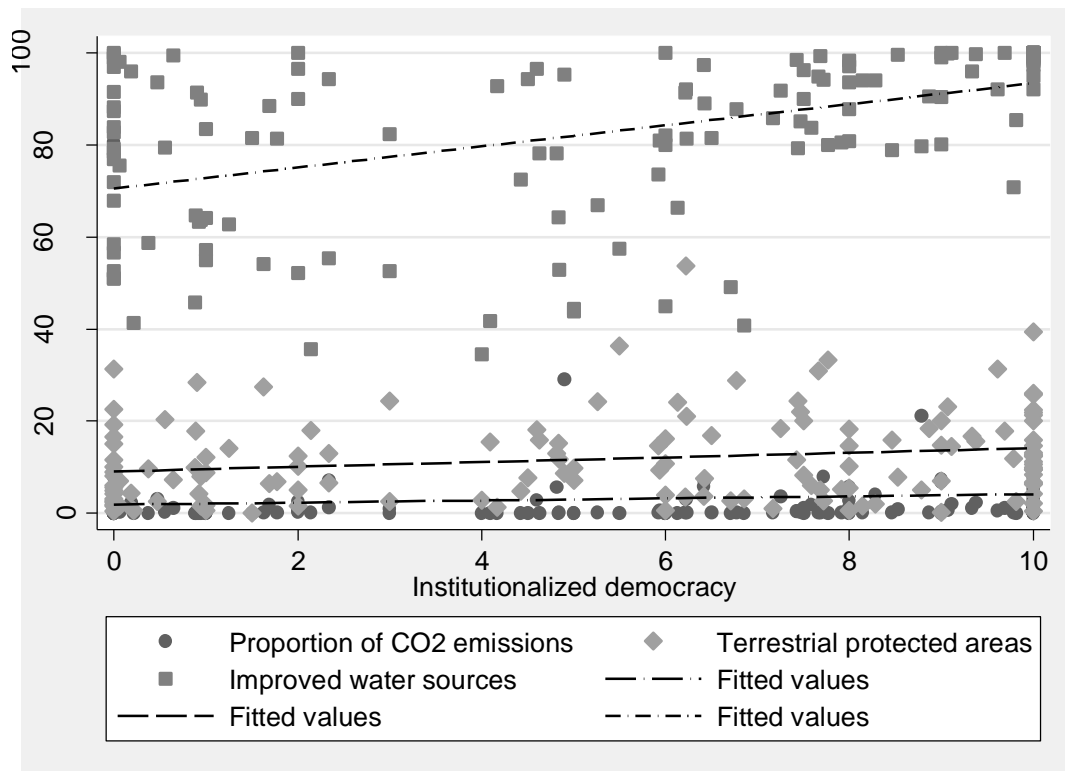


Figure 2. Environmental outcomes over time.

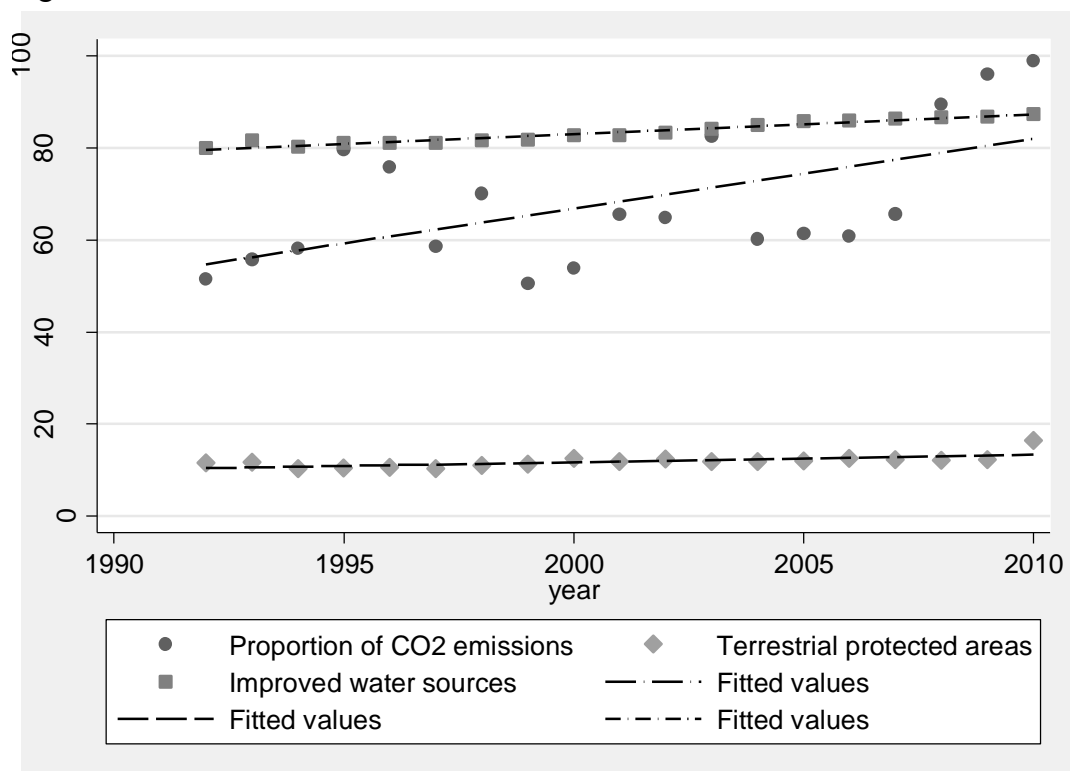


Table 1. The three mechanisms and the four corresponding hypotheses.

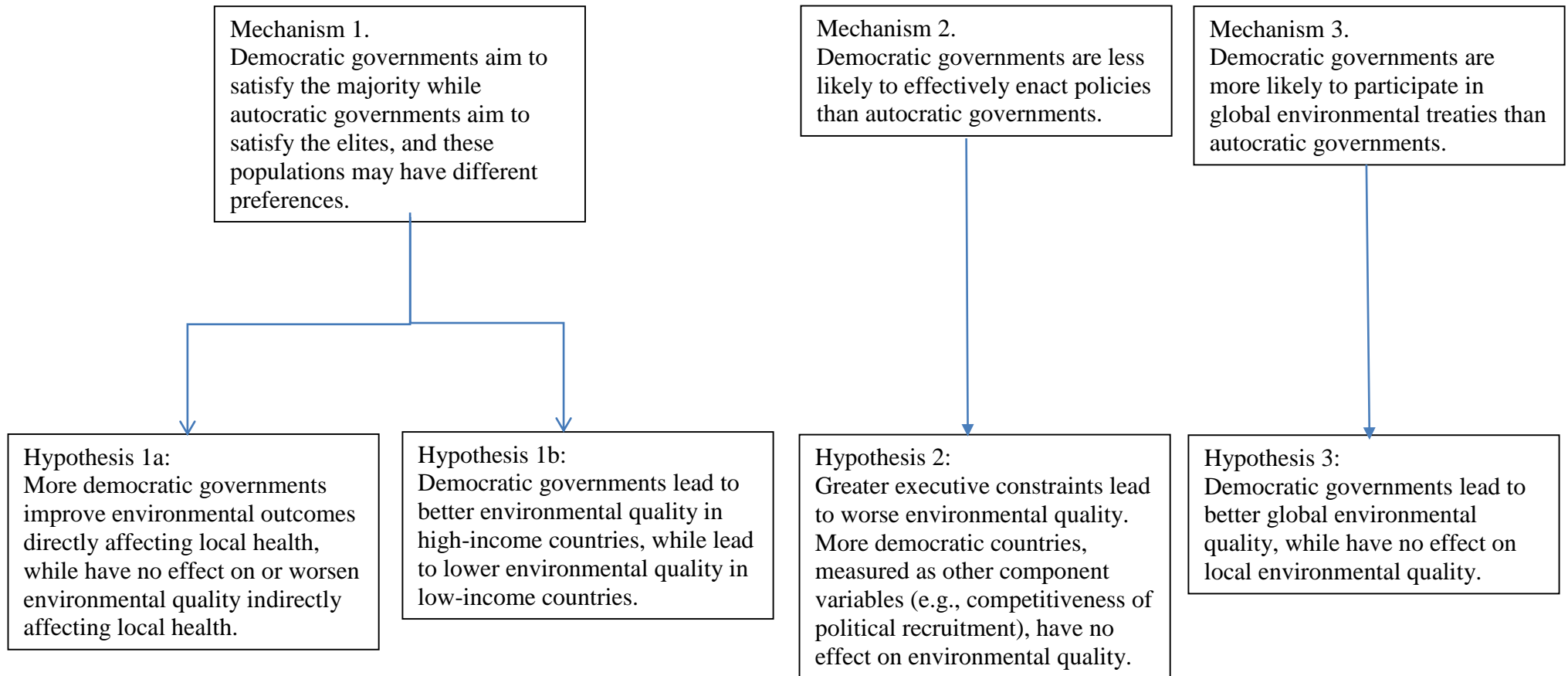


Table 2. Bottom twelve countries for each variable

Rank (lowest to highest)	CO_2 emissions (kt) _{<i>i</i>}	<i>Terrestrial protected areas</i> (% of total land area) _{<i>i</i>}	<i>Improved water sources</i> (% of population with access) _{<i>i</i>}	<i>Revised combined Polity score</i> _{<i>i</i>}	<i>Institutionalized autocracy</i> _{<i>i</i>}	<i>Institutionalized democracy</i> _{<i>i</i>}	<i>Competitiveness of executive recruitment</i> _{<i>i</i>}	<i>Openness of executive recruitment</i> _{<i>i</i>}	<i>Executive constraint</i> _{<i>s</i>} _{<i>i</i>}	<i>Competitiveness of political participation</i> _{<i>i</i>}
1	Lesotho	Djibouti	Papua New Guinea	Qatar	Papua New Guinea	Cuba	Equatorial Guinea	Congo	Saudi Arabia	Papua New Guinea
2	Solomon Islands	Solomon Islands	Ethiopia	Saudi Arabia	Lebanon	Uzbekistan	Chad	Central African Republic	Qatar	Bhutan
3	Central African Republic	Uruguay	Madagascar	Swaziland	Slovenia	Eritrea	Sudan	Gabon	Uzbekistan	Nigeria
4	Burundi	Syria	Mauritania	Uzbekistan	Canada	Swaziland	Cambodia	Yemen	Sudan	Syria
5	Chad	Lesotho	Mozambique	Oman	Guyana	Morocco	Rwanda	Uganda	Swaziland	Laos
6	Cape Verde	Lebanon	Niger	Bahrain	Chile	Congo	Yemen	Rwanda	Cuba	Qatar
7	Guinea-Bissau	Yemen	Guinea-Bissau	Syria	El Salvador	Qatar	Burkina Faso	Sudan	Congo	Cuba
8	Gambia	Mauritania	Democratic Republic of the Congo	United Arab Emirates	Romania	Equatorial Guinea	Uganda	Burkina Faso	Bahrain	United Arab Emirates
9	Bhutan	El Salvador	Chad	Laos	Estonia	Saudi Arabia	Gabon	Cambodia	Gabon	China
10	Djibouti	Fiji	Mali	Kuwait	Luxembourg	Cote d'Ivoire	Central African Republic	Chad	Yemen	Saudi Arabia
11	Mali	Tunisia	Equatorial Guinea	China	Hungary	Kuwait	Congo	Equatorial Guinea	Equatorial Guinea	Uzbekistan
12	Eritrea	Morocco	Swaziland	Cuba	Argentina	Sudan	Guinea	Guinea	Chad	Kyrgyz Republic

Table 3. Top twelve countries for each variable

Rank (lowest to highest)	CO_2 emissions (kt) _i	<i>Terrestrial protected areas (% of total land area)_i</i>	<i>Improved water sources (% of population with access)_i</i>	<i>Revised combined Polity score_i</i>	<i>Institutionalized autocracy_i</i>	<i>Institutionalized democracy_i</i>	<i>Competitiveness of executive recruitment_i</i>	<i>Openness of executive recruitment_i</i>	<i>Executive constraints_i</i>	<i>Competitiveness of political participation_i</i>
134	South Africa	United Kingdom	United Kingdom	Japan	Laos	Uruguay	Uruguay	Azerbaijan	India	Netherlands
135	Italy	New Zealand	Israel	Cyprus	China	Slovenia	Argentina	Laos	Belgium	United States
136	South Korea	Tanzania	Norway	Sweden	Cuba	Austria	Trinidad and Tobago	Cyprus	Lesotho	United Kingdom
137	Saudi Arabia	Bhutan	Finland	Denmark	Kuwait	United Kingdom	Bulgaria	Belgium	Australia	Spain
138	Canada	Guatemala	Germany	Italy	Syria	Switzerland	Panama	Costa Rica	Uruguay	Japan
139	United Kingdom	Botswana	Italy	New Zealand	United Arab Emirates	New Zealand	Belgium	China	Denmark	Switzerland
140	Germany	Saudi Arabia	Japan	Ireland	Bahrain	Portugal	India	Malawi	Paraguay	Slovenia
141	India	Trinidad and Tobago	Spain	Switzerland	Oman	United States	El Salvador	Finland	Czech Republic	Hungary
142	Japan	Nicaragua	Netherlands	United Kingdom	Uzbekistan	Germany	Israel	Angola	Norway	France
143	Russia	Zambia	New Zealand	Netherlands	Swaziland	Japan	Nicaragua	Bolivia	Mauritius	Canada
144	China	Germany	Australia	Finland	Saudi Arabia	Italy	Slovenia	Eritrea	United States	Austria
145	United States	Venezuela	Denmark	Hungary	Qatar	Mauritius	Colombia	Mexico	Switzerland	Finland

Table 4. Descriptive statistics of response, key explanatory, and control variables.

Time periods	(1) 1992-2010	(2) 1992	(3) 2000	(4) 2010
Response variables				
<i>CO₂ emissions (kt)_{i,t}</i>	167,662 (612,992)	123,605 (345,681)	129,280 (249,455)	237,416 (956,188)
<i>Terrestrial protected areas (% of total land area)_{i,t}</i>	11.93 (9.322)	11.49 (9.456)	12.49 (9.063)	16.43 (10.87)
<i>Improved water sources (% of population with access)_{i,t}</i>	83.81 (18.10)	79.96 (19.94)	82.75 (20.15)	87.35 (15.65)
Key explanatory variables				
<i>Revised combined Polity score_{i,t-1}</i>	3.820 (6.522)	2.975 (7.227)	3.761 (6.681)	4.748 (5.940)
<i>Institutionalized autocracy_{i,t-1}</i>	1.854 (2.790)	2.364 (3.211)	1.924 (2.884)	1.427 (2.499)
<i>Institutionalized democracy_{i,t-1}</i>	5.687 (3.968)	5.455 (4.247)	5.667 (4.066)	6.182 (3.732)
<i>Competitiveness of executive recruitment_{i,t-1}</i>	2.096 (1.071)	2.078 (1.073)	2.076 (1.100)	2.200 (1.056)
<i>Openness of executive recruitment_{i,t-1}</i>	3.428 (1.309)	3.481 (1.242)	3.348 (1.353)	3.473 (1.290)
<i>Executive constraints_{i,t-1}</i>	5.003 (2.038)	4.831 (2.273)	5 (2)	5.273 (1.891)
<i>Competitiveness of political participation_{i,t-1}</i>	3.490 (1.321)	3.312 (1.507)	3.576 (1.266)	3.627 (1.291)
Control variables				
<i>GDP per capita (constant 2005 US\$)_{i,t-1}</i>	9,847 (14,636)	8,799 (12,198)	9,824 (13,698)	11,417 (15,806)
<i>Total Population_{i,t-1}</i>	3.968×e ⁷ (1.330×e ⁸)	4.858×e ⁷ (1.647×e ⁸)	3.795×e ⁷ (1.287×e ⁸)	5.159×e ⁷ (1.736×e ⁸)
<i>Urban population (% of total)_{i,t-1}</i>	55.08 (22.51)	51.93 (24.41)	56.33 (22.46)	57.29 (23.06)
<i>Land area (sq. km)_{i,t-1}</i>	808,583 (1.963×e ⁶)	896,555 (1.897×e ⁶)	807,116 (1.767×e ⁶)	824,667 (1.837×e ⁶)
<i>Trade (% of GDP)_{i,t-1}</i>	79.61 (41.17)	66.96 (43.66)	76.43 (31.58)	82.79 (34.90)
<i>Primary education enrollment rate_{i,t-1}</i>	0.362 (0.0892)	0.354 (0.0891)	0.358 (0.0892)	0.378 (0.0803)
Number of observations	1899	79	67	111
Number of countries	145	79	67	111

Notes: Standard deviations are in parentheses.

Table 5. Correlations among response variables.

Response variables	(1) <i>CO₂ emissions</i> <i>(kt)_{i,t}</i>	(2) <i>Terrestrial protected areas (% of</i> <i>total land area)_{i,t}</i> 1992-2010
Time periods		
<i>Terrestrial protected areas (% of</i> <i>total land area)_{i,t}</i>	0.0412*	
<i>Improved water sources (% of</i> <i>population with access)_{i,t}</i>	0.148***	0.0472**
Number of observations	1899	1899
Number of countries	145	145

Notes: ***, **, * is calculated based on t-statistics and denotes 10%, 5%, 1% significance level, respectively.

Table 6. Correlations among key explanatory variables and control variables.

Variables	(1) <i>Revised combined Polity score_{i,t-1}</i>	(2) <i>Institutionalized autocracy_{i,t-1}</i>	(3) <i>Institutionalized democracy_{i,t-1}</i>	(4) <i>Competitiveness of executive recruitment_{i,t-1}</i>	(5) <i>Openness of executive recruitment_{i,t-1}</i>	(6) <i>Executive constraints_{i,t-1}</i>	(7) <i>Competitiveness of political participation_{i,t-1}</i>	(8) <i>GDP per capita (constant 2005 US\$)_{i,t-1}</i>	(9) <i>Total Population_{i,t-1}</i>	(10) <i>Urban population (% of total)_{i,t-1}</i>	(11) <i>Land area (sq. km)_{i,t-1}</i>	(12) <i>Trade (% of GDP)_{i,t-1}</i>
Time periods	1992-2010											
<i>Institutionalized autocracy_{i,t-1}</i>	-0.953***											
<i>Institutionalized democracy_{i,t-1}</i>	0.977***	-0.865***										
<i>Competitiveness of executive recruitment_{i,t-1}</i>	0.880***	-0.758***	0.917***									
<i>Openness of executive recruitment_{i,t-1}</i>	0.515***	-0.419***	0.553***	0.741***								
<i>Executive constraints_{i,t-1}</i>	0.956***	-0.867***	0.965***	0.878***	0.561***							
<i>Competitiveness of political participation_{i,t-1}</i>	0.856***	-0.771***	0.868***	0.711***	0.409***	0.797***						
<i>GDP per capita (constant 2005 US\$)_{i,t-1}</i>	0.386***	-0.234***	0.471***	0.391***	0.170***	0.426***	0.475***					
<i>Total Population_{i,t-1}</i>	-0.00607	0.0170	0.00197	0.0313	0.0751***	0.0307	-0.0554**	-0.0341				
<i>Urban population (% of total)_{i,t-1}</i>	0.344***	-0.206***	0.423***	0.418***	0.259***	0.395***	0.384***	0.602***	-0.0868***			
<i>Land area (sq. km)_{i,t-1}</i>	0.0347	-0.0374	0.0307	0.0379	0.0691***	0.0180	0.0475*	0.0533**	0.439***	0.113***		
<i>Trade (% of GDP)_{i,t-1}</i>	0.0164	0.0182	0.0399	0.0702***	0.0634***	0.0416*	0.00331	0.130***	-0.234***	0.108***	-0.263***	
<i>Primary education enrollment rate_{i,t-1}</i>	0.218***	-0.171***	0.235***	0.196***	0.0932***	0.235***	0.205***	0.195***	0.0155	0.192***	0.00544	0.0645***
Number of observations	1899	1899	1899	1899	1899	1899	1899	1899	1899	1899	1899	1899
Number of countries	145	145	145	145	145	145	145	145	145	145	145	145

Notes: ***, **, * is calculated based on t-statistics and denotes 10%, 5%, 1% significance level, respectively.

Table 7. Fixed effects (FE) estimation of environmental quality on the three composite indicators (*revised combined Polity score*, *institutionalized autocracy*, and *institutionalized democracy*)

Response variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Time periods	<i>CO₂ emissions (kt)_{i,t}</i> 1992-2010			<i>Terrestrial protected areas (% of total land area)_{i,t}</i> 1992-2010			<i>Improved water sources (% of population with access)_{i,t}</i> 1992-2010		
<i>Revised combined Polity score_{i,t-1}</i>	-3,318 (2,771)			-0.00646 (0.0343)			0.0448 (0.0678)		
<i>Institutionalized autocracy_{i,t-1}</i>		6,638 (5,651)			0.105* (0.0535)			-0.0860 (0.160)	
<i>Institutionalized democracy_{i,t-1}</i>			-5,074 (4,339)			0.0595 (0.0690)			0.0713 (0.104)
<i>GDP per capita (constant 2005 US\$)_{i,t-1}</i>	32.29* (17.64)	32.12* (17.56)	32.64* (17.79)	-9.93e-07 (0.000173)	-1.72e-05 (0.000173)	8.25e-06 (0.000174)	-0.000991*** (0.000229)	-0.000989*** (0.000227)	-0.000995*** (0.000230)
<i>GDP per capita (constant 2005 US\$)_{i,t-1}²</i>	-0.000396 (0.000240)	-0.000394 (0.000240)	-0.000399 (0.000242)	1.26e-09 (2.18e-09)	1.37e-09 (2.16e-09)	1.22e-09 (2.18e-09)	4.62e-09** (2.08e-09)	4.60e-09** (2.07e-09)	4.66e-09** (2.09e-09)
<i>Total Population_{i,t-1}</i>	0.00960* (0.00518)	0.00959* (0.00517)	0.00960* (0.00517)	-6.03e-09 (9.64e-09)	-5.73e-09 (9.85e-09)	-6.47e-09 (9.51e-09)	3.43e-08*** (1.15e-08)	3.44e-08*** (1.14e-08)	3.43e-08*** (1.15e-08)
<i>Urban population (% of total)_{i,t-1}</i>	13,223 (8,856)	13,321 (8,878)	13,150 (8,846)	-0.0466 (0.0522)	-0.0452 (0.0526)	-0.0456 (0.0520)	0.107 (0.139)	0.106 (0.139)	0.108 (0.140)
<i>Land area (sq. km)_{i,t-1}</i>	-7.836 (6.169)	-7.844 (6.175)	-7.838 (6.176)	3.40e-05 (3.31e-05)	3.44e-05 (3.26e-05)	3.35e-05 (3.36e-05)	-3.92e-06 (1.23e-05)	-3.80e-06 (1.22e-05)	-3.90e-06 (1.23e-05)
<i>Trade (% of GDP)_{i,t-1}</i>	198.9 (200.4)	200.8 (203.2)	192.9 (197.0)	0.00739 (0.00493)	0.00769 (0.00489)	0.00720 (0.00494)	-0.000180 (0.00921)	-0.000194 (0.00916)	-0.000107 (0.00925)
<i>Primary education enrollment rate_{i,t-1}</i>	-68,674 (97,580)	-64,222 (99,086)	-76,114 (96,317)	-2.490 (2.688)	-2.181 (2.664)	-2.637 (2.674)	19.72*** (5.317)	19.68*** (5.281)	19.82*** (5.344)
Number of observations	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899
R ²	0.504	0.504	0.503	0.302	0.304	0.303	0.604	0.604	0.604
Number of countries	145	145	145	145	145	145	145	145	145
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Coefficients on year variables and constants are not reported to save spaces. The Huber-White robust standard errors are in parentheses. ***, **, * denotes 10%, 5%, 1% significance level, respectively.

Table 8. Fixed effects (FE) estimation of environmental quality on the four component variables (*competitiveness of executive recruitment, openness of executive recruitment, executive constraints, and competitiveness of political participation*)

Response variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	<i>CO₂ emissions (kt)_{i,t}</i>				<i>Terrestrial protected areas (% of total land area)_{i,t}</i>				<i>Improved water sources (% of population with access)_{i,t}</i>			
Time periods	1992-2010				1992-2010				1992-2010			
<i>Competitiveness of executive recruitment_{i,t-1}</i>	-11,475				0.0115				0.289			
	(13,523)				(0.173)				(0.341)			
<i>Openness of executive recruitment_{i,t-1}</i>		-8,032				0.0309				0.142		
		(9,096)				(0.0871)				(0.247)		
<i>Executive constraints_{i,t-1}</i>			-9,316				0.0521				4.62e-05	
			(7,750)				(0.125)				(0.243)	
<i>Competitiveness of political participation_{i,t-1}</i>				-8,000				0.276*				0.283
				(9,189)				(0.161)				(0.340)
Number of observations	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899
R ²	0.503	0.503	0.504	0.503	0.302	0.302	0.302	0.304	0.604	0.604	0.603	0.604
Number of countries	145	145	145	145	145	145	145	145	145	145	145	145
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Coefficients on control variables, year variables and constants are not reported to save spaces. Coefficients on control variables are very similar to the ones using the three composite indicators. The Huber-White robust standard errors are in parentheses. ***, **, * denotes 10%, 5%, 1% significance level, respectively.

Table 9. Marginal effects of environmental quality on interactions among the three composite indicators and countries with four different income levels (low-, lower middle-, upper middle-, and high-income)

Response variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Time periods	<i>CO₂ emissions (kt)_{i,t}</i>			<i>Terrestrial protected areas (% of total land area)_{i,t}</i>			<i>Improved water sources (% of population with access)_{i,t}</i>		
	1992-2010			1992-2010			1992-2010		
<i>Revised combined Polity score_{i,t-1}×Low- income country dummy_{i,t-1}</i>	-12,643*			0.0710			-0.150		
	(6,995)			(0.0974)			(0.103)		
<i>Revised combined Polity score_{i,t-1}×Lower middle- income country dummy_{i,t-1}</i>	2,881			-0.0422			0.0790		
	(3,840)			(0.0295)			(0.0859)		
<i>Revised combined Polity score_{i,t-1}×Upper middle- income country dummy_{i,t-1}</i>	-10,503			0.00982			0.00307		
	(6,538)			(0.0511)			(0.0775)		
<i>Revised combined Polity score_{i,t-1}×High- income country dummy_{i,t-1}</i>	-9,762*			0.146**			-0.0423		
	(5,822)			(0.0711)			(0.0774)		
<i>Institutionalized autocracy_{i,t-1}×Low- income country dummy_{i,t-1}</i>		24,334			-0.0293			0.361	
		(16,523)			(0.231)			(0.262)	
<i>Institutionalized autocracy_{i,t-1}×Lower middle- income country dummy_{i,t-1}</i>		-6,637			0.154***			-0.171	
		(7,963)			(0.0529)			(0.188)	
<i>Institutionalized autocracy_{i,t-1}×Upper middle- income country dummy_{i,t-1}</i>		23,622			0.0630			0.0333	
		(14,551)			(0.0804)			(0.188)	
<i>Institutionalized autocracy_{i,t-1}×High- income country dummy_{i,t-1}</i>		21,385			-0.206			0.133	
		(13,276)			(0.148)			(0.209)	
<i>Institutionalized democracy_{i,t-1}×Low- income country dummy_{i,t-1}</i>			-19,793*			0.155			-0.221
			(10,401)			(0.164)			(0.172)
<i>Institutionalized democracy_{i,t-1}×Lower middle- income country dummy_{i,t-1}</i>			5,232			-0.0174			0.123
			(6,745)			(0.0572)			(0.144)
<i>Institutionalized democracy_{i,t-1}×Upper middle- income country dummy_{i,t-1}</i>			-14,515			0.0700			0.0299
			(9,672)			(0.0975)			(0.116)
<i>Institutionalized democracy_{i,t-1}×High- income country dummy_{i,t-1}</i>			-13,661*			0.296**			-0.0457
			(8,250)			(0.121)			(0.122)
Number of observations	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899
R ²	0.504	0.504	0.503	0.302	0.304	0.303	0.604	0.604	0.604
Number of countries	145	145	145	145	145	145	145	145	145
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Coefficients on control variables, year variables and constants are not reported to save spaces. The Huber-White robust standard errors are in parentheses. ***, **, * denotes 10%, 5%, 1% significance level, respectively.

Table 10. Marginal effects of environmental quality on interactions among the four component variables and countries with four different income levels (low-, lower middle-, upper middle-, and high-income)

Response variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Time periods		CO ₂ emissions (kt) _{i,t}			Terrestrial protected areas (% of total land area) _{i,t}			Improved water sources (% of population with access) _{i,t}				
		1992-2010			1992-2010			1992-2010				
Competitiveness of executive recruitment _{i,t-1} ×Low-income country dummy _{i,t-1}	-62,939 (46,380)				-0.0759 (0.619)				0.659 (1.386)			
Competitiveness of executive recruitment _{i,t-1} ×Lower middle- income country dummy _{i,t-1}	6,909 (17,699)				-0.109 (0.169)				0.0416 (0.433)			
Competitiveness of executive recruitment _{i,t-1} ×Upper middle- income country dummy _{i,t-1}	-40,192 (29,324)				0.0272 (0.276)				0.545 (0.351)			
Competitiveness of executive recruitment _{i,t-1} ×High- income country dummy _{i,t-1}	-40,581 (28,771)				0.722 (0.450)				0.338 (0.652)			
Openness of executive recruitment _{i,t-1} ×Low- income country dummy _{i,t-1}		-30,947* (18,209)				0.401 (0.442)				-0.175 (0.614)		
Openness of executive recruitment _{i,t-1} ×Lower middle- income country dummy _{i,t-1}		-12,871 (11,684)				0.0467 (0.116)				-0.0603 (0.288)		
Openness of executive recruitment _{i,t-1} ×Upper middle- income country dummy _{i,t-1}		-623.6 (4,890)				-0.130 (0.154)				0.398** (0.166)		
Openness of executive recruitment _{i,t-1} ×High- income country dummy _{i,t-1}		-1,226 (5,325)				0.286 (0.210)				0.691 (0.606)		
Executive constraints _{i,t-1} ×Low- income country dummy _{i,t-1}			-32,145** (15,404)				0.426 (0.268)				-0.872*** (0.320)	
Executive constraints _{i,t-1} ×Lower middle- income country dummy _{i,t-1}			2,548 (10,492)				-0.0908 (0.0989)				0.153 (0.305)	
Executive constraints _{i,t-1} ×Upper middle- income country dummy _{i,t-1}			-20,410 (13,600)				0.110 (0.182)				-0.118 (0.278)	
Executive constraints _{i,t-1} ×High- income country dummy _{i,t-1}			-21,577* (12,654)				0.571** (0.228)				-0.349 (0.273)	
Competitiveness of political participation _{i,t-1} ×Low- income country dummy _{i,t-1}				-20,605 (18,684)				-0.142 (0.453)				-0.241 (0.360)
Competitiveness of political participation _{i,t-1} ×Lower middle- income country dummy _{i,t-1}				14,885 (14,632)				0.215 (0.143)				0.531 (0.408)
Competitiveness of political participation _{i,t-1} ×Upper middle- income country dummy _{i,t-1}				-36,187 (30,845)				0.294 (0.244)				-0.00333 (0.448)
Competitiveness of political participation _{i,t-1} ×High- income country dummy _{i,t-1}				-26,428 (20,529)				0.701** (0.316)				0.115 (0.351)
Number of observations	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899	1,899
R ²	0.503	0.503	0.504	0.503	0.302	0.302	0.302	0.304	0.604	0.604	0.603	0.604
Number of countries	145	145	145	145	145	145	145	145	145	145	145	145
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Coefficients on control variables, year variables and constants are not reported to save spaces. The Huber-White robust standard errors are in parentheses. ***, **, * denotes 10%, 5%, 1% significance level, respectively.

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