Democratic institutions and environmental quality: effects and transmission channels

Kinda, Romuald

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KINDA Somlanare Romuald[1]

Abstract

This paper aims at analysing the effect of democratic institutions on environmental quality (carbon dioxide per capita, sulfure dioxide per capita) and at identifying potential channel transmissions. We use panel data from 1960 to 2008 in 122 developing and developed countries and modern econometric methods. The results are as follows: Firstly, we show that democratic institutions have opposite effects on environment quality: a positive direct effect on environment quality and a negative indirect effect through investments and income inequality. Indeed, democratic institutions attract investments that hurt environment quality. Moreover, as democratic institutions reduce income inequality, they also damage environment. Secondly, we find that the direct negative effect of democratic institutions is higher for local pollutant (SO2) than for global pollutant (CO2). Thirdly, the nature of democratic institutions (presidential, parliamentary) is not conducive to environmental quality. Fourtly, results suggest that the direct positive effect of democratic institutions on environment quality is higher in developed countries than in developing countries. Thus, the democratic process in the first group of countries has increased their awareness for the environment protection.

Key words: Democratic institutions (043); Air pollution (Q53); Panel data (C23); Income inequality (D31); Investments (E22)

[1]CERDI, University of Auvergne, 32 Bd François Mitterand, 63000 Clermont Ferrand, France

1. Introduction

Many environmental problems can be explained by institutional failure and bad governance methods. At international level it is difficult to elaborate efficient and equity systems for environment resources management like oceans and climate warming. The Summit of Copenhagues (2009) put into in light real and enormous problems in international cooperation between countries for fighting climate warming. Though scientists reports emphasize that countries should act rapidly for reduce greenhouse effect gases responsable of climate warming. They also mention the huge challenge that international community must face, and especially democratic countries, to improve the situation.

In the analysis of the determinants of environmental quality, political determinants received relatively less attention than economic factors. As shown in table (1a & 1b), the simple correlation between an index of democratic instutions and environment quality (CO_2,SO_2) is positive but weak over the period 1960-2008. Thus it comes as no surprise that literature on this topic finds mitigated results. Indeed, some authors find that democratic institutions favour environment protection whereas others conclude to a negative effect. On nineteen empirical studies (table (2)), six uncovers a negative association between democracies and environment quality, nine find a positive association and the remaining four are inconclusive. However, a limit of these papers is that they don't explicitily identify channel transmissions of democratic institutions on environment quality. Indeed, findings that democracy has a mitigated partial effect on environment quality may hide the fact that it entails both costs and benefits. Identifying and specifying the channel transmissions from democratic institutions to environment protection will allow a better understanding of environmental costs and benefits of democratic institutions.

This paper aims at analysing the effect of democratic institutions on environment quality and at identifying channel transmissions. The main contribution of this paper is that we identify and test some channels by which democratic institutions affect the environment quality. We identify and test two transmission channels : income inequality and investments. We use panel data from 1960 to 2008 for 122 countries and modern econometric methods that are one-step GMM-System, two-step GMM-System one step, fixed effect estimators and the residuals generated regressors. The results are as follows: Firstly, we show that democratic institutions have opposite effects on environment quality; a positive direct effect on environment quality and a negative indirect effect through investments and income inequality. Indeed, democratic institutions attract investments that hurt environment quality. Moreover, as democratic institutions reduce income inequality, they also damage environment. Secondly, we find that the direct negative effect of democratic institutions is higher for local pollutant (SO2) than for global pollutant (CO2). Thirdly, the nature of democratic institutions (presidential, parliamentary) is not conducive to environmental quality. Fourtly, results suggest that the direct positive effect of democratic institutions on environment quality is higher in developed countries than in developing countries. Thus, the democratic process in the first group of countries has increased their awareness for the environment protection.

The plan of the paper is as follows. The next section outlines the arguments on the relation between democratic institutions and environment quality and discusses on previous

empirical findings. In section 3, we identify potential channel transmissions between democratic institutions and environment quality. Section 4 derives estimating equations and shows empirical results and the last is devoted to the conclusion.

2. Effect of Democratic institutions on environment quality

The relation between democratic institutions and environment quality has been studied. Some authors conclude that democratic insitutions favour environment protection whereas others find negative effect.

2.1. Theorical arguments

2.1.1. Democracy improves environment quality

According many authors, democracy is vertious and has a positive effect on environment quality. Payne (1995) argues that population, in democratic countries, are free to collect information about environment quality. They can express their preferences and put pressures on their governments. With democacy, citizens are more aware of environment problems (freedom of media). They can also express their preferences for environment (freedom of expression) and create lobbying groups (freedom of association). Political leaders are prompted (rights to vote) to implement environmental policies at national and international levels. McCloskey (1983) and Payne (1995) put on relief an important ability of democratic countries to satisfy people's environmental préférences and their will to commit themselves to international negociations and agreements. Economics models (Page and Shapiro (1983)) about the link between public and political decisions suggest that when people are well informed about major problems, the latter are widely influenced. In autocratic regimes, populations cannot access information and create lobbying groups.

Deacon (1999) and Olson (1993) argue that political freedoms are in favour of environmental protection because non democratic regimes will under produce environment considered as a public good. According to them, autocratics regims are led by political elites who monopolize and hold large share of national incomes and revenues. The implementation of rigorous environmental policies can lower the levels of production, income and consumption, which, in turn impose a higher cost on the elite in an autocracy than on the population whereas the marginal benefit is uniform for both elite and population. Elites in an autocracy are therefore relatively less pro-environment than people in democracy.

According to Acemoglu and Robinson (2006), in democratic countries, the majority of citizens have right to vote, to their preferences and the government is supposed to represent that in economic policies. As the preferences of median voter are important in democratic elections and it marginal cost of the implementation of environmental policies is lower than autocratic leaders, the adoption and implementation of environmental policies will prevail in democratic countries. The leaders in the preservation of biodiversity or fighting of climate change would be models for other countries.

Congleton (1992) analyses the effect of political regimes (democratic or autocratic) on environmental policies. He supposes that temporal short horizon contributes to a weak regulation of environmental policies. As the consequences of environment degradation appear on the long term, political leaders can have myopia behaviour and under produce environment. Indeed, the short duration of electoral cycles incites political leaders to adopt economical politics favourable to their re-elections. It is difficult to implement policies and to impose to population, who are also voters, a change of behaviour on problems which the consequences will be at the future.

2.1.2. Democray hurts environment quality

Many authors think that democracy does not favour environment protection. The implementation of democratic institutions comes with individual freedoms. Desai (1989b) thinks that democracy doesn't protect environment because democracy is a factor of economic growth and prosperity, which hurt the quality of environment. Democracy is also correlated with factors such as property rights and social infrastructures that boost economic growth.

Firstly, Hardin (1968) worries about the management and overexploitation of environmental and natural resources. The property rights of environmental and natural resources (for example air, oceans, forests) are not well defined. This overexploitation is accelerated in democracies in which individuals have business and economic freedom.

Secondly, Paehlke (1996) thinks that the nature of environment and democracy are different. Environment is a global phenomena whereas democacy works on national and local levels. Consequently, environmental problems could not be resolved in an adequate and opportune way. For example, Heilbronner (1974) supports the idea that global growth of population threatens environmental quality. Autocratic countries can restrain demographic dynamic while democratic countriest must respect people freedoms.

Moreover, Dryzek (1987) notices that democracies are also economic markets wherein lobbying groups are very important. According to him, there are many countries where political leaders are influenced by lobbying groups and multilateral companies. Democracies are not considered as protecting environment quality as they are supposed to satisfy the preferences of markets and lobbying groups which aims at maximizing their economic profit that is not in favour of a better environment quality.

Finally, we think that when democracy is established, institutions becomes more complex and rigid. So, Olson (1982) and Midlarksy (1998) claim that lobbying groups are partially responsible for the rigidity of institutions in mature democracies. In other words, in mature and democratic countries, the supply of public goods could be reduced by an important number of lobbying groups which are less or not incited to take care of society interests. They can try to influence or to control legislatif and administratif process. Consequently, public policies could be less favourable to environment quality when they are influenced by lobbying groups.

Theorical arguments show that it's difficult to predict the impact of democratic institutions on environmental quality. Let us now turn to the empirical findings.

2.2. Empirical results

Congleton (1992) is one of the earliest scholars who explored the effect of political institutions on the willingness of governments to control environment quality. He uses ordinary least squares (OLS) regressions and finds that democratic countries have higher methane and Chlorofluorocarbon (CFC) emissions than autocratic countries. He also finds that they are more likely to sign the Vienna Convention and the Kyoto Protocol.

Contrary to him, Barret & Graddy (2000) use panel data (with generalized least squared and random effect) and conclude that political and civic freedoms reduce some pollutants (Sulfur dioxide) but have no effect on other pollutants (water pollution). Torras &Boyce (1998), using the same data and OLS, also find that political and civic freedoms have a positive effect on air and water quality in least developing countries. Scruggs[2] (1998) finds that democracy has no effect on environment quality (dissolved oxygen, fecal coliform and particules emissions) but increases sulphur dioxide emissions.

Gleditsch & Sverdrup (2003) run simple bivariate correlations with Polity data and find that democracy is harmful for climate gases. Midlarsky (1998) runs multivariate OLS regressions and concludes that democracy increases carbon dioxide emissions and deforestation but protect land area.

Li & Reuveny (2006), using a large sample (between 105 and 143 countries), show that democracy (continuous and dichotomous variables) reduces environmental degradation (carbon dioxide emissions, nitrogen oxide, land degradation, deforestation, organic pollution in water). They also indicate that the effect of democracy varies in size accross the five environmental indicators.

Finally, Bernauer & Koubi (2009) test the effects of political institutions on air quality in 42 countries over the period 1971-1996 and find interesting results. Firstly, democracy has an independant positive effect on air quality. Secondly, presidential systems favour environmental protection than parliamentary systems. Thirdly, they show that labor union strength reduces the environment protection whereas the green parties improve it.

A important limitation with these previous studies is that they are interested in the effects of political institutions on environmental quality. None of them explicitly identify channel transmissions through the political institutions affect the environmental quality.

3. Democratic Institutions and environment quality: potential channel transmissions

In this section, we identify the potential transmission channels between democratic institutions and environment quality.

3.1. Democratic institutions and income inequality

[2] He always uses Freedom House data.

An important caracteristic of democracy is the right to vote. Indeed, an exclusion of an important part of population leads to a biais in political leaders's preferences. Many authors assert that an improvement of democratic institutions increases the possiblities of people to ask for a better distribution of income (Boix, 1998). As they are democratically elected, democratic leaders are incited to adopt redistribution policies such as minimum wage, prices subsidy and progressive taxation for the poor and middle classes. In other words, democratic process is supposed to reduce income inequality. On the contrary, autocratic leaders will tend to adopt policies that are in favour of the elite in powers and maintain consequently, they maintain income inequality.

Scully (1992) shows that countries where property rights and political openness exist, are less inequaliterian than countries where they aren't implemented. Using a transversal analysis for 126 countries over 1960-1998, Gradstein et al. (2001) show that the effect of democracy on income inequality depends on ideology that is the dominant religion in the country. So in Judeo-Christian societies, democracy is a factor of reduction of income inequality while it has no effect in Muslims and Confucian societies. In these countries, equity is a social value really important and income transferts are made in an informal way (family for example). Muller and Stratmann (2002) show that a high rate participation of citizens in the elections, affects the government policies, what tends to reduce income inequality. This income inequality reduction is made through income transfers or the size of government (spendings). Reuveny and Li (2003) also conclude that democracies have a positive effect on income distribution.

3.2. Democratic institutions and investments

In the analysis on the relation between democratic institutions and investments, there are two opposing trends. One concludes that democratic institutions reduce investments and the other one, they increase them.

According to Huntington and Dominguez (1975), in democracy, people have to choose between consumption and saving, but tend to be in favour of the latter. Indeed, democracy allows the median voter to redistribute the revenues in favour of the poor what reduces saving and investment. Some authors such as Alesina and Rodrik (1994) think that democracy can allow expropriation of physical capital by the median voter if his income is lower than average income or if he has greater political rights.

However this point of view is questionned by other authors who think that political institutions favour investments. Firstly, the establishment of a political democratic system requires a broad social consensus allowing the political process to be more stable and more efficient than autocratic regimes. Economic agents would also be more incited to invest in democratic countries than in autocratic countries wherein social consensus is low. Helliwel (1994), Pastor and Hilt (1993), Pastor and Sung (1995) conclude that democratic institutions have positive effect on private investments.

Moreover, democratic regimes are also politically stable so they attract investments. In political instability, economic agents consume more and reduce saving. Moreover, political instability is also a factor of uncertainty because it increases risks and/or perception of

investment risks. Its reduces rights and safety of investors. Yi (2001) shows that political freedoms increase investments while uncertainty and political instability reduce them.

4. Empirical Analysis

4.1. Estimation method and empirical procedure

4.1.1. Empirical Procedure

The objective of the paper is to analyse the effect of democratic institutions on environment quality and also to identify potential channel transmissions. We think that one hand, democratic institutions have direct effect on environment quality and other part, indirectly through income inequality and investments.

Our empirical procedure follows three steps. In first step, we estimate our environmental variables carbon dioxide per capita emissions on democratic institutions and control variables without channel transmissions. Control variables are from environment economic literature and are determinants of carbon dioxide per capita emissions. There are income per capita, carbon dioxide per capita at the beginning of period, population growth and trade openness.

$$Log\left(e_{i,t}\right) = \alpha_i + \beta Institutions + \omega X_{i,t} + \gamma_t + \varepsilon_{i,t} \quad (1)$$

With $e_{i,t}$: the average quantity of carbon dioxide per capita (CO2) and sulfur dioxide per capita (SO2) (in ton metric) in a country (i) at a year t ; $x_{i,t}$ are control variables without transmission channels; $Institutions$ is our interest variable. The period is 1960 to 2008 and data are compiled in five-year averages. Our sample is made of 122 developed and developing countries.

In a second step, we include in the equation (1) the channel transmissions variables allowing democratic institutions to affect indirectly environment quality (SO2, CO2). There are income inequality and investments.

$$Log\left(e_{i,t}\right) = \alpha_i + \delta Institutions + \beta TC_{i,t}^{j} + \omega X_{i,t} + \gamma_t + \varepsilon_{i,t} \quad (2)$$

In a last step, we empirically test the effect of democratic institutions on each transmission channel.

$$TC_{i,t}^{j} = \alpha_i + \beta Institutions + \gamma_t + \varepsilon_{i,t} \quad (3)$$

With TC^j a vector of channel transmissions: income inequality and investments.

4.1.2. Estimation strategy

In order to estimate this model we use adequate econometric techniques. The panel data take into account transversal, temporal dimensions observed and unobserved heterogeneity of countries. It is inadequate to estimate equations (1) and (2) using respectively OLS (Ordinary Least Square), Fixed Effects (FE) and/or Random Effect (RE) because the former (OLS) doesn't take into account unobserved heterogeneity of countries

and the latter (FE, RE) is inadequate for dynamic models. Indeed, the dependent variable is lagged and endogenous. We use the GMM-System (Generalized Method of Moment) from Arellano-Bond (1991), Arellano-Bover (1995) and Blundell-Bond (1998).

The GMM-System (Generalized Method of Moment) is a method that estimates a system of two equations: one equation in level and the other in first difference. In the first estimate, we use lagged variables in level of at least one period as instruments of the equation in first difference. It removes unobserved time invariant and unobserved individual characteristics. The conditions to be met are the error terms are uncorrelated and that explanatory variables are weakly exogenous. In the second estimate, we use variables in first difference lagged of at least one period as instruments of the equation in level.

To check the validity of results we use the standard Hansen test of over-identifying restrictions (where the null hypothesis is that the instrumental variables are not correlated with the residual) and the serial correlation test (AR(2), where the null hypothesis is that the errors exhibit no second-order serial correlation).

4.2. Determinants of environmental quality

4.2.1. Environmental quality

In the absence of a single measure of environmental quality, many indicators have been used in the literature as proxy for environmental quality. For the purpose of our study, we use two pollutants variables. These are carbon dioxide $(\boldsymbol{CO_2})$ per capita and sulfurdioxide $(\boldsymbol{SO_2})$ per capita. The choice of CO2 as an environmental indicator is based on two reasons. Firstly, data on carbon dioxide emissions are available for longer time-series than any other pollution indicator. Secondly, at the global level, CO2 is an immediate cause of greenhouse gas, responsible for global warming and climate change. Moreover, carbon dioxide emissions contribute to global warming more than any other greenhouse gas. At the domestic level, while CO2 by itself does not pose any immediate health hazard to human beings, it is usually a by-product of increased industrial activity, which, in the absence of stringent regulation, can be a source of toxic emissions and particulates that pose environmental concerns.

The choice of SO2 as another environmental variable is also based on two arguments. Firstly, contrary to carbon dioxide emissions, sulfure dioxide is a local pollutant. It is widely regarded as one of the most prominent form of air pollution worldwide, since it has direct and visible effects on human health, ecosystems, and the economy ((Konisky, 1999). SO2 has negative effects on the human body. It causes acid rain, which damages forests, lakes, buildings, cultural objects, and agricultural production. It also reduces visibility, from light mist to dense gray smog. Moreover, particles (smoke and soot), sulfur dioxide (SO2), ozone (O3), lead, Nitrogen oxides (NO, and NO2, together NOx), and carbon monoxide (CO) constitute the so-called criteria pollutants. These indicators are used to measure and describe the air quality in a country. Secondly, data for SO2 emissions is more reliable than data for other forms of air pollution (so-called criteria pollutants), and it is also available for a rather large number of countries since the 1970s. Data with similar properties is not available for most other environmental quality indicators, such as NOx, VOC, CO, PM, ozone.

4.2.2. Control variables

We refer to the literature on environmental economics and identify determinants of environmental quality. There are income per capita, trade openness, population growth and air pollution emissions at the beginning of period.

Carbon dioxide and Sulfur dioxide emissions per capita at the beginning of period.

In our opinion, we think that the environment quality (for example carbon dioxide per capita) at the begining of period can be an important determinant of current level of carbon dioxid per capita. It takes into account the inertia degree of air pollution and time neccessary to implement environment policies or to reduce air pollution.

Income per capita

The relation between income per capita and environment quality has been widely studied in literature. Income can affect environment quality through the scale of economic activity, the composition (or structure) of economic activity, and the effect of income on the demand and supply of pollution abatement effort.

The larger the scale of economic activity, all else equal, the higher the level of environmental degradation (pollution, resource depletion) is likely to be, since increased economic activity results in increased levels of resource use and waste generation, if nothing else changes. Since income is acting as an indicator of economic activity, we would expect a positive relationship between environmental degradation and income, while controlling for all other income-related effects.

The composition of economic activity affects environmental quality because of the differential pollution (and resource-using) intensity of different sectors of the economy. The primary sector (agriculture, fisheries, forestry, and mining) tends to be more resource intensive than either the secondary (industry) or tertiary (services) sectors. The industry (especially manufacturing), on the other hand, tends to be more pollution-intensive than either agriculture or services. Since the structure of the economy (sectoral composition of output) changes with economic growth, part of the effect of increases in income per capita on environmental degradation reflects the effects of changing composition of output. Since the share of industry in GDP first rises with economic growth and then declines as the country moves from the pre-industrial to the post-industrial stage of development, we can suppose an inverted-U shaped relationship between environmental pollution and income level while controlling for all other influences transmitted through income. In other words, in the earlier phases of development there is a shift away from agriculture toward heavy industry which increases emissions, while in the later stages of development there is a shift from the more resource intensive extractive and heavy industrial sectors toward services and lighter manufacturing, which supposedly have lower emissions per unit of output. This is environmental Kuznets curve (EKC). This hypothese has been validated for some pollutants such as sulfur dioxide, carbon monoxide, nitrogen oxides (Grossman and Krueger (1995), Selden and Song (1994), Shafik (1994), Suri and Chapman (1998) and Bimonte (2002). For other pollutants such as carbon dioxide, results are mixed or contradictory. Indeed, Holtz-Eakin and Selden (1995) don't validate the EKC while Schmalensee et al. (1998) do it.

While the generation of pollution is driven by scale and composition of economic activity, the abatement of pollution is driven by demand and supply factors both of which are influenced by income. On the demand side, at low-income levels, people are more concerned with food and other material needs and less concerned with environmental quality. At higher income levels, people want higher levels of environmental quality. Selden and Song (1995) think that the relationship between income and demand for environmental quality translates into an inverted-J curve between income and environmental degradation. In contrast to the inverted U-curve relationship of the reduced-form model, the inverted J-curve indicates a non-increasing relationship between environmental degradation and income once the scale and composition of output are controlled for. This is a reflection of the non-negative income elasticity of environmental quality which is visible in the J-curve but masked by scale and structural factors in the U-curve. On the supply side, low incomes cannot afford countries and individuals much expenditure on pollution abatement even if the demand were there. Economic growth not only creates the demand for improved environmental quality, but it also makes the resources available to supply it. Higher incomes enable higher public expenditures on environmental infrastructure as well as environmental regulations that drive private sector expenditure on abatement technologies.

Trade openness

Grossman and Krueger (1995) decompose the effects of trade on environment into scale, technical and composition effects. The scale effect of trade measures the negative environmental consequences of scalar increases in economic activity. The technical effect is the positive environmental consequences of increases in income that call for cleaner production methods. The composition effect can have a positive or negative impact on the environment because it measures the evolution the economy towards a more or less appropriate productive structure. Thus, Antweiler and Al (2001) conclude that trade reduced emissions of pollution of 43 countries over the period 1971-1996. Frankel and Rose (2005) also conclude that trade is favourable to the reduction of pollution. However, other authors such as Managi (2004) conclude that trade has a negative impact on carbon dioxide emissions.

Population growth

Many authors analyse the effect of growth and the level of population on environment quality. According to National Academy of science (NAS, 1992), “The more people there are in the world, the greater is the demand put on resources to provide food, energy, clothing and shelter for them. All these activities necessarily involve emissions of greenhouse gases”. Newell & Marcus show there is a ‘‘nearly perfect’’ correlation (99,8%) between world population growth and growing concentration of carbon dioxide over the period 1958-1983. Holdren (1991) and Harisson (1994) use mathematical formula to find a contribution of population growth to greenhouse gas emissions. They conclude that population growth is responsible for 40% (36%) of the increase in energy consumption (annual emissions growth) respectively. However Lutz (1993) found that population growth has a small role in industrial carbon dioxide emissions. They also show that population growth rate has a positive effect on pollution.

4.2.3. Transmission channels variables

Investments

According to Brock&Taylor (2004), a high investment rate leads to high physical capital stock at regular state and increases carbon dioxide per capita emissions during transitional dynamic. Investments are the motor of economic growth. Foreign and domestic investments allow countries to access international markets, trade, new technologies and competences. However these opportunities can differ with countries development.

In some countries, investments are directed towards building, services and manufacturing sectors. In other countries, they are directed towards natural resource sectors in particular, oil firms, wood companies, big consumers of energy and thus pollutants. For example in Africa, 65% of direct foreign investments go to the natural resources sector. The expected effects are a rise of employment, a rise of taxes, a rise of revenues for the states and the reduction of poverty. These countries can also be less sensitive to environmental problems. In the same way, the weakness of infrastructures, particularly roads, strongly increases the use of energy and consumption of polluting resources.

Income inequality

Many scholars such as Boyce (1994), Marsiliani& Renström (2000), Borghesi (2000) have analysed the effect of income inequality on environment quality. Some authors conclude that income inequality favours environment protection whereas others find negative effect.

Firstly Boyce (1994) develops theorical arguments that income inequaliy increases environment degradation through the rate of time preference and the benefit-cost analysis of environmentally degrading activities. As to the first point, Boyce (1994) thinks that income inequality reduces awarness of environment quality for both rich and poor. The poor would overexploit natural and environmental resources because of survival motivation. Similarly, rich people will not also protect the environment quality. Income inequality increases and exacerbates conflicts in income distribution and political instability. The polarization of resources and incomes causes violence and social trouble. This leads rich people to prefer a policy of overexploiting the environment and natural resources and investing the returns abroad.

Secondly, political power is highly correlated to income inequality. Rich people are likely to have political power and to influence environmental policies. The implementations of environmental policies are based on cost-benefit analysis, the competition between people who benefit from the environment destruction and those who bear the cost of it. Therefore Boyce (1994) concludes that income inequality affects the distribution of power and allows people who benefit from activities that degrade the environment (the rich) to impose environmental cost on the losers.

Thirdly, Borghesi (2000) argues that the implementation of environmental policies is likely with social consensus. It is easier to get this consensus in an equal society that in an unequal society with conflicts among political agents and social instability.

Several empirical studies have found that income inequality degrades environmental quality. Magnani (2000) finds that reductions in pollution are more likely if a country's economic

growth is accompanied by improvements in income equality. In a study of tropical countries, Koop and Tole (2001) conclude that inequalities of income and landownership tend to exacerbate deforestation. Mikkelson *et al.* (2007) and Holland *et al.* (2009) find income inequality to be a statistically significant predictor of biodiversity loss.

However other scholars think that income inequality may have no effect or improve environment quality.

Firstly Ravallion et al.(2000) claim that the impact of income distribution on environmental degradation depends on the marginal propensity to emit (MPE). According to them, each agent has an implicit demand function for air pollution (carbon dioxide) since the consumption of every good pollute the environment quality either directly (via consumption) or indirectly (via its production). If the poor have a higher (lower) MPE than the rich a reduction of income inequality will increase (reduce) pollution emissions respectively. One can't say a priori which of these two effects will happen. On the one hand, the poor may consume goods with more pollution than the rich. On the other hand they can use energy more efficiently than the rich. Therefore the effect of income inequality is not clear and depends on whether the marginal propensity to emit increases or decreases as income grows. In other words it depends on the second derivative of the pollution-income function.

Secondly, Boyce (2003) shows that income distribution affects the demand for environmental quality. At any given level of average income, an increase in income inequality means the rich become more rich and the poor more poor. He supposes that the environment is a normal good and the income elasticity of demand for environmental quality is positive. An increase in income inequality increases the demand for environmental quality of the rich and decreases the demand of the poor. The net effect on demand for environmental quality is ambigious and is function of the shape of the demand-income relation. If the relation is linear or demand for environmental quality increases with income at a constant rate, an increase in income inequality will have no effect on the demand for environmental quality. If the demand-income relation is convex (concave) income inequality reduces (improves) environmental quality.

4. 3. Overview of the Data

The time period under study is 1960-2008 for 122 developed and developing countries. Our panel data are time period corresponding to five-year averages (1960-1964, 1965-1969,…). The data on carbon dioxide per capita, investments, trade openness, population growth and income per capita are from World Development Indicators (2008). Those on democratic institutions, income inequality and sulfure dioxide per capita come respectively from Polity IV (2008), Texas Inequality Project (UTIP 2008) database and David Stern (2004).

The carbon dioxide per capita emissions are measured in metric ton per capita and are estimated from the combustion of fossil energies, cement industries in the liquid, solid or gas form. Trade openness and investment correspond respectively to the share of the sum of (exports and imports) and investments in gross domestic product (GDP).

As democratic institutions, we chose the index of polity(2), which is a score obtained by differencing of the index of democracy and index of autocracy on a scale going from +10 (democracy) to -10 (autocracy). The indicator of democracy is characterized by the effective existence of institutional rules framing of the power and the presence of institutions enabling citizens to express their expectations and choose political elites. The autocracy is

characterized by the absence or the restriction of political competition, economic planning and control. The exercise of the power is slightly constrained by institutions and the leaders are only selected within a "political elite".
Income inequality is a GINI coefficient. It comes from Texas Inequality Project (UTIP 2008) database. We use EHII (Estimated Household Income Inequality) variable that is an index ranging from 0 (no inequality) to 1 (perfect inequality) and is based on database of Deninger and Squire (D&S) and UTIP-UNIDO.
The first column of tables (1a &1b) correlates environment variables (carbon dioxide per capita and sulfure dioxide per capita) with the explicative variables such as democratic institutions, income inequality, investments, income per capita, population growth and trade. The signs of these correlations are consistent with our priors. For example carbon dioxide per capita emissions are positively correlated with investments, democratic institutions and negatively with income inequality, income per capita and population. The second column (table1a) contains the correlations between democratic institutions and variables such as channel transmissions (income inequality and investments). Analysing the democratic institutions- channel and channel –carbon dioxide per capita correlations together (column 1 & 2, table 1a), we have an outline of the direction of channel effects. Indeed democratic institutions are positively correlated with investments and investments are positively correlated with carbon dioxide per capita implying that democratic institutions is positively correlated with carbon dioxid per capita positively through investment. The same analysis can be made with income inequality. We find similar conclusions for sulfur dioxide per capita emissions in table 1b. However to confirm or reject correlation results, it is better to estimate our equations and control for other determinants of environment quality.

[Table 1a &1b]

4.4. Résults

Column (1) of table (4a &4b) shows results of equation (1) estimated by GMM-System. An improvement of democratic institutions contributes to a reduction of carbon dioxide emissions per capita and sulfur dioxide emissions per capita. The effect is -0,015 (-0,027) and significant at 5% (1%) respectively for CO_2 and SO_2 . These results are similar to Gleditsch & Sverdrup (2003), Li & Reveuny (2006) and Bernauer & Koubi (2009) who conclude that democratic institutions improve environment quality.

The next coulumns of Table (4a &4b) show results of equation (2) estimated by GMM-System. We estimate the effect of democratic institutions on environment quality emissions and we include control the transmission channels: investments and income inequality.

[Table4a &Table4b]

In column (2) of table (4a&4b), we include invesments in regression. We find that investments have a positive and significant effect on carbon dioxide emissions per capita and sulfur dioxide emissions per capita. Indeed, an increase in investments of 1% contributes to carbon dioxide emissions per capita by 0,80% and sulfur dioxide emissions per capita by 0,18% respectively. Investments can be considered as an important factor of air pollution.

In column (3) of table (4a&4b), we include only income unequality in regression. We think that there would be an endogeneity between environmental quality and income inequality. According to Arrow *et al.* (1995), economic activity depends on the environmental resource base. High and imprudent use of the environmental resource base may reduce the capacity for generating material production and income in the future. The environmental resource base includes assimilative capacities for waste discharges.Secondly, the poorest are vulnerable to environmental degradation since they depend heavily on natural resources and have less alternative resource. They are also exposed to environment hazards and are less capable of coping to environmental risks (Dagusta and Mäler, 1994; World Bank, DFID, EC, UNDP, 2002). Furthermore, the rich are more capable of looking after themselves from environmental diseases than the poorest. An increase in environment degradation would affect more the incomes of the poor than the rich and increase the income inequality.To solve the problem of endogeneity, we use GMM-System allowing us to instrument income inequality with lagged variables. Result indicates that an increase of income inequality reduces air pollution emissions (carbon dioxide per capita and sulfur dioxide per capita). Income inequality favours environment protection. These results are also similar to scholars (Ravallion et al.(2000)) who claim that income inequality may have improve environment quality.

The inclusion of investments and income inequality in regression (column (4) of table (4a & 4b) improve the magnitude and the significance of the coefficients of democratic institutions on environment quality. The final regression indicates the effect of democratic institutions, transmission channels (investments and income inequality) and control variables on air pollution. The coefficient on democratic institutions indicates the direct effect on environment quality. Moreover, an increase of magnitude and coefficient of democratic institutions (column (1) to column (4)) would indicate that they may have a partial effect through investments and incomeinequality. It would also be very important and interesting to test the existence of these two potential channel transmissions.

4.4.1. Effect of democratic institutions on channel transmissions

Our results seem to indicate that democratic institutions may have both direct and indirect effects through income inequality and investments on environment quality. In this section, we test the existence of these two channel transmissions. In equation (3.a & 3.b) respectively, we estimate democratic institutions on income inequality and investments.

$$Income\ inequality_{i,t} = \alpha_i + \beta_1 Institutions_{i,t} + \gamma_t + \delta X_{i,t} + \varepsilon_{i,t} \quad (3.a)$$

$$Investment\ rate_{i,t} = \alpha_i + \beta_2 Institutions_{i,t} + \delta X_{i,t} + \gamma_t + \varepsilon_{i,t} \quad (3.b)$$

with $X_{i,t}$: income per capita, population growth and trade openness.

[Table5]

Column (1) of table (5) shows result of equation (3.a) estimated with fixed effects (FE) method. Democratic institutions have a positive effect on investments. Our results are similar with Yi (2001) who conclude that political freedoms (democratic freedoms) attract investments.

Similarly, column (2) shows results of equation (3.b) estimated with fixed effects (FE). Result shows that democratic institutions have a positive effect on income inequality. However we suspect an inverse relation (endogeneity problem) between income inequality and democratic institutions. Firstly, income inequality increases and exacerbates conflicts in income distribution and politicalinstability. The polarization of resources and incomes causes violence and social trouble. This situation can allow illegal activities, protest movements and coup d'Etat (Figueroa, 1996). Secondly, Acemoglu and Robinson (2006) show that income inequality reduce strongly the consolidation of democracies. One argument is that it facilitates and allows a redistribution of incomes in favour of the poors and defavour of richs in power. The burden of democracy on the elites is increasing in the income gap between them and citizens. They would have an incitative to destabilize democracy. Latin America is an example wherein income inequalities do not allow democracy to consolidate. Estimation results are biaised. To solve the problem of endogeneity, we use GMM-System allowing us to instrumente democratic institutions with lagged variables.

Column (3) concludes that democratic institutions reduce income inequality. Thus democracy allows the poor to get more resources through income redistribution.Result is similar with authors such as Boix (1998), Muller and Stratmann (2002). Muller and Stratmann (2002) show that a better participation of citizens in elections (from 40% to 80%) reduces income inequality (Gini Index) in 10%. The reduction of income inequality is explained by income transfers or by government size (expenditure).

Results indicate that democratic institutions have a positive (negative) effect on investments and income inequality respectively. Democratic institutions also affect environment quality indirectly through investments and income inequality.

Indeed, democratic institutions attract investments that hurt environment quality (carbon dioxide emissions per capita and sulfur dioxide emissions per capita). We can conclude that democratic institutions increase air pollution through investments. Similarly, democratic institutions hurt environment quality because they reduce income inequality. Then democratic institutions have opposite effect on environment quality: a positive direct effect on environment quality and negative indirect effects through investments and income inequality. In other words, on one hand democratic institutions improve environment quality and other part, they hurt it through income inequality and investments.

4.4.2. The importance of economic development

An important characteristic of democratic institutions is that their levels are different according to economic development. Table (6) shows that the level of democratic institutions is higher in developed countries (6.95) than in developing countries (-1.37).

[Table6]

Our results indicate that democratic institutions have a positive direct on environment quality. The question is that these results may be biaised and explained by the quality of democratic institutions in developed countries? To answer this question, we distinguish two groups of countries that are developing countries and developed countries and analyse the effect of democratic insitutions on environment quality. The results shown in columns (1) and (2) of table (7) indicate that democratic institutions in both groups have a direct positive effect on environment quality. More interesting, the direct effect of democratic institutions on environment quality in developed countries is higher than in developing countries. This can be explained by the fact that the quality of democratic institutions is better in developed countries than in developing countries.

Another result is that the direct positif effect of democratic institutions is higher for sulfur dioxide per capita than for carbon dioxide per capita in developed countries and in developing countries. These results can be explained by the fact that sulfur dioxide emissions are a local pollutant contrary to carbon dioxide that is a global pollutant.

[Table7]

4.4.3. The form of democratic system

We find that democratic institutions have a direct positive effect on air quality. In democratic institutions there are different forms of gouvernment: presidential and parliamentary. Does the form of democratic gouvernment affect environment quality? Indeed recent research on the provision of public goods such as environment argues that the form of government in democratic political systems is an important factor. Persson et al. (2000) think that presidential system would underproduce public goods because legislative coalitions are unstable and leaders promote the allocation of spending to powerfull minorities. Parliamentary system would increase spending on public goods and satisfy the majority of voters. However, Bueno de Mesquita et al. (2003) develop selectorate theory and show that presidential system would produce more public goods (prosperity, peace, transparency, political rights, and civil liberties) than parliamentary system. Results are mixed for public goods such as education, health care, social security, and foreign policy. Bernauer & Koubi (2008) also find that presidential system reduce sulfur dioxide emissions more than parliamentarysystem. We include in our analysis an index of the type of democratic system. It is a trichotomous variable that takes the value of 0 for presidential democracies; 1 for assembly-elected president democracies and 2 for parliamentary democracies.

[Table8]

Results (columns 2 & 4, table8) indicate that the form of democratic system have no effect on environment quality (carbon dioxid per capita and sulfur dioxide per capita). In other words the nature of democratic institutions has no effect on the environment quality.

4.4.3. Sensitivity analysis

4.4.3.1. The environmental kuznets curve

Most previous papers in the environmental Kuznets curve (ekc) assume that environmental quality is a polynomial function of income per capita. In our paper, we have chosen a linear

relation between income per capita and environmental quality. However, as choice of the functional form, some authors estimate environmental degradation as a quadratic function of income per capita. We test the existence of environmental Kuznets curve by including the squared income per capita. Results (column 1&3 of table 8) conclude that the hypothese[3] of environmental Kuznets curve isn't verified.

4.4.3.2. Econometric method

For estimations, we used one-step Generalized Method of Moments (GMM-system). We re-estimate our equations using two step GMM-system because two step GMM-system estimator is more efficient than one-step GMM-system estimator even if their standards errors can be severly downward biaised in small sample. This potential biais is solved by the method of correction (Windmeijer (2005)) of covariance matrice in finite sample. Results are in tables 9a &9b. We note that results are similar with those obtained by one-step GMM estimator and are robust.

[Table 9a &9b]

Democratic institutions have opposite effect on environment quality: a positive direct effect on environment quality and negative indirect effects through investments and income inequality. In other words, on one hand democratic institutions improve environment quality and other part, they hurt it through income inequality and investments.

4.4.3.4. Alternative empirical strategy: the residuals generated regressors

We use another empirical strategy to analyse the effect and transmission channels of democratic institutions on environment quality. We apply the approach of the residuals generated regressors (Gomanee et al.(2005) to test if income inequality and investments are robust transmission channels of democratic institutions on environmental quality. Our empirical procedure also follows three steps.

In first step, we estimate a basic specification of environmental quality on democratic institutions, transmission channels (investments ($Inv_{i,t}$), Income inequality ($Ineq_{i,t}$)) and control variables.

$$Log(e_{i,t}) = \alpha_i + \delta Institutions + \beta TC_{i,t}^{j} + \omega X_{i,t} + \gamma_t + \varepsilon_{i,t} \qquad (4.a)$$

$X_{i,t}$: Income per capita, carbon dioxide per capita at the beginning of period, population growth, trade openness and $TC_{i,t}^{j}$: investments ($Inv_{i,t}$), Income inequality ($Ineq_{i,t}$).

Secondly, we empirically test the effect of democratic institutions on each transmission channel and run a bivariate regression between the transmission variables (investments ($Inv_{i,t}$), Income inequality ($Ineq_{i,t}$)) and democratic institutions.

$$\text{TC} = \Omega Institutions + K \qquad (4.b)$$

[3] Others authors (Grossman and Krueger (1994), Sha…k (1994), Grossman (1995), Torras &Boyce (1998)) have found that for some environmental variables the environment income relationship may be better described by a cubic function of income per capita. In others words environmental degradation first increases, then decreases and finally rises again. We also test the cubic function of income per capita but results are similar to quadratic form of income per capita. Results are available upon request.

Where the coefficient Ω gives a measure of the strength of the relation between the channel transmission and democratic institutions and *K*, representating the part of transmission channel (investments or income inequality) that is not attributed to democratic institutions.
In equation (4.a), we have both democratic institutions and transmission channels. If democratic institutions affect the transmission variables and if democratic institutions and the transmissions variables are determinants of environmental quality, thus the coefficient of democratic institutions,δ, is an estimate of a direct effect on environmental quality while the coefficient of the transmission channel variable, β, gives an estimate of the effect on transmission channel on environmental quality –including the effect of democratic institutions on environmental quality via each transmission channel. To be able to check if democratic institutions have direct and indirect effects on environmental quality, we need to purge for transmission channel induced by democratic institutions.
From equation (3.b), we construct the residual estimates ($TC_{i,t}^{j}$res) of each trasmission channel (investments (Invres) and income inequality (Ineqres)). These are the part of transmission channel (investments or income inequality) that is not attributed to democratic institutions. Thirdly, we substitute $TC_{i,t}^{j}$res (Invres, Ineqres) for $TC_{i,t}^{j}$ (Invesments, Income inequality) respectively in the basic equation (4a). We have:

$$Log(e_{i,t}) = \alpha_i + (\delta + \Omega * \beta)\, Institutions + \beta TC_{i,t}^{j}\text{res} + \omega X_{i,t} + \gamma_t + \varepsilon_{i,t} \quad (4.c)$$

This transformation will affect only the coefficient on the democratic institutions variables. In cases where the ‘‘transmission’’ variable has a positive effect on explained variable ($Log(e_{i,t})$) and democratic institutions has a negative effect on the ‘‘transmission’’ variable, this method will provide for a lower coefficient on democratic institutions. If the variable has a negative on $Log(e_{i,t})$ and democratic institutions are a positive determinant of the transmission variable, the coefficient on democratic institutions will increase. If democratic institutions is not a determinant of ‘‘transmission variable’’ there is no effect and this method is not used.

Columns (2, 4 and 6) of table10 (a&b) present the estimation results of equation (4.c) with the generated regressor (Invres and Ineqres). Results indicate that Invres (the part of investments that is not attributed to democratic institutions) and Ineqres (the part of income inequality that is not attributed to democratic institutions) are determinants of environment quality. A comparaison of columns (1) and (2) of tables 10a&b indicate that the coefficient on democratic institutions reduce (from -0.123 to -0.119) when we substitute Invres for Investment. This reduction allows us to conclude that the coefficient on democratic institutions (column (2)) capt its direct effect on environment quality and the indirect effect through investments. In other words, investments are a transmission channel of democratic institutions. Conclusions are similar for income inequality.

5. Conclusion

This paper aims at analysing the effect of democratic institutions on environment quality and at identifying channel transmissions. The main contribution of this paper is that we identify and test some channels by which democratic institutions affect the environment

quality. We identify and test two transmission channels : income inequality and investments. We use panel data from 1960 to 2008 for 122 countries and modern econometric methods that are one-step GMM-System, two-step GMM-System one step, fixed effect estimators and the residuals generated regressors. The results are as follows: Firstly, we show that democratic institutions have opposite effects on environment quality: a positive direct effect on environment quality and a negative indirect effect through investments and income inequality. Indeed, democratic institutions attract investments that hurt environment quality. Similarly, democratic institutions hurt environment quality because they reduce income inequality.

Secondly, we find that the direct negative effect of democratic institutions is higher for local pollutant (SO2) than for global pollutant (CO2). Thirdly, the nature of democratic institutions (presidential, parliamentary) is not conducive to environmental quality. Fourtly, results suggest that the direct positive effect of democratic institutions on environment quality is higher in developed countries than in developing countries. Thus, the democratic process in the first group of countries has increased their awareness for the environment protection.

Results are robust with alternative econometric methods such as two-step GMM-system, the approach of residuals generated regressors and the inclusion of variables such as income per capita squared, the form of democratic government. The positive effect of democratic institutions shows that they allow people to more conscious of environmental problems. Democratic institutions are also responsive to the demand of people by reducing income inequality and increasing investments that favour economic growth. The negative effect on environment quality through income inequality and investments put highlights some importants factors explaining free riding behaviour of some democratic countries. Our empirical analysis also indicates that democracy don't "works" through the form of democratic system: controlling for the form of democratic government, democratic institutions always have a direct positive impact on environment quality. Our results suggest policy implications. They suggest that an improvement of democratization process in countries (specially developing countries) allowing a high awareness of people. Countries should also find ways to reduce the indirect negative impact of democratic institutions on environment quality (for example the implementation of ecologically appropriate investments).

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List of countries included in the sample

Albania,Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Belgium, Burundi, Benin, Bangladesh, Burkina-Faso, Bangladesh, Bulgaria, Bahrain, Bolivia, Brazil, Botswana, Canada, Central Africa, Chile, China, Cote d'Ivoire, Cameroun, Congo, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Germany, Denmark, Ecuador, Egypt, Eritrea, Ethiopia, Spain, France, Finland, Fiji, Gabon, Ghana, Greece, Guatemala, Honduras, Haiti, Holland, Hungary, Indonesia, India, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Korea, Kuwait, Liberia, Libya, Luxembourg, Lesotho, Lithuania, Macedonia, Mexico,Madagascar, Mali, Mauritania, Malawi, Malaysia,Morocco, Moldovia, Mongolia, Mozambique, Myanmar, Nigeria, Netherland, New Zealand, Niger, Nicaragua, Nepal, Norway, Pakistan,Panama, Peru, Philippines, New Guinea, Guinea, Poland, Portugal, Paraguay, Qatar, Romania, Russia, Rwanda, the United Kingdom, Saudi Arabia, Senegal, Sri Lanka, Sierra Leone, El Salvador, Sudan, Syria, Sweden, Switzerland, Tanzania, Togo, Thailand, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, the USA, Uruguay,Venezuela, South Africa, Zambia, Zimbabwe.

Table 1a : Correlation matrix for explicatives variables and Carbon dioxide per capita

	C02/ capita	Democratic Institutions	Income Inequality	Investment	Income /capita	Population	Trade
C02/ capita	1.0000						
Democratic Institutions	0.2787	1.0000					
Income Inequality	-0.2577	-0.3898	1.0000				
Investment	0.1153	0.0492	-0.2643	1.0000			
Income/ capita	-0.0050	-0.0235	-0.0256	0.2497	1.0000		
Population	-0.1364	-0.5537	0.4609	-0.1123	-0.0255	1.0000	
Trade	0.1468	0.0406	-0.0338	0.2648	-0.0742	-0.0922	1.0000

Source : Author

Table 1b : Correlation matrix for explicatives variables and sulfur dioxide per capita

	S02/ capita	Democratic Institutions	Income Inequality	Investment	Income /capita	Population	Trade
S02/ capita	1.0000						
Democratic Institutions	0.0832	1.0000					
Income Inequality	-0.1521	-0.3834	1.0000				
Investment	0.0787	0.0531	-0.2819	1.0000			
Income/ capita	-0.0211	-0.0324	-0.0256	0.2593	1.0000		
Population	-0.0121	-0.5690	0.4855	-0.1230	-0.0344	1.0000	
Trade	0.1034	0.0282	-0.0295	0.2738	-0.0725	-0.0340	1.0000

Source : Author

Table2: Papers studying the effect of democracy on environment quality

Authors	**Environment indicators**	**Results**	**Sample**
Congleton (1992)	Methane per capita	+	118 countries for 1989
	CFC per capita	+	
Midlarsky (1998)	CO2 per capita	+	98 countries i for 1990
	soil erosion by water	+	97 countries for the 1980s,
	% of annual deforestation	+	77 countries from 1981 to 1990
	% of protected land area	+	100 countries in 1993
	freshwater availability	No effect	97 countries in 1990
	the level of soil erosion by chemicals	No effect	97 countries during the 1980s.
Barrett & Graddy (2000)	sulfur dioxide per capita	-	a pooled sample of countries for about 33 years
	water pollution	No effect	45 countries for about 29 years.
Torras and Boyce (1998)	Air pollution (SO2, smoke, particulate emissions)	-	Samples of 19–42 countries from 1977 to 1991
	Water pollution (dissolved oxygen, fecal	-	58 countries from 1977 to 1991

	coliform, access to safe water, and access to sanitation)		
Scruggs (1998)	water pollution and particulate emissions	No effect	148–185 sites in 24 countries three periods (1979–1982, 1983–1986, and 1987–1990)
	SO2 emissions	-	
Gleditsch and Sverdrup (2003)	CO2 per capita	-	108 countries in 1990
Li & Reveuny (2006)	land degradation	-	105 countries in the 1980s.
	Carbon dioxide emissions	-	143 countries from 1961 to 1997
	NOx emissions	-	118countries in 1990, time series cross sectional
Bernauer & Koubi (2009)	sulfur dioxide (SO_2) concentrations	-	42 countries from 1971 to 1996

Table3: Descriptive statistics

	Average	**Standard dev**	**Min**	**Max**
Carbon dioxide per capita	4,04	6,69	0	76,16
Democratic Institutions	0 ,32	7,33	-10	10
Investment rate	21,37		2,53	86,79
Income Inequality	41,58	6,67	21.82	62,32
Trade openness	67,83		2,35	466,31
Population growth rate	1,87	1,54	-20,36	11,80
Income per capita	5147,74	7842,89	83,50	53653.35

Source: WDI (2008), Polity IV, University of Texas Inequality Project (UTIP) database (2008) and author

Table4a : Effect of democratic institutions on environment quality

Log of carbon dioxide emissions per capita (One step GMM-System)	(1)	(2)	(3)	(4)
Log of initial carbon dioxide per capita	0.936 (5.09)***	0.826 (13.67)***	0.820 (11.13)***	0.902 (20.45)***
Log of Democratic Institutions	-0.015 (2.01)**	−0.123 (1.83)*	−0.144 (2.15)**	−0.195 (2.03)**
Log of income per capita	0.01 (0.14)	0.005 (0.63)	−0.005 (0.34)	−0.019 (2.10)**
Population growth	-0.015 (0.42)	−0.044 (1.36)	−0.036 (0.79)	−0.025 (0.67)
Log of Trade openness	0.08 (1.13)*	0.055 (0.36)	0.261 (2.39)**	0.12 (1.02)
Log of investment		0.494 (2.97)***		0.50 (2.85)***
Income Inequality			−0.032 (3.66)***	-0.021 (2.32)**
Constant	0.23 (0.90)	−1.237 (1.63)	0.840 (1.72)*	−0.25 (0.30)
Observations	887	823	608	577
Number of countries	122	143	120	117
AR (1)	0.001	0.01	0.001	0.01
AR(2)	0.464	0.92	0.13	0.10
Hansen Test	0.18	0.44	0.11	0.29
Number of instruments	12	15	19	17

NB: * significatif at10%; ** at 5%; *** at 1%. The study period is 1960-2008. Temporal dummies are included.

Table4b: Effect of democratic institutions on environment quality

Log of sulfure dioxide emissions per capita (One step GMM-System)	(1)	(2)	(3)	(4)
Log of initial sulfur dioxide per capita	0.865	0.991	0.852	0.879
	(6.86)***	(7.06)***	(32.00)***	(11.33)***
Log of Democratic Institutions	-0.029	-0.203	-0.063	-0.268
	(3.20)***	(2.59)**	(2.00)**	(2.07)**
Log of income per capita	0.006	0.003	-0.002	-0.012
	(1.10)	(0.49)	(0.26)	(1.31)
Population growth	-0.054	-0.016	-0.015	-0.073
	(1.21)	(0.31)	(0.61)	(1.40)
Log of Trade openness	0.865	-0.056	0.050	-0.031
	(6.86)***	(0.74)	(1.28)	(0.71)
Log of investment		0.183		0.187
		(2.97)***		(1.87)*
Income Inequality			-0.01	-0.019
			(2.11)**	(1.69)*
Constant	-1.797	0.030	-1.447	-1.520
	(1.06)	(0.02)	(3.67)***	(1.16)
Observations	813	751	577	548
Number of countries	115	115	104	101
AR (1)	0,02	0,01	0,03	0,05
AR(2)	0 ,24	0,15	0,21	0,24
Hansen Test	0,12	0,24	0,11	0,13
Number of instruments	20	19	11	26

NB: * significatif at 10%; ** at 5%; *** at 1%. The study period is 1960-2008. Temporal dummies

Table 5: Democratic Institutions and channel transmissions

	Log of investment	Income Inequality	
	(1) FE	(2) FE	(3) GMM System
Log of Democratic Institutions	0.037 (1.90)*	0.380 (1.26)*	-1,29 (-2,31)**
Log of income per capita	0.075 (1.81)*	-2.274 (3.51)***	-0,385 (2.19)**
Population growth	0.059 (3.24)***	-0.047 (0.23)	1.760 (4.18)***
Log of Trade openness	0.290 (7.09)***	0.529 (0.85)	4.978 (1.73)*
Constant	1.014 (2.50)**	60.348 (10.22)***	25.297 (2.12)**
R-squared	0.15	0.25	
Observations	662	663	663
Number of countries	122	122	122
AR (1)			0,18
AR(2)			0,23
Test Hansen			0,13
Numberof instruments			11

NB: * significatif at10%; ** at 5%; *** at 1%. The study period is 1960-2008. Dummy variables are included.

Table 6: Difference of democratic institutions according to economic development

Democratic Institutions	Mean	mini	max	S D
Whole sample	0.32	-10	10	7.33
Developing countries	-1.37	-10	10	6.65
Developed countries	6.95	-10	10	6.01

Source: Polity IV and author

Table (7): Effect of democratic institutions on environment quality according to economic development

Dependent variables (One step GMM-System)	Log of carbon dioxide per capita		Log of sulfur dioxide per capita	
	Developing Countries (1)	Developed Countries (2)	Developing Countries (3)	Developed Countries (4)
Log of intial carbon dioxide per capita	0.836 (15.06)***	1.056 5.21)***		
Log of initial sulfurdioxide per capita			0.864 (31.73)***	0.848 (16.48)***
Log of Democratic Institutions	-0.189 1.92)**	-0.252 (3.92)***	−0.207 (2.19)**	−0.543 (2.79)**
Log of income per capita	-0.020 (1.54)	-0.017 (0.52)	−0.011 (1.10)	−0.045 (1.19)
Population growth	-0.049 (1.68)*	-0.080 (1.72)*	−0.027 (0.73)	−0.087 (1.01)
Log of Trade openness	0.227 (1.61)	-0.321 (1.56)	0.055 (1.02)	−0.159 (2.12)**
Log of investment	0.553 (2.57)**	0.698 (2.47)**	0.187 (1.87)*	0.282 (1.82)*
Income inequality	-0.011 (2.22)**	-0.018 (1.70)*	−0.019 (1.69)*	−0.013 (0.89)
Constant	-1.231 (1.30)	-0.571 (0.76)	−0.942 (1.34)	0.591 (0.68)
Observations	406	171	380	168
Number of codepays	90	27	76	25
AR(1)	0.001	0.09	0.0 3	0.22
AR(2)	0,13	0.32	0.47	0.26
Hansen Test	0,44	0.70	0.60	0.31
Number of instruments	17	17	18	17

NB: * significatif at 10%; ** at 5%; *** at 1%. The study period is 1960-2008. Temporal dummies are included.

Table (8) : Effect on democratic institutions on environment quality

Dependent variables	Log of carbon dioxide per capita		Log ofsulfur dioxide per capita	
(One step GMM-System)	(1)	(2)	(3)	(4)
Log of initial carbon dioxide per capita	0.905 20.01)***	0.887 (20.45)***		
Log of initial sulfur dioxide per capita			0.881 (11.36)***	0.887 (20.45)***
Log of Democratic Institutions	-0.204 (2.16)**	-0.152 (2.17)**	-0.270 (2.08)**	-0.241 (2.64)***
Log of income per capita	-0.047 (1.90)*	-0.015 (1.90)*	-0.018 (0.42)	-0.019 (1.67)*
Population growth	-0.028 (0.73)	-0.016 (0.64)	-0.073 (1.41)	-0.096 (1.74)*
Log of Trade openness	0.106 (0.93)	0.083 (0.82)	-0.031 (0.68)	-0.046 (0.91)
Log of investment	0.491 (2.81)***	0.494 (3.15)***	0.351 (3.75)***	0.458 (3.99)***
Income inequality	-0.021 (2.32)**	-0.018 (2.20)**	0.001 (0.15)	0.000 (0.03)
Income per capita squared	0.002 (1.14)		0.000 (0.13)	
Form of democratic government		0.027 (0.71)		-0.142 (1.49)
Constant	-0.048 (0.05)	-0.401 (0.55)	-1.473 (1.08)	 (2.64)***
Observations	577	568	548	541
Number of codepays	117	115	101	100
AR(1)	0.01	0.01	0.05	0.01
AR(2)	0.10	0.12	0.23	0.59
Hansen Test	0.27	0.22	0.40	0.25
Number of instruments	18	23	27	25

NB: * significatif at 10%; ** at 5%; *** at 1%. The study period is 1960-2008. Temporal dummies are included.

Table 9 a: Effect of Democratic institutions on environment quality

Log of carbon dioxide per capita (Two step GMM-System)	(1)	(2)	(3)	(4)
Log of initial carbon dioxide per capita	0.844 (6.57)***	0.874 (14.04)***	0.785 (12.03)***	0.911 (20.36)***
Log of Democratic Institutions	-0.025 (2.47)**	-0.093 (1.72)*	-0.168 (1.84)*	-0.210 (2.26)**
Log of income per capita	0.019 (1.18)	0.005 (0.62)	-0.010 (0.52)	-0.017 (1.72)*
Population growth	-0.049 (1.22)	-0.041 (1.60)	-0.031 (1.10)	-0.031 (1.00)
Log of Trade openness	0.139 (1.01)	-0.001 (0.02)	0.342 (2.71)***	0.131 (1.16)
Log of investment		0.417 (3.13)***		0.446 (2.73)***
Income inequality			-0.037 (3.66)***	-0.020 (2.30)**
Constant	-0.486 (0.85)	-0.857 (1.88)*	0.960 (1.76)*	-0.164 (0.21)
Observations	887	823	608	577
Number of countries	143	143	120	117
AR (1)	0,003	0,01	0,003	0,008
AR(2)	0,73	0,96	0,13	0,11
Hansen Test	0,13	0,21	0,35	0,29
Number of instruments	14	23	19	17

NB: * significatif at 10%; ** at 5%; *** at 1%. The study period is 1960-2008. Dummy variables are included.

Table 9 b: Effect of Democratic institutions on environment quality

Log of sulfurdioxide per capita(Two step GMM-System)	(1)	(2)	(3)	(4)
Log of initial sulfurdioxide per capita	1.286 (6.52)***	1.063 (13.78)***	0.852 (32.00)***	0.896 (28.31)***
Log of Democratic Institutions	-0.022 (2.19)**	-0.110 (1.89)*	-0.063 (2.00)**	-0.289 (1.87)*
Log of income per capita	0.005 (0.49)	0.002 (0.28)	-0.002 (0.26)	-0.014 (1.11)
Population growth	0.044 (0.83)	0.022 (0.79)	-0.015 (0.61)	-0.042 (1.12)
Log of Trade openness	-0.153 (1.39)	-0.107 (2.05)**	0.050 (1.28)	-0.084 (1.48)
Log of investment		0.191 (3.13)***		0.299 (3.19)***
Income inequality			-0.007 (2.11)**	-0.008 (1.45)
Constant	3.931 (1.49)	0.779 (0.73)	-1.447 (3.67)***	-0.564 (0.65)
Observations	813	751	577	548
Number of countries	115	115	104	101
AR (1)	0,04	0,01	0.03	0,04
AR(2)	0,60	0,23	0.21	0,24
Hansen Test	0,13	0,68	0.18	0,30
Number of instruments	12	22	11	17

NB: * significatif at 10%; ** at 5%; *** at 1%. The study period is 1960-2008. Dummy variables are included.

Table (10a): Effect on democratic institutions on environment quality with residual generated regressors

Dependent variable	Log of carbon dioxide per capita					
	(1)	(2)	(3)	(4)	(5)	(6)
Log of initial carbon dioxide per capita	0.826 (13.67)***	0.830 (8.06)***	0.820 (11.13)***	0.870 (10.14)***	0.902 (20.45)***	0.914 (48.97)***
Log of Democratic Institutions	−0.123 (1.83)*	−0.119 (2.08)**	−0.144 (2.15)**	−0.13 (1.69)*	−0.195 (2.03)**	−0.187 (2.55)**
Log of income per capita	0.005 (0.63)	−0.002 (0.34)	−0.005 (0.34)	−0.001 (0.18)	−0.019 (2.10)**	−0.012 (1.85)*
Population growth	−0.044 (1.36)	−0.013 (0.46)	−0.036 (0.79)	−0.001 (0.07)	−0.025 (0.67)	0.001 (0.06)
Log of Trade openness	0.055 (0.36)	0.047 (0.84)	0.261 (2.39)**	0.061 (0.87)	0.12 (1.02)	−0.011 (0.44)
Investments	0.494 (2.97)***				0.50 (2.85)***	
Investment residue		0.858 (2.65)***				0.431 (4.73)***
Income inequality			−0.030 (3.69)***		−0.021 (2.35)**	
Income inequality residue				−0.023 (2.19)**		−0.018 (3.25)***
Constant	−1.237 (1.63)	0.294 (1.33)	0.840 (1.72)*	0.198 (0.48)	−0.25 (0.30)	0.751 (3.28)***
Observations	823	823	608	608	577	577
Number countries	143	143	120	120	117	117
AR(1)	0.01	0.00	0.001	0.004	0.01	0.006
AR(2)	0.92	0.41	0.13	0.16	0.10	0.25
Hansen test	0.44	0.68	0.11	0.13	0.29	0.30
Instruments	15	17	19	12	17	20

* significant at 10%; ** significant at 5%; *** significant at 1%

Table (10b): Effect on democratic institutions on environment quality with residual generated regressors

Dependent variable	Log of sulfur dioxide per capita					
	(1)	(2)	(3)	(4)	(5)	(6)
Log of initial sulfur dioxide per capita	0.991 (7.06)***	0.978 (7.39)***	0.852 (32.00)***	0.849 (32.16)***	0.879 (11.33)***	0.861 (30.95)***
Log of Democratic Institutions	-0.203 (2.59)**	-0.191 (2.51)**	-0.063 (2.00)**	-0.087 (2.62)**	-0.268 (2.07)**	-0.254 (2.04)**
Log of income per capita	0.003 (0.49)	-0.004 (0.60)	-0.002 (0.26)	-0.003 (0.35)	-0.012 (1.31)	-0.015 (1.46)
Population growth	-0.016 (0.31)	0.000 (0.01)	-0.015 (0.61)	-0.003 (0.13)	-0.073 (1.40)	-0.036 (0.81)
Log of Trade openness	-0.056 (0.74)	-0.059 (0.83)	0.050 (1.28)	0.049 (1.30)	-0.031 (0.71)	-0.006 (0.13)
Investments	0.183 (2.97)***				0.351 (3.91)***	
Investment residue		0.489 (3.29)***				0.473 (3.78)***
Income inequality			-0.007 (2.11)**		0.001 (0.13)	
Income inequality residue				-0.012 (2.14)**		-0.008 (1.31)
Constant	0.030 (0.02	0.441 (0.27)	-1.447 (3.67)***	-1.728 (4.42)***	-1.520 (1.16)	-0.813 (1.40)
Observations	751	751	577	577	548	548
Number countries	115	115	104	104	101	101
AR(1)	0.001	0.001	0,03	0.06	0,05	0.02
AR(2)	0.15	0.14	0,21	0.50	0,24	0.21
Hansen test	0.24	0.19	0,11	0.18	0,13	0.88
Instruments	19	19	11	11	26	16

Robust t statistics in parentheses* significant at 10%; ** significant at 5%; *** significant at 1%

Table 11: Définition and data sources

Variables	Définitions	Source de données
Emissions of carbon dioxide per capita	Carbon dioxide per capita (metric ton per capita)	Word Development Indicators (2008)
Emissions per capita initial	Carbon dioxide per capita at the beginning of each period	
Investment rate	Investment/PIB	
Trade openess rate	(Exportations+Importations) / Gross Domestic Product	
Population growth rate	Population growth rate	
Democratic institutions	Combined score of democracy and autocracy on a scale going from -10 to 10. (- 10) large represents a big autocracy and 10, large democracy	Polity IV
Income Inequality	EHII (Estimated Household Income Inequality) variable is an index ranging from 0 (no inequality) to 1 (perfect inequality)	University of Texas Inequality Project (UTIP) database (2008)