

# Does Education Really Matter For Environment Quality?

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## **Abstract**

This paper examines the importance of education on growth of carbon dioxide per capita emissions over the period 1970-2004 for 85 countries. We use panel data and apply GMM-System estimation. This rigorous approach takes into account observed and unobserved heterogeneity of countries and solves the endogeneity problems of some variables. Our results suggest that education doesn't matter for air pollution growth for 85 countries. In developed countries, education is a factor of pollution growth although its effect is mitigated in presence of political institutions. In developing countries, education doesn't matter for carbon dioxide per capita growth. The absence of effect of education might be explained by the low education level and the relative weakness of political institutions. The combination of these factors strongly reduces the capability of people to express their preferences for a better environment. Our results are robust with alternative education measures.

**Key words:** Carbon dioxide per Capita; Education; GMM-System

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## **1. Introduction**

In recent years, the climate change debate has been renewed attention because these environmental and socio-economic effects are now more evident. Climate Change debate is now the most popular public topic in developed countries. According to many scientists, climate warming is caused by greenhouse gases effect produced essentially by the increase of carbon dioxide emissions.

In the analysis of determinants of environment quality, economic growth is an important factor. An important trend of economic littérature verified the existence of the hypothese of environmental kuznet's curve. According to the environmental kuznet's curve, environment quality is reduced initially with the rise of the income and development process. At a given level, income raises can be then associated with an improvement of environment. Some economists like Grossman & Kruguer (1995) and World Bank Report (1992) justify this hypothese because there would be a positive relation between income and elasticity of environment demand. In other words, environment quality demand increases with income.

Since the Rio summit (1992) education is also considered to be an essential tool for environment protection and sustainable development. Educated people would be more conscious of environmental problems and therefore would have behaviors and lifestyles in favour of environment improvement. Considered as an engine of the economic growth, education also appears to be a vector of the environmental protection.

The paper aims to determine the importance of education on environment quality over the period 1970-2004 for 85 developing and developed countries. We use panel data and apply modern GMM-System estimation. This rigorous approach takes into account observed and unobserved heterogeneity of countries and solves the endogeneity problems of some variables. Our results suggest that education doesn't matter for air pollution growth for 85 countries. However results are different with development. In developed countries, education is a factor of pollution growth although its effect is mitigated in presence of political institutions. In developing countries, education doesn't matter for carbon dioxide per capita growth. The absence of effect of education in developing countries might be explained by the low education level and the relative weakness of political institutions. The combination of these factors strongly reduces the capability of people to express their preferences for a better environment. Our results are robust in presence of income per capita, trade openness, population growth and the use of alternatives education data.

The remainder of the paper is organized as follows. Section 2 shows how education can influence environment quality. Section 3 derives an estimating equation and shows results and the last is devoted to the conclusion.

## **2. How does education affect environment quality?**

From the literature on environmental economics, we group the papers in two different trends.

The first approach is about the civic externalities of education. Nelson & Phelps (1966) consider that education enhances one's ability to receive, decode, and understand information, and that information processing and interpretation matter for learning and change behaviours. In recent years, education is considered as a vehicle for sustainable development and thus for the fight against pollution. For Robitaille (1998), education is a permanent process of learning contributing to the training of citizens whose goal is the acquisition of knowledge, knowledge-being, know-how and good manners. They can engage in individual and collective actions, based on the principles of interdependence and solidarity. This will promote the harmonization of relations "person-society-environment and emergence of sustainable societies, socio-political and economically just here and elsewhere, now and in future."

Farzin and Bond (2006) identify three channels for a positive relation between education level and environmental quality improvement.

Firstly, educated people would be more conscious of environmental problems and therefore would have behaviors and lifestyles in favour of environment improvement. The lack of information and knowledge about the consequences of environmental damage may limit the consumers' willingness to pay. Then, educated people have access to information and change their behaviour. Bimonte (2002) shows that an increase in people's education is often accompanied by increases in their preferences favoring a higher level of environmental protection. For a given income, education increases the minimum level of environmental quality that a country requires.

Secondly, educated people have a higher capacity or ability to use existing means and channels in order to express their environmental preferences. They can also get organized in pressure groups, lobbies to obtain the implementation of environmental public policies. Wheeler et al. (1997) analyse factors encouraging people to complain about environmental damages in China. They show that Chinese provinces with relative low education have a lower marginal propensity to complain about environmental damages. Without education,

people have little information about harmful risks, effects of the environmental damages in the long term and are interested only in obvious impact. That could be also explained by the fact that less educated people have little confidence in their own capacity to influence authorities. Some empirical studies from the World Bank (Wheeler & Huq, 1993) show that without effective government policies, communities with high education take favorable actions to control or reduce emissions of pollution.

Third, Farzin and Bond (2006) consider that educated people are “more likely to generate an environmentally progressive civil service, and therefore have democratically-minded public policymakers and organizations that are more receptive to public demands for environmental quality”.

Despite the relative consensus on the positive effect of education, other authors believe that education is a factor that increases pollution. Jorgenson (2003) finds that education has a positive effect on the ecological footprint. Educated people have more income and purchasing power and are encouraged to an overconsumption of material goods. Indeed, they desire to live well by accumulating material goods without caring about the consequences of this happiness and the ideological model of “consume more to be happier” (Princen et al. 2002) conveyed by advertising and media lead to great consumption of material goods. Because the overconsumption of goods is a factor of over-exploitation of natural resources, educated people contribute to environmental degradation (pollution of air, soil, and water). These empirical results show a positive and significant effect of enrollment on the ecological footprint per capita.

According to the second approach, the accumulation of education has a positive impact on labor productivity and income (Mankiw, Romer and Weil, 1992). According to the environmental kuznet's curve, environment quality is reduced initially with the rise of the income and development process. At a given level, income raises can be then associated with an improvement of environment. That is explained by fact that an increase of income generates resources necessary for pollution abatement. The effect of education on the environment quality can be indirect through income.

Secondly, education facilitates the development and adoption of new technologies more productive in a closed economy (Ann Bartel and Lichtenberg (1987)). According to Welle (1972), educated people adopt innovation sooner than less educated people. From marketing literature, he shows that early (consumer) purchasers of new products are more educated. Nelson & Phelps (1966) conclude that “a better educated farmer is quicker to adopt profitable new processes and products since for him, the expected payoff from innovation is

likely to be greater and the risk likely to be smaller; for he is better able to discriminate between promising and unpromising ideas, and hence less likely to make mistakes. The less educated farmer, for whom the information in technical journals means less, is prudent to delay the introduction of a new technique...”

Education also stimulates the creation of knowledge, innovation as a result of these functions of research and dissemination from research centers and institutions and promotes new ideas and knowledge. These institutions can train many engineers and scientists and develop research sector favorable to pollution abatement. Formal R&D spending is concentrated in OECD countries and developing countries spend relatively less on basic science and innovations. So they rely even more on international diffusion of technology. Many recent researches (Eaton & Kortum 1999; Keller 2001a) concluded that international technology transfers are the major sources of technical progress for both developed and developing countries. Keller (2004) argues that technology comes more from abroad (90 percent or more) than from inside the country. The important question is: is human capital also important for international technology adoption and diffusion? Empirical and theoretical papers suggest the affirmative. Eaton & Kortum (1996), Caselli & Coleman (2001), Xu (2000) show that inward technology diffusion increases with country's human capital. Other major determinants of international technology diffusion are Research and Development expenditures, trade through intermediate input imports (Eaton & Kortum (2001, 2002), learning-by-exporting experience (Bernard and Jensen 1999; Clerides, Lach, and Tybout 1998; Mary Hallward-Driemeier, Giuseppe Iarossi, and Kenneth Sokoloff 2002), Foreign direct investment (FDI) and communication (Keller 2001).

Finally, education can change the structure of exports, which can become relatively more intensive in education and relatively less dependant on polluting extractive exports and increase their capacity to implement environmental policies. If an economy grows initially with the accumulation of polluting physical capital and later with the accumulation of non polluting human capital, then pollution can appear in the shape of a reversed U curve.

### **3. Empirical analysis**

#### **3.1. Econometric specification**

The econometric approach of our paper is to analyze the role education on growth of carbon dioxide per capita emissions. For this purpose, we use the empirical method of Brock & Taylor (2004) and estimate the growth of carbon dioxide per capita emissions on the level of education and a set of control variables.

We write the baseline model as follows :

$$\log\left(\frac{e_{i,t}}{e_{i,t-1}}\right) = \beta_1 \log(e_{i,t-1}) + \beta_2 \log(h_{i,t}) + \delta x_{i,t} + \gamma_t + \alpha_i + \varepsilon_{i,t} \quad (1)$$

with  $e_{i,t}$  the average quantity of carbon dioxide per capita (in ton metric) in a country  $i$  at a year  $t$ ;  $x_{i,t}$  control variables. This equation will enable us to analyze on the one hand the role of education on the growth of pollution and on the other hand, to check if the countries with same economic characteristics and initial conditions have a convergence in pollution emissions per capita. The period is 1970 to 2004 and data are compiled in five-year averages. Our sample is made of 85 countries including 22 developed ones and 63 developing ones.

### **3.1.1 Determinants of growth rate of carbon dioxide per capita emissions**

A large number of variables have been considered in the literature as possible determinants of dioxide carbon emissions. We follow the literature and select control variables reflecting investment rate, population growth, the openness of the economy, political institutions and technical progress.

#### **Level of carbon dioxide per capita emissions**

This is the key variable in the convergence hypothesis. If the estimated coefficient is negative and significative, then we can conclude that countries with low carbon dioxide per capita emissions catch up countries with high carbon dioxide per capita emissions. In other words, convergence occurs when countries with high initial level of per capita CO<sub>2</sub> emissions have lower emission growth rate than countries with low initial level of per capita CO<sub>2</sub> emissions.

#### **Investment and population growth rate**

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 dynamics. Many authors have analyzed the importance of population on environment. 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.

### **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. And 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 Ai (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 favorable to the reduction of pollution. However, other authors such as Managi (2004) conclude that trade has a negative impact on carbon dioxide emissions.

### **Political institutions**

A free political and civil system allows people to easily express their preferences for a better environmental protection. Many authors have analyzed the relationship between political freedom and the quality of environment. Deacon (1999) and Olson (1993) argue that political freedoms are favorable to environmental protection because non democratic regimes will under produce environment considered as a public good. For them, autocratics are governed by political elites who monopolize and hold large share of national incomes and revenues. The implementation of rigorous environmental policies can lower 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. However, Congelton (1992) thinks that political freedoms can have a positive impact on pollution. According to him, democratic governments can be affected by a political myopia contrary to non democratic rulers which lead them to decide on a temporal short horizon.

### **Technical progress**

We define technical progress as all technology and production processes contributing to the reduction even cancellation of environmental damages and/or the use of raw materials, energy and natural resources. We model technical progress from the estimation of economy's carbon dioxide intensity. We suppose that pollution intensity is explained on the one hand by the structure of economy and on the other hand by technical progress which reduce it. Structural factors are the level of economy activities (income per capita), openness to international trade

and the prices of energy. Our approach consists to estimate carbon dioxide intensity on structural factors. Technical progress is then proxied by the coefficient associated to the time trend variable. We estimate the equation (10) by OLS for each country  $i$ .

$$\text{Log}\left(\frac{e_{i,t}}{y_{i,t}}\right) = \gamma_i + \gamma_1 \text{Log}(pcpib_{i,t}) + \gamma_2 \text{energ}_{i,t} + \gamma_3 \text{ouv}_{i,t} + \gamma_4 \text{trend} + \omega_{i,t} \quad (2)$$

( $\frac{e_{i,t}}{y_{i,t}}$ ) being the carbon dioxide intensity,  $pcpib_{i,t}$  the income per capita,  $\text{energ}_{i,t}$  the price of oil and  $\text{ouv}_{i,t}$  the trade openness.  $\text{trend}$  is the time specific dummies.

### 3.2. Estimation method

In order to estimate this model we use adequate econometric techniques. The panel data take into account transversal and temporal dimensions and also the unobserved heterogeneity (for example influence of economic specificities and environmental policies, etc).

We can run estimations using OLS (Ordinary Least Square). However, OLS estimator is weak and biased because our model is a dynamic panel and dependent variable is lagged and endogenous. We then take country and time -specific effects into account and use the System GMM (Generalized Method of Moment). The first-differenced generalized method of moments estimators applied to panel data models addresses the problem of the potential endogeneity of some explanatory variables, measurement errors and omitted variables. The idea of the first-differenced GMM is “to take first differences to remove unobserved time invariant country specific effects, and then instrument the right-hand-side variables in the first-differenced equations using levels of the series lagged one period or more, under the assumption that the timevarying disturbances in the original levels equations are not serially correlated” (Bond, Hoeffler and Temple, 2001). The System GMM estimator combines the previous set of equations in first differences with suitable lagged levels as instruments, with an additional set of equations in levels with suitably lagged first differences as instruments. Blundell and Bond (1998) provide evidence with Monte Carlo simulations that System GMM performs better than first-differenced GMM, the latter being seriously biased in small samples when the instruments are weak.

To test the validity of the lagged variables as instruments, 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, where the null hypothesis is that the errors exhibit no second-order serial correlation. In our regressions, none of the tests of the statistics allows us to reject the validity of the lagged variables as instruments as well as the lack of second order autocorrelation.

### **3.3. Descriptive analysis of data**

The data on carbon dioxide per capita emissions, investment rate, the trade openness and population growth rate are from the World Development Indicators (World Bank, 2005). The data on education and political institutions come respectively from Barro and Lee (2000) and Polity IV (2002).

The carbon dioxide per capita emissions are measured in metric ton per capita come and are estimated from the combustion of fossil energies and 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 political institutions variable, 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”. The data of education resulting from Barro and Lee (2000) correspond to the average schooling years in the total population.

Table (1) presents descriptive statistics of education, carbon dioxide emissions level and growth rate. It shows a high growth rate of carbon dioxide per capita emissions in world (8.23%). This can be explained by pollution growth rate in developing countries (9,4%) indicating their importance in the pollution phenomenon contrary to developed countries (4,3%). We also noticed that countries (Developed countries) with high carbon dioxide emissions are relatively more educated and have low carbon dioxide growth rate.

**Table1:** Descriptive statistics of emissions of dioxide carbon and education

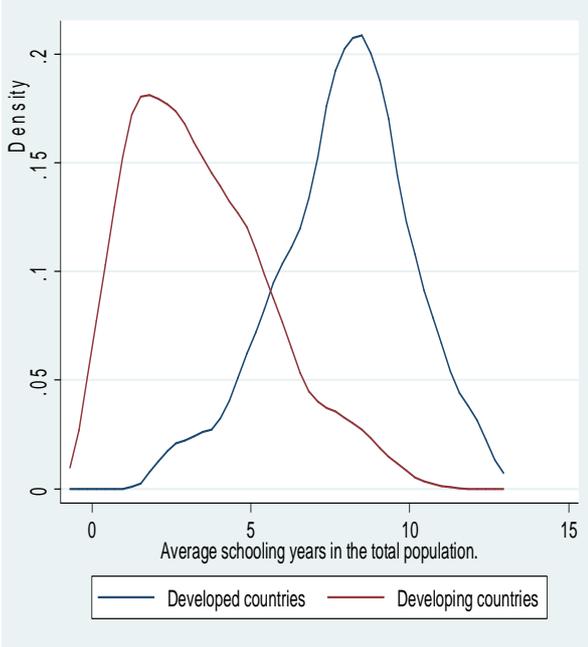
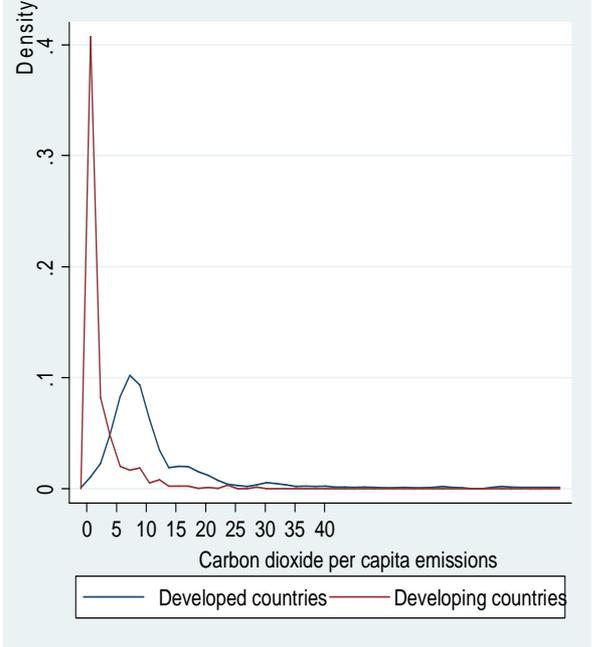
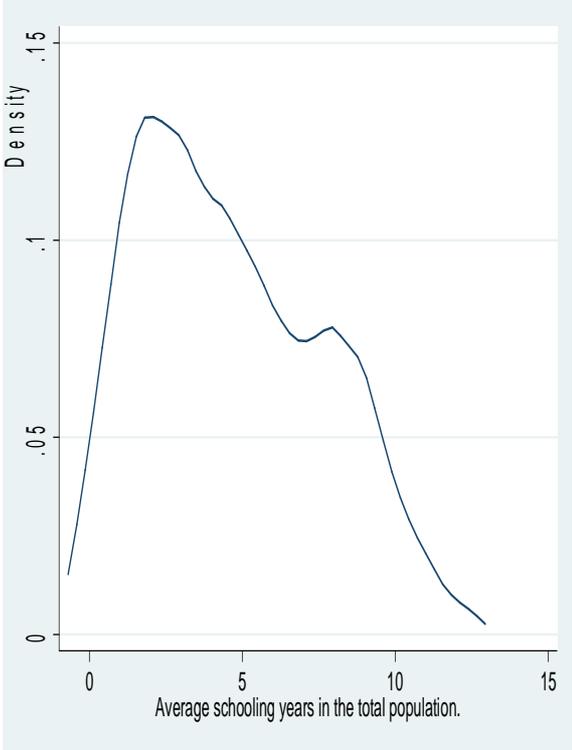
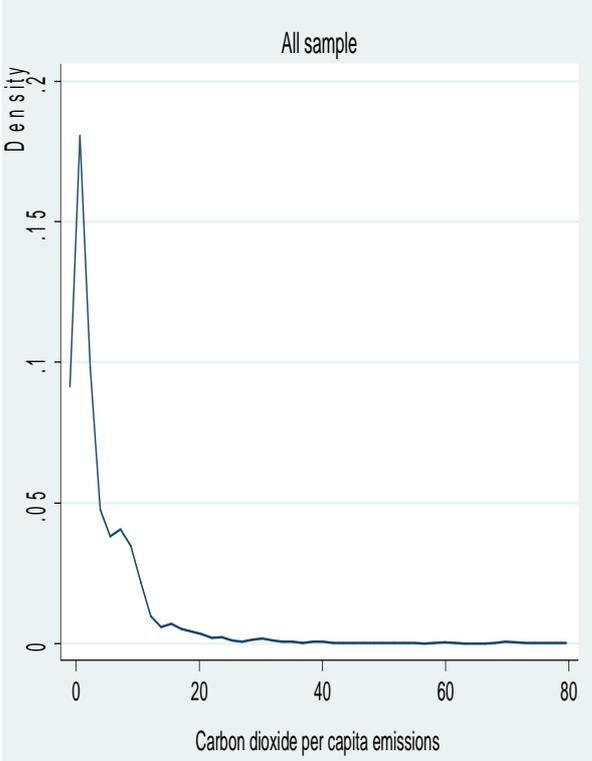
	Average	Standard deviation	Min	Max
<b>World</b>				
Growth of emissions per capita	0,08	0,35	-4,44	2,76
Emissions per capita	4,56	7,91	0,001	78,61
Education	4,67	2,06	0,042	12,21
<b>Developed countries</b>				
Growth of emissions per capita	0,04	0,29	-1,03	2,76
Emissions per capita	12,26	12,11	1,72	78,61
Education	7,93	2,05	2,44	12,21
<b>Developing countries.</b>				
Growth of emissions per capita	0,09	0,37	-4,44	2,59
Emissions per capita	2,17	3,55	0,001	29,10
Education	3,41	2,19	0,04	10,27

Notes: the total sample is composed of developed and developing countries over the period 1970 -2004

Source: Author

In addition, a deep analysis of carbon dioxides and education levels allows noting that their distribution (figure1) differs according to economic development. The distribution graphs of emissions and education of developed countries are more on the right side than those of developing countries. This implies not only a more polluting economic structure in developed countries contrary to developing countries but also a positive correlation between education and carbon dioxide per capita emissions.

**Figure1:** Kernel density of carbon dioxide per capita emissions and education



### 3.4. Results

Table (2) presents our estimate results obtained by Generalized Method of Moments-system (GMM-system). Column (1) shows the absence of conditional convergence in carbon dioxide per capita emissions in world because the coefficient is insignificant and equals - 0.003. This result is in conformity with the preceding studies (Stegman (2005), Aldy (2006), Nguyen (2006)) that conclude to an absence of a convergence in air pollution at the international level. The investment, engine of economic growth and economic development, contributes enormously to pollution growth. Technical progress has a negative and significant effect on pollution growth whereas education and political institutions have no impact on it.

As countries have pollution behaviour according to economic development, we do separate developing countries from developed countries in our estimations. Indeed, we can suppose that Botswana and Luxembourg could have different pollution behaviors.

Columns 2 and 3 of the table (3) show that basic results change when the sample is restricted to developing countries or developed countries. We find a conditional convergence in carbon dioxide per capita emissions for developed countries and a divergence for developing countries. We also note that the effects of education and political institutions on pollution growth are significantly different according to the level of development (developing or developed countries). Indeed, contrary to developing countries where it doesn't influence, education favours pollution growth in developed countries. We get the same result for institutions which contribute respectively to pollution (depollution) in developing (developed) countries.

The role of institutions and human capital as fundamental sources of difference in economic development, highlighted by economic literature, questions us about the possibility that the effect of education on the environment could differ according to the quality of institutions in a given country. Political institutions have a positive impact (negative) on pollution growth in developing countries (developed countries).

#### 3.4.1. The nonlinear effect of education: Interaction between education and institutions

When considered as a public good, environment quality improvement could not be directly determined by the preference of people but rather by their reflection through political institutions. In other words, the interaction between education and institutions could affect environmental protection. Mahon (2006) considers that the effect of education on environment quality could be more effective in the presence of stable political institutions

considered as a channel of expression of people. Including an interactive variable between education and institutions in our equation suggests that the effect of education on pollution growth would be conditional with political institutions.

Columns (4) and (5) confirm that growth rate of carbon dioxide per capita depends positively and significantly on investment rate. This later variable is an important determinant of air pollution in developing countries. In these countries, people are not very concerned by environment problems. They are worried by many developments problems (low and unstable growth, unemployment). These investments can also reduce poverty because they are 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.

**Tableau2:** Estimation of growth of carbon dioxide per capita (GMM-System)

	All countries (1)	Developing countries (2)	Developed countries(3)	Developing countries(4)	Developed countries(5)
Log of initial carbon dioxide per capita	-0.003 (-0.18)	0.008 (0.05)	-0,305 (-2,17)**	-0.009 (-0.72)	-0,201 (-2,14)**
Log of investment	0.326 (2.50)**	0.315 (2.40)**	0.549 (3.19)**	0.401 (3.29)**	0.337 (2.85)**
Log of trade openness	0.086 (0.93)	0.203 (1.51)	0.027 (0.48)	0.151 (1.32)	0.017 (0.43)
Technical progress	-0.209 (1.88)*	-0.209 (1.90)*	0.045 (1.75)*	-0.178 (2.16)**	0.026 (1.03)
Political Institutions	0.036 (1.73)	0.043 (2.07)**	-0.049 (10.56)***	0.034 (1.75)**	-0.035 (1.36)
Growth of population	-0,034 (0,30)	-0,160 (1,43)	-0,104 (2,47)**	-0,15 (1,37)	-0,026 (1,84)**
Education	0.253 (0.83)	-0.219 (0.96)	0.445 (3.76)***	-0.047 (0.27)	0.545 (12.45)***
Education* Political Institutions				-0,008 (0,94)	-0,035 (2,91)***
Constant	-1.293 (1.84)*	-1.329 (1.90)*	-0.294 (1.91)*	-1.562 (2.32)*	-1.269 (2.51)**
Observations	229	182	47	182	47
Countries	85	63	22	63	22
AR (1) /AR(2)	0,82/0,21	0,57/0,75	0,52/0,40	0,70/0,36	0,07/0,18
Hansen Test	0,40	0,69	0,91	0,82	0,62
Number of Instruments	17	17	14	17	14

Note: \* significant at 10%; \*\* at 5%; \*\*\* at 1%. The period is 1970-2004. Temporal dummy variables have been included in the estimations

Political institutions have a significant and opposite effect according to the level of development. In developing countries, the positive effect can be explained by “free rider behavior” (Carlsson and Al 2003). Political leaders consider pollution as a public good and have no willingness to fight it. In developed countries, political institutions reduce carbon dioxide per capita growth. This effect is more important and significant with people education. Columns (3) and (5) show that the effect of the quality of institutions on pollution growth is conditional on the level of education.

Education seems to be a factor of environmental pollution in developed countries although its effect is slightly mitigated in presence of political institutions. Without political institutions, education increases pollution. Our results are similar to Jorgenson (2003). We think that education have more income and are encouraged to overconsume. They also desire to live well by accumulating material goods without caring about the consequences of this happiness and the ideological model of "consume more to be happier" (Princen et al. 2002). With political institutions, the effect of education is mitigated. Although they pollute, they are also more conscious of environmental problems. Their education level will increase their preferences favoring a higher level of environmental protection. They will reflect their preference through political institutions.

In developing countries, education and its interactive variable have no effect on the growth of carbon dioxide per capita emissions. The absence of effect of education in developing countries might be explained by the low education level and the relative weakness of political institutions. The combination of these factors strongly reduces the capability of people to express their preferences for a better environment. So the average effect of education on emissions growth is negligible. Furthermore, less educated people (relatively to those of developed countries) are also poorer and consume least materials goods factor of environmental degradation.

Technical progress has no impact on pollution growth in developed countries whereas it is the key engine of depollution in developing countries. These results are not surprising. In developed countries, high levels of education are also factors of knowledge creation and technical progress. We can then think that developing countries have few technical progress and they could need technology transfers. As technical progress level is relatively low and that their technology needs are so enormous, an increase of technical progress (new technology transfers) has a high marginal effect on pollution growth. In other words technical progress is more effective in countries weakly endowed with such progress.

### 3.4.2. Robustness checks

To analyse the strength of results we consider other education measures. These are seven average schooling years: in general for individuals being +15 years old, - at higher level, - at higher level for individuals being +15 years old, - at secondary level for individuals, - at the secondary level for individuals having more than 15 years, - with percentage of population having completed higher education, - with percentage of population having completed secondary school. As suggested by tables (4a and 4b), our results remain stable in spite of use of seven alternative variables. Thus the average secondary and high schooling years in the population have similar effects on growth of carbon dioxide per capita emissions and these effects are different according to the level of development.

Secondly, we check if the effect of education on the emissions per capita would be simply due to the omission of the income variable (GDP per capita). From the point that education contributes to a rise of income and economic growth, education increases use of environmental resources. It is thus a source of pollution through income per capita. Our results may also be simply explained omission of GDP/capita. That leads us to control the strength of our results by including income per capita. Table (5) shows that income per capita does not have a significant effect on growth of emissions per capita. Results are stable, coherent and valid.

In recent years, the climate change debate has been renewed attention because these environmental and socio-economic effects are now more evident. In response, some international agreements were signed between countries. To take into account the effect of international agreements, we include The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The UNFCCC is an international environmental treaty produced at the Earth Summit in Rio de Janeiro (1992). The objective of Treaty is to encourage a stabilization of greenhouse gas concentrations at a level that would prevent people from dangerous anthropogenic interference with climate system.

The Kyoto protocol establishes flexible mechanisms and commitments of countries to stabilize or reduce emissions of greenhouse gases (GHGs) from 5,3% over the period 2008-2012. It will be very interesting to test the impact of Kyoto Protocol and UNFCCC on growth of carbon dioxide per capita. In table 6, we include « Kyoto » and « UNFCCC » variables. The dummy takes the value of one, if a country has ratified the Kyoto Protocol and faces emissions reduction obligations or UNFCCC treaty, otherwise it takes the value zero.

Our results show that Kyoto Protocol and UNFCCC have no impact on growth of carbon dioxide per capita. The coefficient of dummy variable is not significant for developed and developing countries. Two arguments can explain these results. Firstly it is very early to verify the effect of Kyoto protocol commitments on pollution because our analysis covers the period 1970-2004 and many countries ratify it only in 2002. Secondly countries are not incited to respect their international agreements.

Tableau4a : Estimation of growth of carbon dioxide per capita (GMM-System with alternative human capital for developed countries)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log of initial carbon dioxide per capita	-0.16 (-2,05)**	-0,15 (-2,98)***	-0,14 (-2.89)***	-0,24 (-2.64)***	-0,16 (-2.02)**	-0,13 (-2.71)***	-0,14 (-2.28)**	-0,30 (-2.30)**
Educ1	0.539 (12.52)***							
PolityEduc1	-0.040 (3.89)***							
Educ2		0.447 (13.27)***						
PolityEduc1		-0.038 (6.68)***						
Educ3			0.439 (13.62)***					
PolityEduc3			-0.039 (7.22)***					
Educ4				0.588 (10.91)***				
PolityEduc4				-0.039 (4.37)***				
Educ5					0.487 (10.46)***			
PolityEduc5					-0.044 (10.02)***			
Educ6						0.442 (11.70)***		
PolityEduc6						-0.038 (8.53)***		
Educ7							0.522 (9.76)***	
PolityEduc7							-0.048 (11.79)***	
Educ8								0.551 (10.49)***
PolityEduc8								-0.043 (8.72)***
Number of countries	22	22	22	22	22	22	22	22

Notes: \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%. period is 1970-2003. Other variables of controls and temporal dummies are taken into account in estimations.

Variables Educ1,... Educ8 correspond respectively to the logarithm of mean of years of education: in general for individuals being +15 years old, - at higher level, - at higher level for individuals being +15 years old, - at secondary level for individuals, - at the secondary level for individuals having more than 15 years, - with percentage of population having completed higher education, - with percentage of population having completed secondary school.

Tableau 4b : Estimation of growth of carbon dioxide per capita (GMM-System with alternative human capital measures for developing countries)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log of initial carbon dioxide per capita	-0.11 (-0.28)	0.05 (-0.10)	-0.16 (-0.42)	-0.47 (0.69)	-1.15 (-0.67)	-0.03 (-0.08)	0.42 (0.52)	-0.41 (0.74)
Educ1	-0.204 (0.37)							
PolityEduc1	-0.001 (0.09)							
Educ2		-0.114 (0.30)						
PolityEduc1		-0.002 (0.34)						
Educ3			0.074 (0.31)					
PolityEduc3			-0.001 (0.28)					
Educ4				-0.531 (0.89)				
PolityEduc4				-0.013 (0.85)				
Educ5					-0.429 (0.62)			
PolityEduc5					0.001 (0.05)			
Educ6						-0.047 (0.15)		
PolityEduc6						-0.002 (0.35)		
Educ7							1.102 (0.65)	
PolityEduc7							0.016 (0.54)	
Educ8								-0.619 (0.83)
PolityEduc8								-0.009 (0.69)
Number of countries	65	63	65	63	65	63	63	63

Notes: \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%. period is 1970-2003. Other variables of controls and temporal dummies are taken into account in estimations. Variables

Educ1,... Educ8 correspond respectively to the logarithm of mean of years of education: in general for individuals being +15 years old, - at higher level,- at higher level for individuals being +15 years old, - at secondary level for individuals, - at the secondary level for individuals having more than 15 years, - with percentage of population having completed higher education, - with percentage of population having completed secondary school.

**Table 5:** Estimate of growth of carbon dioxide per capita including GDP/capita

	Developed countries	Developing countries
Log of initial carbon dioxide per capita	-0,19 (-2,14)**	-0,084 (-0,61)
Log of investment	0.340 (2,80)**	0.402 (3.30)***
Log of trade openness	0.026 (0.51)	0.147 (1.30)
Technical progress	0.031 (1.04)	-0.178 (2.16)**
Political institutions	0.035 (1.45)	0.034 (1.76)*
Growth of population	-0.029 (1.69)	-0.140 (1.27)
Log of income per capita	0.006 (0.42)	0.004 (0.33)
Education	0.542 (12.63)***	0.005 (0.02)
Education* Political Institutions	-0.036	-0.009
Constant	(3.14)*** -1.407 (2.55)**	(0.95) -1.61 (2.46)**
Observation	47	161
Number of countries	22	63
AR(1)	0,22	0,51
AR(2)	0,72	0,81
Hansen Test	0,83	0,72
Number of Instruments	14	17

Notes: \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%. period is 1970-2004. Temporal dummies are taken into account in estimations

**Table 6:** Estimate of growth of carbon dioxide per capita including international agreements

Growth of carbon dioxide per Capita (GMM-system)	Developed countries		Developing countries		(5)
	(1)	(2)	(3)	(4)	
Log of initial carbon dioxide per capita	0.19 (3.16)***	0.19 (2.92)***	0.11 (0,99)	0.19 (1.30)	
Log of Investment	0.330 (1.39)***	0.328 (1.37)***	0.388 (3.21)***	0.489 (3.52)***	0.39 (2.69)***
Log of trade openness	0.025 (0.46)	0.024 (0.43)	0.068 (0.50)	0.044 (0.36)	0,013 (0.11)
Technical progress	0.046 (0.43)	0.047 (0.70)	-0.104 (2.01)**	-0.091 (1.71)*	-0.04 (1.85)*
Political institutions	0.943 (0.22)	0.717 (0.12)	0.036 (1.89)*	0.033 (2.24)**	0.043 (2.24)**
Population rate	-0.093 (1.69)	-0.096 (1.66)	-0.100 (0.81)	-0.075 (0.69)	0.004 (0.13)
Education	18.015 (2.32)**	13.918 (2.25)**	0.084 (0.56)	0.212 (1.07)	-0.008 (0.04)
Education* Political Institutions	-1.787 (2.32)**	-1.377 (2.24)**	-0.010 (0.90)	-0.004 (0.49)	-0.02 (1.04)
UNFCCC	0.090 (1.54)		-0.018 (0.06)		
Kyoto		0.081 (1.14)		-0.134 (1.15)	
CDM					0.21 (1.19)
Constant	-10.193 (2.25)**	-7.913 (2.16)**	-0.877 (1.84)*	-1.232 (2.27)**	1.48 (2.17)*
Observations	47	47	170	170	170
Number of countries	22	22	63	63	63
AR (1)	0,071	0,06	0,32	0,35	0.52
AR(2)	0,24	0,17	0,45	0,47	0.40
Hansen Test	0,75	0,69	0,72	0,48	0.90
Number of Instruments	15	15	27	27	27

Notes: \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%. period is 1970-2004. Temporal dummies are taken into account in estimations.

#### **4. Conclusion**

This study brings in light that education doesn't matter for air pollution growth for 85 countries. Results are different with development. In developed countries, education is a factor of pollution growth although its effect is mitigated in presence of political institutions. In developing countries, education doesn't matter for carbon dioxide per capita growth.

It also shows a divergence in carbon dioxide per capita at global level during the period of 1970-2004. For developing countries, there is a divergence in carbon dioxide per capita. Technical progress contributes to pollution growth reduction. Investment, the engine of economic growth, is an important source of pollution in both developing countries and developed countries. For the latter, pollution per capita converges. The carbon dioxide emissions convergence in developed countries and divergence in developing countries highlight interests and difficulties of multilateral negotiations on climate warming. The article also highlights the importance of other factors such as technical progress, political institutions and investments in pollution growth.

Our results are important for economic policies. Initially, they highlight the importance of education in environmental protection. The current accumulation of knowledge is a factor of economic growth as well as of pollution growth. We are not recommending questioning education policies whose intrinsic values are obvious. On the contrary, there is a need for introducing a change of perception and role of education in favor of environment. That should be very urgent in developing countries because the realization of the Millennium Development Goals (MDG) regarding education will be followed by environmental pollution. Then, there is a phenomenon of free rider of some countries in fight against climate warming. In addition, investments being a key factor of economic growth and determinant of pollution, reduction of these effects will be necessarily followed by the setting up of ecologically appropriate investments. Finally, divergence of pollution at an international and developing countries levels requires the transformation of protocol of Kyoto which should include agreements of technology transfers and promote of ecological development.

This paper brings avenues for future research. Indeed, it highlights a differentiated impact on environment of political institutions in developed and developing countries. It will be then interesting to analyze the deep determinants of this behaviour of free riders of developing countries.

## References

- Antweiler, W., Copeland, B. R., and Taylor M. S. (2001): “Is free trade good for the environment?”, *American Economic Review*, 91(4):877–908.
- Bernard, Andrew and Bradford Jensen (1999) : “Exceptional Exporter Performance: Cause, Effect, or Both? ”, *J. Int. Econ.* 47:1, pp. 1–25.
- Bimonte (2002): “Information access, income distribution, and the environmental Kuznets curve”, *Ecological Economics* 41 (2002), pp. 145–156.
- Bartel, A. and Lichtenberg, (1987) : “The Comparative Advantage of Educated Workers in Implementing New Technology”, *Review of Economics and Statistics*, 64 1-11.
- Bond, S., A. Hoeffler, and J. Temple, (2001): “GMM Estimation of Empirical Growth Models”, *Centre for Economic Policy Research Discussion Paper no. 3048*.
- Bongaarts, John (1992): “Population Growth and Global Warming”, *Population and Development Review*. 18.2 (Jun. 1992): 299-319.
- Brock, W. A. and M. S. Taylor (2004): “Economic growth and the environment: a review of theory and empirics”, NBER Working Paper 10854, Cambridge MA
- Brock W A. & M. Scott Taylor (2004): “The Green Solow Model”, NBER Working Papers 10557, National Bureau of Economic Research
- Caselli, Francesco and Wilbur Coleman II (2001) : “Cross-Country Technology Diffusion: The Case of Computers”, *Amer. Econ. Rev. Pap. Proceed.* 91:2, pp. 328–35.
- Clerides Sofronis, Saul Lach and James Tybout (1998) : “Is Learning by Exporting Important? Microdynamic Evidence from Colombia, Mexico, and Morocco”, *Quart. J. Econ.* 113, pp. 903–48.
- Cole, M. A., Elliot, R. J. R., and Fredriksson, P. G. (2004): “Endogenous pollution havens: Does fdi influence environmental regulations?”, Working Paper 2004/20, University of Nottingham.
- Copeland, Brian R. and M.S. Taylor. (1994): “North- South Trade and the Environment”, *Quart J. Econ.* 109:3, pp. 755–87.
- Congleton, Roger D. (1992): “Political Institutions and Pollution Control”, *Review of Economics and Statistics* 74 (3): 412-421.
- Duchin F.; Lange G.-M.; Kell G.(1995): “Technological change, trade and the environment”, *Ecological Economics*, Volume 14, Number 3, September 1995, pp. 185-193(9)
- Eaton, Jonathan and Samuel Kortum (1999) : “International Patenting and Technology Diffusion: Theory and Measurement”, *Int. Econ. Rev.* 40, pp. 537–70.

Eaton, Jonathan and Samuel Kortum (1996) : “Trade in Ideas: Patenting and Productivity in the OECD”, *J. Int. Econ.* 40:3-4, pp. 251–78.

Eaton, Jonathan and Samuel Kortum (2000) : “Knowledge Spillovers at the World’s Technology Frontier”, CEPR work. pap. 2815.

Eaton, Jonathan and Samuel Kortum (2001) : “Trade in Capital Goods”, *Europ. Econ.Rev.* 45:7, pp. 1195–235.

Eaton, Jonathan and Samuel Kortum (2002) : “Technology, Geography, and Trade”, *Econometrica* 70:5, pp. 1741–79.

Farzin Y.H. and C.A. Bond, (2006): “Democracy and environmental quality”, *Journal of Development Economics*, 81 213– 235.

Frankel and Rose (2005): “Is trade good or bad for the environment? Sorting out the causality”, *The Review of Economics and Statistics* 87

Gassebner, Lamla et Jan-Egbert Sturm (2006): “Economic, Demographic and Political Determinants of Pollution Reassessed: A Sensitivity Analysis”, CESifo Working Paper Series No. 1699

Grimes, P. and J. Kentor (2003): “Exporting the greenhouse: Foreign capital penetration and CO2 emissions 1980-1996”, *Journal of World-Systems Research* 9, 261-276.

Grossman and Krueger (1995): “Economic growth and the environment”, *Quarterly Journal of Economics* 110 (1995) (2), pp.

Hallward-Driemeier, Mary; Giuseppe Iarossi and Kenneth Sokoloff (2002) : “Exports and Manufacturing Productivity in East Asia: A Comparative Analysis with Firm-Level Data” work. ap., UCLA.

Heil, M.T., Wodon, Q.T. (2000): “Future inequality in CO2 emissions and the impact of abatement proposals”, *Environmental and Resource Economics* 17, 163–181.

Jaffe et al. (2000): “Technological Change and the Environment”, RFF Discussion Paper 00 47, Resources for the Future, Washington, DC.

Jorgenson, Andrew (2003): “Consumption and Environmental Degradation: A Cross National Analysis of the Ecological Footprint”, *Social Problems*, in press.

Joseph E. Aldy (2006): “Per Capita Carbon Dioxide Emissions: Convergence or Divergence?”, *Environmental and Resource Economics*, Volume 33, Number 4, April 2006, pp. 533-555(23)

Klick, J. (2002): “Autocrats and the environment or it’s easy being green”, Working Paper Series 02-16, George Mason University.

Managi, Shunsuke (2004): “Trade Liberalization and the Environment: Carbon Dioxide for 1960–1999”, *Economics Bulletin*, Vol. 17, No. 1 pp.

Mani, M; Wheeler, D.(1998): “In search of pollution havens? Dirty industry in the world economy, 1960 to 1995”. In *Journal of Environment and Development* Vol. 7, no. 3, pp. 215-247. Sep 1998.

Mankiw, N.G., D. Romer et D.N. Weil (1992): “A Contribution to the Empirics of Economic Growth”, *Quarterly Journal of Economics*, Vol. 107, N°. 2, pp. 407-427, Mai.

Matthew A. Cole and Robert J.R. Elliott (2005): “FDI and the Capital Intensity of 'Dirty' Sectors: A Missing Piece of the Pollution Haven Puzzle”, *Review of Development Economics*, Vol. 9, No. 4, pp. 530-548, November 2005

McKibbin W. and A. Stegman (2005): “Convergence of Per Capita Carbon Emissions”, Lowy Institute Working Paper in International Economics

McKittrick, R. (2007): “Why Did US Air Pollution Decline After 1970?”, *Empirical Economics*, 33(3), 2007, 491–513.

Nelson, R. and Phelps, E. (1966) : “Investment in humans, technological diffusion, and economic growth”, *American Economic Review: Papers and Proceedings* 61, 69–75.

Olson, Mancur. (1993): “Dictatorship, Democracy and Development”, *American Political Science Review* 87 (3): 567-576.

P Nguyen Van (2005): “Distribution Dynamics of CO2 Emissions”, *Environmental and Resource Economics*, Springer, Volume 32, Number 4 / Decembre, 2005

Pargal, S., and D. Wheeler (1996): “Informal Regulation in Developing countries: Evidence from Indonesia”, *Journal of Political Economy*. December

Robitaille J., Lafleur J.M., Archer A (1998): “*Quelle éducation pour demain Réflexion sur le développement durable et l'éducation pour un avenir viable*”, Colloque en Direct. <http://199.212.18.76/eco/education/Papers/robitail.htm>

Stegman A (2005): “Convergence in carbon emissions per capita”, Centre for Applied Macroeconomic Analysis Working Paper, The Australian National University.

Sevestre Patrick (2002) : “Econométrie des données de panel”, Dunod, Paris France.

Strazicich, M. C., & List, J. A. (2003): “Are CO2 emission levels converging among industrial countries?”, *Environmental and Resource Economics*, 24, 263–271.

Torras, M. and J.K. Boyce (1998): “Income, inequality, and pollution: A reassessment of the environmental Kuznets curve”, *Ecological Economics*, 25(2), (1998): 147-160.

Xu, Bin (2000) : “Multinational Enterprises, Technology Diffusion, and Host Country Productivity Growth”, *J. Devel. Econ.*, 62:2, pp. 477–93.

Wheeler, David and Mody, Ashoka. (1992): “International Investment Location Decisions: The Case of U.S. Firms”, *Journal of International Economics*, Aug. 1992, 33(1,2), pp. 57–76.

Wheeler, David. (2000): “Racing to the Bottom? Foreign Investment and Air Pollution in Developing countries”, Mimeo. Washington D.C.: World Bank.

Wheeler, David and Dasgupta, Susmita (1997): “Citizen Complaints as Environmental Indicators: Evidence from China”, World Bank Policy Research Working Paper No. 1704

Wheeler D and Pargal (1996): “Informal Regulation of Industrial Pollution in Developing countries: Evidence from Indonesia”, In *Journal of Political Economy*, 104(1996): 1314-27.

Wells, Louis T., Jr. (1972): “The Product Life Cycle and International Trade”, In Boston: Harvard Business School Division of Research.

## Appendices

**Table6: Definition and source of variables**

<b>Variables</b>	<b>Definitions</b>	<b>Data Source</b>
Emissions of carbon dioxide per capita	Carbon dioxide per capita (metric ton per capita)	World Development Indicators (2006)
Emissions per capita initial	Carbon dioxide per capita at the beginning of each period	
Investment rate	Investment/PIB	
Trade openness rate	(Exportations+Importations) / Gross Domestic Product	
Population growth rate	Population growth rate	
Political 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
Education	Number of average years of instruction of population	Barrolee 2000
Technical progress	Rate of technical progress, computed as the coefficient of the trend (t) in a regression in OLS where explained variable is the intensity of economy in carbon dioxide and explanatory variables are GDP per capita, trade and price of energy	Author

### List of countries included in the sample

Algeria, South Africa, Germany, Australia, Austria, Belgium, Burundi, Benin, Bangladesh, Bahrain, Bolivia, Brazil, Botswana, Canada, Central Africa, Chile, China, Cameroun, Congo, Colombia, Costa Rica, Denmark, Dominican Republic, Ecuador, Egypt, Spain, France, Finland, Fiji, Ghana, Greece, Guatemala, Honduras, Haiti, Holland, Hungary, Indonesia, India, Iran, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Luxembourg, Mexico, Mali, Mauritania, Malawi, Malaysia, New Zealand, Niger, Nicaragua, Nepal, Norway, Pakistan, Peru, Philippines, New Guinea, Guinea, Poland, Portugal, Paraguay, Rwanda, the United Kingdom, Senegal, Sri Lanka, Sierra Leone, El Salvador, Syria, Sweden, Switzerland, Togo, Thailand, Trinidad and Tobago, Tunisia, Turkey, Uganda, the USA, Uruguay, Zambia

**Table7: Descriptive statistics**

	<b>Average</b>	<b>Standard deviation</b>	<b>Minimum</b>	<b>Maximum</b>
Log of initial per capita dioxide carbon emissions	4,56	0,35	0,0015	78,61
Growth rate of dioxide carbon emissions per capita	0,08	7,91	-4,44	2,76
Investment rate	21,42	7,39	2,53	86,79
Trade opening rate	71,14	41,51	5,71	297,33
Technological progress rate	-1,46	1,22	-7,28	0,64
Political Institutions	0,49	7,47	-10	+10
Population growth rate	1,97	1,61	-20,36	16,17
Education	4,67	2,95	0,042	12,21

Source: WDI (2006), Polity IV, Barrolee 2000 and author