International Journal for Quality research
UDK- 338.31:502/504 / 614.7
Original Scientific Paper (1.01)

INTERRELATIONSHIPS BETWEEN HEALTH, ENVIRONMENT QUALITY AND ECONOMIC ACTIVITY: WHAT CONSEQUENCES FOR ECONOMIC CONVERGENCE?

Alassane Drabo[1]

[1] *PhD candidate at the Centre for Studies and Research on International Development (CERDI)- France*
Email: alassanedrabo@hotmail.com

Abstract:*This paper examines the link between health indicators, environmental variables and economic development, and the consequences of this relationship on economic convergence for a large sample of rich and poor countries. While in economic literature income and environment are seen to have an inverted-U shaped relationship (Environment Kuznets Curve hypothesis), it is also well established that an improvement in environmental quality is positively related to health. Our study focuses on the implications of this relationship for economic convergence. In the early stage of economic development, the gain from income growth could be cancelled or mitigated by environmental degradation through populations' health (and other channels) and create a vicious circle in economic activity unlike in developed countries. This in turn could slow down economic convergence. To empirically assess these issues, we proceeded to an econometric analysis through three equations: a growth equation, a health equation and an environment equation. We found that health is a channel through which environment impacts economic growth. When we take into account the effect of environment quality on economic growth, the speed of convergence tends to increase slightly. This shows that environmental quality could be considered as a constraint for economic convergence.*
Keywords: *Environmental quality, Health indicator, Income growth, economic convergence, speed of convergence*

1. INTRODUCTION

Environmental protection is an important issue that is gradually more present in the development strategies. It occupies a significant place in the economic policy of many countries and constitutes a major concern for the international community. This concern expressed at international level, is illustrated at many international meetings and conferences: two Nobel Peace Prizes were awarded to the personalities who raised public awareness on environmental issue (Wangari Maathai 2004 and Al Gore 2007) and it is one of the eight Millennium Development Goals adopted by the United Nations in 2000. In fact, 192 United Nations member states undertook in 2000 to "integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources; reduce biodiversity loss and halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation." This great interest is explained by the fact that environment is intimately connected to a viable ecosystem as explained by the United Nations Secretary General in the United Nations Environmental Programme (UNEP) 2007 annual Report: "it keeps the climate stable, clothes our backs, provides the medicines we need and protects us from radiation from space."

Although environmental protection is nowadays an important emerging concept, the search for a large and sustainable pro poor economic growth remains a necessity and a priority for all economies. The simultaneous pursuit of these two objectives, that is the wish of all countries, gives rise to some questions: what is the relationship between economic activity and environmental degradation? During the early decades, many authors tried to give theoretical and empirical responses to this question and the most popular remains the Environmental Kuznets Curve Hypothesis (EKC). The EKC (Grossman 1995; Grossman and Krueger 1995 ; Torras and Boyce 1998) describes the relationship between declining environmental quality and income as an inverted-U, that is, in the course of economic growth and development, environmental quality initially worsens but ultimately improves with improvements in income level. The first explanation for the EKC relationship is that the environment can be thought of as a luxury good. In the early stage of economic development a country would be unwilling to exchange consumption for investment in environmental regulation, hence environmental quality declines.

When the country reaches the threshold level of income, its citizens start to demand improvement in environmental quality. Another explanation of the EKC hypothesis is that countries pass through technological life cycles, as they move from high polluting technology (agriculture-based economies) to less polluting technology (service-based systems). In addition to these macroeconomic explanations, the EKC hypothesis is supported by some microeconomic foundations (Andreoni and Levinson 2001).

The relationship between income and environmental quality should not be limited to the ECK, the environmental degradation in turn can have significant effects on economic activity (Bovenberg and Smulders 1995 and 1996; Bruvoll and al. 1999). These effects impact growth through many channels among which health status. Health occupies a dominating role in the economic policy of many developing countries. This importance is illustrated through its weight among the MDG. Some works estimate the cost of pollution and they show that morbidity and mortality should be considered (OMS 2004; Scapecchi 2008).

This interrelationship between health, environment and economic activity can have different consequences depending on the development level and this can slow down the speed of economic convergence.

We propose, in this article, a theoretical and empirical explanation of the relationship between health, environment and economic activity and its consequences on economic convergence. The interest comes from the fact that very few studies are interested, in a simultaneous way, in these three elements in spite of the importance granted by the international community. The major part of international studies on this relation, nevertheless, focuses on the EKC hypothesis and those interested in the reverse causality are scarce.

Our works show that there is a feedback relationship between economic activity and environmental quality on one the hand and between health and economic activity on the other hand. Health status remains an important channel through which environmental degradation affects economic growth even if it is not the only one. Once the effect of the environment quality is controlled, the speed of convergence tends to increase slightly.

The rest of this article is organised in four sections: the first is about the literature review on the relationship between economic activity, health and environment. In the second we develop a growth model that takes into account environmental aspect. The third one show the evidence of the relationship between health, environmental degradation and economic growth through an econometric technique better adapted. Finally, we proceed to some sensitivity analysis before concluding.

2. LITERATURE REVIEW:

2.1 Economic growth and convergence

Economic convergence, concept introduced in economic literature by Solow (1956) has been many times tested and improved by economists. It was generalised by Barro and Sala-i-Martin (1992), Mankiw, Romer and Weil (1992), Levine and Renelt (1992) through the conditional convergence notion. Conditional convergence implies that countries would reach their respective steady states. Hence, in looking for convergence in a cross country study, it is necessary to control for the differences in steady states of different countries. The choice of control variables is very important because the statistical significant level as well as the coefficient amplitude of the variable of interest is sensitive in this choice (Levine et Renelt 1992). In 1992, Mankiw, Romer and Weil provided an analysis of economic convergence by adding human capital, represented by education level, to Solow (1956) model and they showed that their results fit better to the predictions of Solow model. Knowles and Owen (1995) completed this work by adding health as second human capital.

All these improvements are important but not enough because they do not take into account the role that could play some omitted variables, in particular the environmental quality which arouses a renewed interest these last years with the natural resources curse and EKC hypothesis.

2.2 Consideration of the environmental aspect

The existence of an intrinsic relation between economic activity and environmental quality remains evident. At the theoretical level several authors tried to give an explanation to the way the environment degradation could impact the economic activity (Bovenberg and Smulders 1995 and 1996; Bruvoll and al. 1999; Resesudarmo and Thorbecke 1996; Hofkes 1996; Geldrop and Withagen 2000). These theoretical works can be divided into four major categories following Panayotou (2000). Optimal growth models build on a Ramsey (1928) model, as extended by Koopmans (1960) and Cass (1965) constitute the first category (Keeler and al.. 1971; Mäler 1974; Gruver 1976; Brock 1977; Becker 1982; Tahvonen and Kuuluvainen 1994; Selden and Song 1995 and Stokey 1998). These are dynamic optimisation model, in which the utility-maximisation problem of the infinitely lived consumer is solved using the techniques of optimal control theory. Most of these models were developed in 1970s to show that the dependence of industrialised economies on petroleum constituted a limit to growth. Some of these models considered the effects of pollution on growth path (Keeler and al. 1971; Gruver 1976, Van der Ploeg and Withagen 1991) whereas others focused on natural resources depletion (Dasgupta and Heal 1974; Solow 1974). In general, models of pollution and optimal growth suggest that some abatement or curtailment of growth will be optimal.

The second category considers not only pollution as an argument of production and utility function, but also it includes environment itself as a factor of production (Lopez 1994; Chichilinsky 1994 ; Geldrop and Withagen 2000). This measure of environmental quality can be conceptualised as a stock that is damaged by production or pollution. The presence of environmental stock in the production function means that optimal pollution taxes or regulations are not sufficient to achieve the optimal level of environmental quality in the steady state.

The third group is constituted of endogenous growth model that relax the neoclassical specification of the production function assumed in the optimal growth models (Bovenberg et Smulders 1995 and 1996; Hofkes 1996; Ligthhard and Van der Ploeg 1994; Gradus and Smulders 1993 and Stokey 1998). Based on the works of Romer (1986, 1990), these models are characterised by constant or increasing returns to scale to some factors, or a class of factors, because private returns on investment may differ from the social returns on investment, often because of externality effects. This category consists in extending this new growth theory to include the environment or pollution as factor of production and environment quality as an argument of the utility function. Bovenberg and Smulders (1995, 1996) modify the Romer (1986) model to include the environment as a factor of production. Lighhard and Van der Ploeg (1994), Gradus and Smulders (1993) and Stockey (1998) extend the simple "AK" used by Barro by including environment. Hung, Chang and Blackburn (1994) use the Romer (1990) work. In general, optimal pollution control requires a lower level of growth than would be achieved in the absence of pollution.

Finally, we have other models that connect environmental degradation and economic growth. This category includes the overlapping generation model based on diamond (1965), this is the case of John and Pecchenino (1994, 1995). We also have a two country general equilibrium model of growth and environment in presence of trade (Copeland and Taylor 1994). The models reinforce the results of the optimal growth model.

At the empirical level, some economists tried to assess this impact of the environmental degradation on the economic activity. Bruvol and al. (1999) estimated the cost to society of environmental constraints, called environmental drag, in Norwegian economy through a dynamic resource environment applied model (DREAM). Their study indicates that the environmental drag reduces annual economic growth rates by about 0.1 percentage point and annual growth in wealth, including environmental wealth, is reduced by 0.23 percentage points until 2030. Resosudarmo and Thorbecke (1996), show through Social Environmental Accounting Matrix (SEAM) and some simulations, that the improvement of environment quality reduces health problems and therefore stimulates economic growth.

The best way to understand how environmental degradation can affect economic growth is to explain the channels through which this occurs. In economic literature we can find implicitly or explicitly some of these channels. Most of the channels met in the literature are the labour supply and labour productivity[1]. Air pollutions by CO2, SO2, NOx, CO, traffic noise, etc. affect health and leave people unable to work over short or long periods and reduce the productivity of those who work. Bruvoll and al. (1999) show that the health damages increase by 28% from 1989 up to 2030 in Norway because of emissions and this health damages contribute to 39% of the disutility from environmental services in 2030. Several ecological studies show that respiratory and cardiovascular diseases are closely linked to air quality (Poloniecki and al. 1997 ; Samet and al. 2000 ; Schwartz 1999 ; Schwartz and Morris 1995 ; Evans and Smith 2005 ; etc.). Zanobetti and al. (2000) show that the rate of hospitalisation due to cardiovascular diseases increases by 1.27 % when particle PM10 increases by 10 µg/m3. Peter and al. (2001) find that an increasing of particle level raises the risk of heart attack in the days following the increase of these particles. For Schirnding (2002), in the poorest regions, twenty percent of children do not reach their fifth birthday mainly because of the diseases connected to environmental degradation.

The other channels have not been broadly developed in the literature. Among them, we have the deterioration of physical capital (Bruvoll et al. 1999 ; Bovenberg et Smulders 1996 ; etc.). In fact, some pollutants such as SO2, induces corrosion on capital equipment and increases road depreciation and thus depreciation of public capital. This increased burden on public expenditures eventually crowds out private activity (Bruvoll et al. 1999). Another channel is welfare degradation. People receive utility from environmental services like recreational values. Some pollutants, such as SO2 and NOx, contribute to acidification of lakes and forests and others such as CO and PM10, provoke health related suffering. This can discourage foreign direct investment and skilled labour. Finally, environmental quality improvement affects saving behaviour, therefore investment Ricci (2007).It is now clear that environment quality affects economic performance. Economic activity in turn deteriorates environment quality and this in almost all the economic sectors (Shafik 1994, Mansour 2004; Mansour 2004; Yadav 1997; WRI 1996; Hettige, Mani and Wheeler 1998). This effect of economic activity on environment quality is complex and depends on some factors, namely preferences, production technology and the economic structure which are intrinsically linked to development level. Pollution level depends on gross domestic product (GDP) composition which itself is linked to development level (ECK hypothesis).

There is therefore a link between environmental quality, people health and economic activity. However, the empirical assessment of the impact of environmental degradation on economic performance in an

[1] This channel will be the object of particular attention in this article.

international framework is rare: it is dominated by microeconomic studies and does not pay enough attention to the channels of transmission.

The first goal of this paper is to bridge this gap by including environmental variable in a neoclassical growth model. Moreover, most of the studies that access the effect of GDP on environ, do not pay attention to the feedback effect and that can bias their results. We take this into account here.Finally, this paper discusses the consequence of the interrelationship between environment, health and economic performance on economic convergence. In fact, this interrelationship provokes different consequences depending on development level if the EKC hypothesis is verified.In countries below EKC income threshold, all attempts to boost economic growth will result in greater environmental degradation.

And this will burden economic growth through health and other channels creating a vicious circle. When countries above the EKC income threshold try to boost their economic growth, their environment quality will be improved and therefore they will be in a virtuous circle. That will penalise poor countries by slowing down the speed of convergence.

3. ECONOMIC GROWTH AND ENVIRONMENT QUALITY

In this section, we introduce environmental capital in a growth model, and we observe the consequences on economic convergence process.

3.1 The model

We begin this model by a neoclassical growth model augmented by human capital, and then we add environment quality as factor of production.

(1) $Y_{it} = K_{it}^{a} H_{it}^{b} Q_{it}^{c} (A_{it} L_{it})^{1-a-b-c}$

Where Y is the real product, K, H and Q are respectively the stock of physical capital, the stock of human capital and the natural environment quality. L is the labour factor and A the technological progress.

Q, the stock of environment capital affects the production process through the providing of productive services (an example is the impact of air quality on employees' health, the productivity of labour and the depreciation of physical equipment). We are not the first authors who use environment quality as factor of production, others did it (Bovenberg and Smulders 1995 and 1996; Bruvoll and al. 1999 ; Resesudarmo and Thorbecke 1996 ; Hofkes 1996 ; Geldrop and Withagen 2000.).

Geldrop and Withagen (2000) used environment as a factor of production, a production that can be consumed and invested for the improvement of environment quality and for the increasing of natural resource stock.

The equation (1) can be written in per unit of effective labour:

(2) $y_{it} = k_{it}^{a} h_{it}^{b} q_{it}^{c}$

With $L_{it} = L_{io} \exp(n_i t)$ an $A_{it} = A_t = A_o \exp(gt)$

where n_i is the growth rate of labour force and g that of technology.

The accumulation of physical capital, human capital and environmental capital can be modelled as (3)

(3) $\dot{k}_{it} = s_{ki} y_{it} - (n_{it} + g_t + \delta_t) k_{it}$

(4) $\dot{h}_{it} = s_{hi} y_{it} - (n_{it} + g_t + \delta_t) h_{it}$

(5) $\dot{q}_{it} = s_{qi} y_{it} - (n_{it} + g_t + \delta_t) q_{it}$

to (5):

Where s_{ki}, s_{hi} and s_{qi} are the proportion of income respectively invested in physical capital, human capital and natural environment improvement and δ the capital depreciation rate. As in MRW (1992), we assume that physical capital depreciation rate is the same as that of human capital.

We also assume that environmental capital depreciation rate is the same as that of physical capital. Following MRW (1992), we can show that (3) to (5) give (6) to (8) at steady state:

(6) $k_i^* = \left(\frac{s_{kit}^{1-b-c} s_{hit}^{b} s_{qit}^{c}}{n_i + g + \delta}\right)^{1/\eta}$

(7) $h_i^* = \left(\frac{s_{kit}^{a} s_{hit}^{1-a-c} s_{qit}^{c}}{n_i + g + \delta}\right)^{1/\eta}$

(8) $q_i^* = \left(\frac{s_{kit}^{a} s_{hit}^{b} s_{qit}^{1-a-b}}{n_i + g + \delta}\right)^{1/\eta}$

Where the asterisk indicate the steady state value and η=1-a-b-c

Replacing (6) to (8) in (2), and using natural logarithm, we have:

$$(11) \quad \ln\left(\frac{Y_{it}^*}{L_{it}}\right) = \ln A_0 + gt - \frac{1-\eta}{\eta} \ln(n_i + g + \delta)_t + \frac{a}{\eta} \ln(s_{kit}) + \frac{b}{\eta} \ln(s_{hit}) + \frac{c}{\eta} \ln(s_{qit})$$

The equation (11) shows that the investment in the accumulation of physical capital, human capital and natural environment improvement impacts positively on production per capital. The variable Y^* cannot be observed and suppose that we are at the steady state at the estimation period and this is a strong assumption. To solve this problem, we use the linearization method of MRW (1992), Bassanini and Scarpetta (2001 and 2007) and we have:

$$(12) \qquad \frac{d \ln \hat{y}_t}{dt} = -\lambda (\ln \hat{y}_t - \ln \hat{y}^*) \text{ where}$$

$\hat{y} = \frac{Y}{L}$ and $\lambda = (1-a-b-c)(n+g+\delta)$ is the speed of convergence. This speed of convergence changes with the addition of environmental variables through the parameter c. If c is negative, the speed of convergence will increase.

The transition through the steady state can be written as (13) since a+b+c<1.

$$(13) \qquad \ln \hat{y}_t - \ln \hat{y}_{t-s} = \theta (\ln \hat{y}^* - \ln \hat{y}_{t-s}),$$

where (t-s) is a period arbitrary chosen.

Replacing steady state y value by it value in current period, (11) gives (14):

$$(14) \qquad \ln(\hat{y}_{it}) - \ln(\hat{y}_{it-s}) = \theta \ln A_0 + \theta g t - \frac{1-\eta}{\eta}\theta \ln(n_i + g + \delta)_t + \frac{a}{\eta}\theta \ln(s_{kit}) + \frac{b}{\eta}\theta \ln(s_{hit}) + \frac{c}{\eta}\theta \ln(s_{qit}) - \theta \ln(\hat{y}_{it-s})$$

Where $\theta = (1 - \exp(-\lambda_i t))$

Equation (14) can be simply written by adding both $\ln(y_{t-s})$ to the left and right hand sides in order to have only $\ln(y_t)$ as left hand side member and we have (15):

This equation can be estimated in all time intervals by panel data.

$$(15) \qquad \ln(\hat{y}_t) = \theta \ln A_0 + \theta g t - \frac{1-\eta}{\eta}\theta \ln(n_i + g + \delta)_t + \frac{a}{\eta}\theta \ln(s_{ki}) + \frac{b}{\eta}\theta \ln(s_{hi}) + \frac{c}{\eta}\theta \ln(s_{qi}) + e^{-\lambda t} \ln(\hat{y}_{t-s})$$

3.2 Empirical study

1- econometrical specification

Equation (15) can be written econometrically as a dynamic panel specification as (16):

$$(16) \qquad y_{it} = \mu_i + \kappa_t + \alpha_1 y_{it-1} + \alpha_2 m_{it} + \alpha_3 k_{it} + \alpha_4 h_{it} + \alpha_5 q_{it} + \upsilon_{it}$$

Where $\mu_i = \theta \ln A_0$ is the country fixed effect, $\kappa_t = \theta g t$ is the time fixed effect and υ_{it} represents the error term. $y_{it} = \ln(y_{it})$, $y_{it-1} = \ln(y_{it-1})$, $m_{it} = \ln(n_i + g + \delta)_t$, $k_{it} = \ln(s_{kit})$ $h_{it} = \ln(s_{hit})$ and $q_{it} = \ln(s_{qit})$

$\alpha_1 = e^{-\lambda t}$; $\alpha_2 = \frac{1-\eta}{\eta}\theta$; $\alpha_3 = \frac{a}{\eta}\theta$; $\alpha_4 = \frac{b}{\eta}\theta$; $\alpha_5 = \frac{c}{\eta}\theta$

This econometric model can be estimated through panel data with country and time specific effects. However, the use of panel dataset requires the precision whether the specific effects are fixed or random. In the present work this problem does not matter because the random effects model is not the appropriate method here (Islam 1995), the specific effects could be correlated with exogenous variables included in the model. In fact, A_0 is not only made up of the technological level, but it also made up of resource endowment, institutions level, etc., and it is less convincing to think that saving behaviour, education and fertility rate will not be affected by these elements. The more appropriate is the fixed effects model. Islam (1995) used both the fixed effects estimator and that of minimum distance (Chambenlin 1982), and found that there is not any significant difference between them. The fixed effects estimator is therefore suitable for our analysis even if it is exposed to some criticisms. Another suitable estimator for our model is that of generalized method of moments (GMM) in dynamic panel developed by Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998). Another interest of this estimator, apart from the presence of lagged dependant variable among explanatory variables, is the consideration of endogeneity because the environment variable is linked to economic growth through an inverse causality.

2- Data

This study is based on a panel data of developed and developing countries for which data are available from 1970 to 2000 subdivided into five year periods. Data are from many sources: some are from World

Development Indicator 2007 (WDI 2007). These are the gross domestic product per capita (GDP), gross fixed capital formation as percentage of GDP (INVEST), annual population growth rate (n), under five mortality rate (U5MR) and life expectancy (LIFE_EXPECT) for health status. For under five mortality we use the logit of under five survival rate (U5SR). In fact the under-five survival indicator is limited asymptotically, and an increase in this indicator does not represent the same performance when its initial level is weak or high, the best functional form to examine is that where the variable is expressed as a logit, as Grigoriou (2005) underlined.

$$\log itU5MR = \ln\left(\frac{U5SR}{1-U5SR}\right) = \ln(U5SR) - (\ln U5MR)$$

We also take from WDI 2007 the carbon dioxide emission for air pollution (CO2) and biological oxygen demand (BOD) for water pollution. BOD is a measure of the oxygen used by microorganisms to decompose waste. Microorganisms such as bacteria are responsible for decomposing organic waste. When organic matter such as dead plants, leaves, grass clippings, manure, sewage, or even food waste is present in a water supply, the bacteria will begin the process of breaking down this waste. If there is a large quantity of organic waste in the water supply, there will also be a lot of bacteria present working to decompose this waste. In this case, the demand for oxygen will be high (due to all the bacteria) so the BOD level will be high (CIESE). Sulfur dioxide variable (SO2) is from the dataset compiled by David Stern[2] in 2004. The variable of education is from Barro and Lee.The characteristics of each variable are summarized in table 1 annexe 1. Table 2 completes these characteristics by presenting the correlation coefficients among variables. This table shows that carbon dioxide is positively correlated to GDP per capita contrary to BOD and sulfur dioxide. Health variable is negatively correlated to BOD and SO2 and positively correlated to CO2.

3- Estimations results:

We have estimated equation (16) with the generalized method of moments (GMM) and that of fixed effects two steps least squares (2SLS), by replacing some variables potentially endogenous by their lag, to assess the effect of environment quality on economic activity. Environmental variables are instrumented by their lag.

The results are summarised in table 1. The first four columns of this table present the results obtained with fixed effects. The first column presents the results in the estimation without environment variable. All relevant variables present expected signs and are statistically significant at 10% level, except education level which presents the unexpected sign.

The coefficient of lagged GDP per capita is 0.842, this corresponds to a rate of convergence of 3.44% per year. That means that, each year poor countries reduce their gap to their steady state to 3.44 percent. This convergence rate is closed to that found in the literature. In the second column we introduce environment variable represented by carbon dioxide per GDP (CO2GDP) instrumented by its lag.

This variable is significant at 5% with negative sign indicating the destructive effect of pollution on economic activity. The two following columns (columns 3 and 4) present the results when we use respectively the biological oxygen demand per GDP (BODGDP) and the sulphur dioxide per GDP (SO2GDP) as environmental indicators.

All these environmental variables have negative effect on economic growth, except BODGDP which appears not significant but this does not contradict our theoretical argument.

In fact, the environment variable can affect economic growth through health variable which appears highly significant. Environment quality can be viewed as an obstacle for developing countries by reducing their ability to get closer to developed countries economically.

That could also be explained by a problem of omitted variable. In fact, being correlated to lagged GDP (LGDPCAP(-1)), the omission of environmental variable could bias the coefficient of LGDPCAP(-1). Without environmental variable, the coefficient of LGDPCAP(-1) is overestimated and the speed of convergence underestimated. It is the same justification used to augment solow model by human capital.

The four last columns of table 1 show the results obtain with GMM. All non environmental variables keep their sign and their significativity. The main difference with the fixed effect is the coefficient amplitude. With this method environmental variables have negative signs and are significant at 5%.

These results indicate a consequence of the EKC hypothesis. In fact, because of environmental constraints, countries which are below the EKC income threshold will meet many difficulties to catch up developed ones. However, those above this income threshold will converge more rapidly to developed countries.

This could partly explain the actual convergence process. Very poor countries, such as those of Sub-Saharan Africa tend to diverge while emergent countries converge more rapidly toward the rich ones even if their level of pollution remains high.

[2] We thank David Stern for the provision of data

Table 1: effects of environment quality on economic activity

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependant variable: log GDP per capita							
	OLS	2SLS			2SLS			
LGDPCAP(-1)	0.842***	0.748***	0.673***	0.846***	0.940***	0.895***	0.965***	0.892***
	(45.79)	(26.15)	(16.59)	(45.92)	(27.03)	(21.14)	(19.52)	(29.33)
n+g+δ	-0.983***	-1.314***	-1.654***	-0.997***	-3.309	-1.288	-1.427	-1.599
	(-2.861)	(-3.806)	(-4.752)	(-2.885)	(-0.754)	(-1.050)	(-0.383)	(-0.877)
INVESTMENT	0.943***	1.180***	1.120***	1.103***	1.132***	1.916***	0.981***	1.293***
	(10.50)	(10.33)	(6.802)	(10.84)	(5.485)	(5.390)	(3.629)	(6.212)
SCHOOL(-1)	0.193***	-0.0082	-0.047	0.182***	0.141	-0.116	0.324	0.068
	(3.460)	(-0.119)	(-0.443)	(3.024)	(0.744)	(-0.823)	(1.200)	(0.603)
LIFE EXPECT(-1)	0.051***	0.119***	0.165***	0.051***	0.100***	0.112***	0.076*	0.131***
	(2.950)	(5.862)	(6.667)	(2.932)	(2.605)	(2.808)	(1.722)	(3.693)
CO2GDP		-0.141**				-0.212**		
		(-2.255)				(-2.405)		
BODGDP			-28468**				-30567**	
			(-2.479)				(-2.112)	
SO2GDP				147897				-977657**
				(0.248)				(-2.235)
Constant	1.228***	2.199***	2.998***	1.170***	0.761	1.045**	0.420	1.131***
	(7.402)	(8.370)	(8.273)	(6.994)	(1.617)	(2.524)	(0.834)	(3.359)
R^2	0.89	0.83	0.83	0.89				
Shea partial R^2		0.47	0.42	0.89				
Sargan p-value					0.15	0.33	0.93	0.20
AR(2)					0.93	0.15	0.60	0.26
Observations	615	474	308	604	479	474	402	470
Countries	101	100	93	99	101	100	96	99

These regressions allowed us to assess the impact of environment degradation on economic growth and economic convergence when health status is among control variables.

However, this remains insufficient because it does not take into account the interrelation between health, environment and economic growth.

Moreover, it does not permit to assess the impact of environment degradation which affects growth through health. To assess this, we add to equation (16) two other equations: an equation of health and an equation of environment.

4. INTERRELATION BETWEEN INCOME, HEALTH AND ENVIRONMENT

4.1 Methodology

Here we add to equation (16) an equation of health and an equation of environment, and we estimate them.

The object is to highlight the interrelation between these different variables and assess the impact of environment degradation which affects growth through health.

4.1.1 Health equation

Through this second equation, we want to assess the impact of income and environmental degradation on health. Generally it assumed that health outcomes for a population improve when the economy grows and this improvement are made easy by the rise in general standard of living (access to educational opportunities and health services).

Health depends also on the quality of physical environment such as the amount of air pollution and the quality of drinking water.

At the same time, the quality of a country's physical environment is a result of certain growth factors in the economy (intensive use of land, forest, air and water pollution).

We follow Gangadharan and Valenzuela (2001) by expressing health as a function of income, physical environment quality and other control variables.

$$(17) \qquad h_{it} = f(y_{it}, q_{it}(y_{it}, z_{it}), w_{it})$$

Where h is health indicator, y is income, q the environment quality, z the non economic variables that determine environment quality and w the non economic variables that determine health status (provision and access to health services, physicians number, immunisation rate, education).

The third equation being devoted to environment quality, we ignore **it**s determinants and the second equation can be written as:

$$(18) \qquad h_{it} = \beta_0 + \beta_1 y_{it} + \beta_2 q_{it} + \beta_3 w_{it}$$

4.1.2 Physical environment quality equation

Here our purpose is to highlight the relation between economic development and environment quality. The economic growth is generally made at the cost of a deterioration of the quality of the natural environment.

But through which analytical relation development level affects environment? Several studies tried to assess this effect empirically and theoretically (Grossman 1995; Grossman and Krueger 1995; Torras and Boyce 1998; Andreoni and Levinson 2001). Generally, they found that income is linked to environment quality through an inverted U relationship.

In our model environment quality is explained by income and some social variables.

$$(19) \qquad q_{it} = f(y_{it}, z_{it}) = c + \gamma_{it} y_{it} + \gamma_{it} y_{it}^2 + \gamma_{it} z_{it}$$

Where z is the non economic variables that could affect environment quality such as population density, education …This work consists in estimating by the method of two steps least square (2SLS) equations (20) and (21).

$$(20) \qquad h_{it} = \beta_0 + \beta_1 y_{it} + \beta_2 q_{it} + \beta_3 dpt + \beta_4 doc + \beta_5 e + \beta_6 upop + \beta_7 fert + \varphi_t + \varepsilon_{it}$$

$$(21) \qquad q_{it} = \gamma_0 + \gamma_1 y_{it} + \gamma_2 y_{it}^2 + \gamma_3 popdens + \gamma_4 e + \varsigma_t + \omega_{it}$$

4.2 Estimation results:

The results obtained through 2SLS are summarised in table 2.

The first two columns of this table (columns 1 and 2) present the results when sulphur dioxide (SO2GDP) is used as environmental indicator. These results show that education level (EDUC), lagged income per GDP (GDPGDP(-1)), immunisation rate (IMDPT) and physicians number (DOC) are factors that contribute to improve health status.

However, environment degradation and fertility rate worsen it. The negative coefficient of environment variable confirms our theoretical argument, namely health is an important channel through which health affects economic growth.

The result of the first step regression (environment quality equation in column 2) indicate that the coefficient of lagged income per GDP (GDPGDP(-1)) is positive and significant at 1%, showing that economic activity deteriorates environment quality. But the negative and significant coefficient of lagged income square (LGDPCAPSQ(-1)) indicates that the negative effect of GDP on environment quality is conditioned to an income threshold above which the effect becomes positive and income improve environment quality confirming the Environmentale Kuznets Curve hypothesis (EKC).

The four last columns of this table present the results when carbon dioxide per GDP (columns 3 and 4) and the biological oxygen demand (columns 5 and 6) are used as environmental variables. All the environmental variables have the correct sign and the EKC hypothesis is verified in each case.The 2SLS estimations of these two equations allow us to draw some conclusions: there is an inverse causality between economic activity and environmental degradation and health status is an important channel through which environment degradation affect**s** economic growth even if it is not alone. The effect of economy on environment quality being dependent on income level, countries whose income is below the EKC income threshold will slow down in a poverty trap due to environment degradation.However, those whose income is above this threshold will be in a virtuous circle due to the improvement of environment quality.

This could reduce the ability of poor countries to catch up the rich ones. Any ambitious economic policy must take into account environmental concerns to avoid it perverse effects.

Table 2 : Health and environment equations in 2SLS

	Dependant Variables					
	2SLS WITH SO2GDP		2SLS WITH CO2GDP		2SLS WITH BODGDP	
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	LIFE EXPECT	SO2GDP	LIFE EXPECT	CO2GDP	LIFE EXPECT	BODGDP
IMDPT	0.0472	-1.63e-9	-0.124	-0.0069	0.166	0.057
	(0.226)	(-0.71)	(-1.091)	(-0.13)	(0.922)	(0.49)
DOC	0.575***	2.32e-9**	0.106*	0.0291	0.218*	-0.177***
	(6.849)	(2.16)	(1.927)	(1.07)	(1.731)	(-3.24)
SCHOOL(-1)	1.041	8.93e-9	0.535*	-0.0338	0.880	0.140
	(1.586)	(1.34)	(1.713)	(-0.23)	(1.549)	(0.41)
FERTILITY	-0.140*	-1.07e-9	0.00655	-0.0424*	-0.124*	-0.076
	(-1.754)	(-1.05)	(0.0980)	(-1.65)	(-1.770)	(-1.46)
INEQUALITY	-0.137	-1.29e-8	-0.179	-0.0756	-2.272*	-2.276***
	(-0.130)	(-1.18)	(-0.364)	(-0.33)	(-1.690)	(-3.86)
POPDENS		-6.99e-9*		0.4330***		-0.572***
		(-1.67)		(3.19)		(-2.67)
FERTILIZER		1.57e-13		-3.31e-6		-4.36e-6
		(1.09)		(-1.07)		(-0.59)
LGDPCAP(-1)	0.191	2.83e-8***	-0.0522	0.6474***	-0.477*	0.513
	(1.302)	(2.91)	(-0.467)	(2.63)	(-1.799)	(1.03)
LGDPCAPSQ(-1)		-1.88e-9***		-0.0494***		-0.063**
		(-3.06)		(-3.16)		(-2.02)
SO2GDP	-63311022***					
	(-2.664)					
CO2GDP			-0.780*			
			(-1.675)			
BODGDP					-1.384***	
					(-3.311)	
Constant	-3.850***	-6.30e-8	0.190***	-0.0462***	-16.27***	-9.667***
	(-2.726)	(-1.36)	(6.677)	(-3.16)	(-4.758)	(-4,09)
R^2	0.38	0.11	0.13	0.25	0.21	0.52
Sargan p-value	0.36		0.55		0.87	
Observations	323	323	226	226	321	321
Countries	90	90	83	83	91	91

5. SENSITIVITY ANALYSIS

To verify the robustness of our results, we estimate by the three steps least square method (3SLS) equations (16), (20) and (21). The argument that guides this choice is the ability of this method to take into account the fact that the dependant variable of some equation can be used as explanatory variables in others.

In fact, in our system the variable of economic activity is both used as dependant variable and explanatory variable, it is the same for health and environment quality. This simultaneity bias can be corrected for each equation by the 2SLS method and for the system by the 3SLS. The results obtained by this method are summarized in table 3. These results are similar to those obtained previously in tables 1 and 2.

We also take again all the regressions by replacing life expectancy by the logit of under five survival rate. The results remain unchanged.

	DEDENDANT VARIABLES								
	3SLS WITH CO2GDP			3SLS WITH SO2GDP			3SLS WITH BODGDP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	LGDPCAP	LIFE EXPECT	CO2GDP	LGDPCAP	LIFE EXPECT	SO2GDP	LGDPCAP	LIFE EXPECT	BODGDP
n+g+δ	-1.440***			-1.797***			-1.116***		
	(-3.615)			(-4.305)			(-2.984)		
INVESTMENT	1.500***			1.543***			1.140***		
	(10.60)			(13.73)			(11.08)		
LGDPCAP(-1)	0.896***			0.843***			0.824***		
	(54.77)			(53.84)			(37.49)		
IMDPT		0.0961			0.226**			0.115	
		(1.069)			(2.100)			(1.282)	
DOC		0.0828**			0.179***			0.106***	
		(2.308)			(5.868)			(3.712)	
SCHOOL	0.0562	-0.0120	0.347***	-0.0644	-0.167	0.414	-0.0226	-0.666***	-1.180***
	(1.167)	(-0.0716)	(2.719)	(-0.908)	(-0.958)	(1.137)	(-0.335)	(-3.103)	(-7.191)
FERTILITY		-0.139***			-0.106***			-0.113***	
		(-5.835)			(-4.460)			(-4.856)	
INEQUALITY		1.088**	0.192		0.363	-1.162*		-1.835***	-4.294***
		(2.277)	(0.539)		(0.814)	(-1.884)		(-3.134)	(-9.134)
LIFE EXPECT	0.228***			0.0682**			0.275***		
	(7.411)			(2.068)			(10.26)		
POPDENS			4.75e-05			-1.13e-05			-5.33e-05
			(1.373)			(-0.196)			(-1.131)
FERTILIZER			-2.24e-08			5.20e-06			1.73e-05***
			(-0.00666)			(0.897)			(3.445)
LGDPCAP		0.399***	1.378***		0.0850**	1.803***		0.0360	0.815***
		(9.659)	(8.719)		(1.994)	(4.760)		(0.358)	(3.768)
LGDPCAPSQ			-0.0798***			-0.142***			-0.0068***
			(-8.169)			(-6.125)			(-7.217)
CO2GDP	-0.153**	-0.886***							
	(-2.158)	(-3.791)							
SO2GDP				-0.228***	-0.393***				
				(-7.491)	(-4.900)				
BODGDP							-0.0742**	-0.355***	
							(-2.485)	(-2.680)	
Constant	1.241***	-5.155***	-5.446***	-3.218***	-10.78***	-24.36***	0.922***	-6.164***	-11.45***
	(6.804)	(-13.51)	(-8.464)	(-5.296)	(-7.326)	(-15.31)	(3.081)	(-7.650)	(-13.16)
Observations	321	321	321	320	320	320	319	319	319
R^2	0.993	0.737	0.074	0.976	0.719	0.365	0.992	0.809	0.751

6.CONCLUSION

The main goal of this paper is the analysis of the interrelationships between health, income and environment quality and it consequences on economic convergence process. We introduce environment variable in a growth model and we observe its effect on economic growth. Our results show that environmental degradation affects negatively economic activity and when we neutralise environmental effect, the convergence speed tend to increase slightly. This reinforces our theoretical argument according to which environment quality improvement plays a considerable role in economic convergence process. Least square estimations of health and environment equations allow us to confirm the inverse causality between environment quality and economic growth and between economic growth and health. Health status remains an important channel through which environment degradation affects economic growth even if it is not alone. Poor countries which have chosen rapid economic growth at the price of environment quality will penalise themselves and have little chance to reach their goal. Such policy can reduce growth through health and other channels.

Poor countries cannot postpone attending environmental concerns in the hope that the environment will improve with increased incomes and avoid poverty trap due to environment degradation. Policy makers in these countries should contrary take into account environmental concerns as promoted by international community through the MDGs.This paper can also be placed into the debate about development aid effectiveness. In fact, a development assistance based on less polluting production technology will help poor countries to avoid the vicious circles shown in this paper.

One way this research can be extended is to use other health and environment indicators and compare the results for each indicator. Another way to extend it is the use of other technical approach in order to confirm our idea.

REFERENCES:

[1] Agras, J., D. Chapman, 1999, A dynamic approach to environmental Kuznets curve hypothesis, Ecological Economic, 28, 267-277

[2] Andreoni, J et Levinsion, A., 1998, The Simple Analysis of the Environmental Kuznets Curve, NBER Working Paper Series 6739.

[3] Arellano, M. et C. Borrego, (1995) Symmetrically Normalized Instrumental Variables Estimation of Error Components Models, *Journal of Econometrics*, 68, 29-52.

[4] Arellano, M., et S. Bond, (1991), Some test of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equation, *Review of economic Studies*, 58, 277-2997.

[5] Arnold, J., A. Bassanini et S. Scarpetta, 2007, Solow or Lucas ? Testing growth models using panel data from OECD countries. Economics Department working papers N°592

[6] Barro R. J., 1989, Economic Growth in Cross section of Countries, NBER Working Paper No 3120, Cambridge.

[7] Barro, J.R. et Sala-i-Martin, 1996, la croissance économique, Collection Sciences économiques

[8] Barro, J.R. et X. Sala-i-Martin, 1992, Convergence, Journal of Political Economy, C, 223-251.

[9] Bassanini A. et S. Scarpetta, 2001, Does Human Capital Matter for Growth in OECD Countries? Evidence from Poold Mean-Group Estimates, OECD Department Working Paper No. 282

[10] Baumol, William J., 1986, Productivity Growth, Convergence and Welfare: What the Long Run Data Show, American Economic Review, LXXVI, 1072-1085.

[11] Becker, G.S., 1965, A theory of allocation of time, Economic Journal, 75: 493-517.

[12] Becker, R.A., 1982, Intergenerational Equity: The Capital-Environment Trade-Off, Journal of Environmental Economics and Management, 9, 165-185.

[13] Bovenberg A., L. et S. Smulder, 1995, Environmental quality pollution-augmenting technological change in a two sector endogenous growth model, Journal of Public Economics, 1, 369-391

[14] Bovenberg A., L. et S. Smulder, 1996, transitional impacts of environmental policy in an endogenous growth model, International Economic Review, 37, 861-893.

[15] Brock W.A. et M.S. Taylor, 2004, The green Solow Model, NBER Working Paper No. 10557

[16] Brock, W.A., 1977, A Polluted Golden Age, Economics of Natural Environmental Resources.

[17] Bruvol A., S. Glomsrod et H. Vennemo, 1999, Environnemental drag : evidence from Norway, Ecological Economics 30, 235-249

[18] Cass, D., 1965, Optimal Growth in an Aggregate Model of Capital Accumulation, Review of Economic Studies, 32, 233-240.

[19] Chamberlain G., 1982, Multivariate Regression Model for Panel Data, Journal of Econometrics, XVIII, 5-46
[20] Chichilinsky, G., 1994, North-South Trade and the Global Environment, The American Economic Review 851-874.
[21] Copeland, B.R., et Taylor, M.S., 1994, North-South Trade and the Environment, Quaterly Journal of Economics 755-785
[22] Dasgupta P. et G. Heal, 1974, The Optimal Depletion of Exhaustible Resources, Review of Economic Studies, 3-28.
[23] Diamond, P., 1965), National Debt in a Neoclassical Growth Model, American Economic Review 55, 1126-1150
[24] Evans M. F., et V. K. Smith,2005, Do new health conditions support mortality – air pollution effects? Journal of Environmental Economics and Management, 50, 496-518.
[25] Galeotti M. et A. Lanza, 1999, Desperately seeking (environmental) kuznets, Working Paper CRENoS 199901, Centre for North South Economic Research, University of Cagliari and Sassari, Sardinia.
[26] Galeotti, M., et A., Lanza, 1999, Desperately seeking (environmental) Kuznets. Mimeo, International Agency
[27] Gangadharan, L. et Valenzuela M. R., 2001, Interrelationships between income, health and the environment : extending the environmental Kuznets Curve hypothesis, Ecological Economics, 36, 513-531
[28] Geldrop, V. et Withagen, C., 2000, Natural Capital and Sustainability, Ecological Economics, 32(3), 445-455.
[29] Gradus, R., et Smulders, S., 1993, The Trade off between Environment Care and Long –term Growth-Pollution in the three Prototype Growth Models. Journal of Economic, 58(1), 25-51
[30] Grigoriou, C., (2005), Essais sur la vulnérabilité des enfants dans les pays en développement: l'impact de la politique économique, Thèse pour le doctorat ès sciences économiques, Université d'Auvergne, Centre d'Etudes et de Recherches sur le Développement International
[31] Grossman, G. et Krueger A.B., 1995, Pollution Growth and the environment, Quaterly Journal of Economics, 110, 353-377
[32] Grossman, M., 1972, On the concept of health capital and the demand for health, Journal of Political Economy, 80, S74-S103.
[33] Gruver, J.W., 1976, Optimal Investment in Pollution Control Capital in a Neoclassical Context, Journal of Environmental Economics and Management 3, 165-177
[34] Guillaumont P., Korachais C., Subervie J., (2006), Comment l'instabilité macroéconomique diminue la survie des enfants.
[35] Hausman, J., (1978), Specification Test in Econometrics. *Econometrica,* 46, 1251-1271.
[36] Hettige H., M. Mani et D. Wheeler, 1998, Industrial Pollution and Economic Development, Policy research working paper 1876, World Bank 1998
[37] Holfes, M.W., 1996, Modelling sustainable development: an economy-ecology integrated model, Economic Modelling, 13, 333-353
[38] Hung, V.T.Y., Chang, P., et Blackburn, K., 1993, Endogenous Growth, Environment and R&D dans C. Carraro, Trade Innovation and Environment.
[39] Islam N., 1995, Growth Empirics: A Panel Data Approach, The Quarterly Journal of Economics, 110, 1127-1170.
[40] John, A., Pecchenino, R., 1994, An Overlapping Generation Model of Growth and the Environment, The Economic Journal 104, 1393-1410
[41] Kaufmann, R.K., B. Davidsdottir et P. Pauly, 1998, The determinants of atmospheric SO2 concentration : Reconsidering the environmental Kuznets curve, Ecological Economics, 25, 209-220
[42] Keeler, E., Spence, M., et Garnham, D., 1971, The Optimal Control of Pollution, Journal of Economic Theory 4, 19-34.
[43] King R. G., et S. T. Rebbelo, 1989, Transitional Dynamics and Economic Growth in the Neoclassical Model, NBER Working Paper No 3185, Cambridge.
[44] Knowles, S. et P.D. Owen, 1994, Health Capital and Cross-country variation in income per capita in the Mankiw-Romer-Weil model
[45] Koopmans, T.C., 1965, On the Concept of Optimal Economic Growth, The Economic Approach to Development Planning.
[46] Levine R., et D. Renelt, 1992, A Sensitivity Analysis of Cross Country Growth Regressions, American Economic Review, 82, 942-963
[47] Ligthart, J.E., et Van Der Ploeg, F., 1994, Pollution, the Cost of Public funds and Endogenous Growth, Economic Letter 339-349.

[48] Lopez, R., 1994, The Environment as a factor of production: the Effect of Economic Growth and Trade Liberalization, Journal of Environmental Economics and Management 27, 163-184.
[49] Mäler, K.G., 1974, Environmental Economics: A theoretical Inquiry
[50] Mankiw,N.G., Romer et D.N. Weil, 1992, A contribution to the empirics of economic growth, The Quaterly Journal of Economics 107, 407-437
[51] Mansour S. A., 2004, pesticide exposure – Egyptian scene, Toxicology, 198, 91-115.
[52] Pnanyotou, T., 2000, economic growth and the environment, CID working paper no. 56
[53] Peters A., W. D. Douglas, E. M. James, A. M. Murray, 2001, Increase particulate air pollution and the triggering of myocardial infarction, Circulation, 103, 2810-2815
[54] Ploeg F.V.D et C. Withagen, 1991, Pollution Control and the Ramsey Problem, Environmental and Resource Economics 1: 215-236
[55] Poloniecki J. D., Atkinson R. W., De Leon A. P. et Anderson H. R., 1997, Daily time series for cardiovascular hospital admissions and previous day's air pollution in London, UK. Occupational & Environmental Medicine, 54, 535-540.
[56] Programme des Nations Unies pour l'Environnement, 2007, UNEP 2007 annual report
[57] Ramsey, F.P., 1928, A mathematical Theory of Saving, Economic Journal 38, 543-559.
[58] Rebbelo S., 1991, Long Run Policy Analysis and Long Run Growth, Journal of Political Economy, XCIX, 500-521.
[59] Resosudarmo, B.P. et Thorbecke, E., 1996, The impact of environment policies on household income for different socio-economic classes: the case of air pollutants in Indonesia, Ecological Economics, 17(2), 83-94.
[60] Ricci, F., 2004, Channels of transmission of environmental policy to economic growth: A Survey of the Theory, Ecological Economics, 60(4), 688-699.
[61] Romer P., 1989, Capital Accumulation in the Theory of Long Run Growth, dans R.J. Barro éd., Modern Business Cycle Theory.
[62] Romer, P.M., 1986, Increasing Returns and Long Run Growth, Journal of Political Economy 94, 1002-1037
[63] Romer, P.M., 1990, Endogenous Technological Change, Journal of Political Economy 71-101.
[64] Sala-i-Martin X., 1997, I Just Run Two Million Regression, American Economic Review, 87, 178-183.
[65] Samet JM et alii., 2000, The National Morbidity, and Air Pollution Study. Health Effect Institute Number 94 Part II.
[66] Schirnding V. Y., 2002, International Environmental Law and Global Public Health, Bulletin de l'OMS, 2002, 80 (12).
[67] Schwartz J. et A. Zanobetti, 2000, Using Meta-smoothing to estimate dose-response trends across multiple studies, with application to air pollution and daily death, Epidemiology, 11, 666-672.
[68] Schwartz J., 1999, Air pollution and hospital admissions for heart disease in eight U.S Counties. Epidemiology, 10, 17-22
[69] Schwartz J., R. Morris, 1995, Air pollution and hospital admissions for cardiovascular disease in Detroit, Michigan. American Journal of Epidemiology, 142, 23-35.
[70] Selden, T.M. et Song, D., 1994, Environmental Quality and Development : Is There a Kuznets Curve for Air Pollution Emissions ? Journal of Environmental Economics and Management, 27, 147-162.
[71] Selden, T.M. et Song, D., 1995, Neoclassical Growth, the J Curve for Abatement, and the Inverted U Curve for Pollution, Journal of Environmental Economics and Management, 29, 162-168.
[72] Shafik N., 1994, Economic development and environment quality: an econometric analysis, Oxford Economic Paper, 46, 757-773.
[73] Solow, R., 1974, Intergenerational Equity and Exhaustible Resources, Rev. Economic. Studies (Symposium Issue) 29-46.
[74] Solow, Robert M., 1956, A contribution to the theory of economic growth, Quarterly Journal of Economics, LXX 65-94.
[75] Stern, D., 2005, Reversal in the Trend of Global Anthrogenic Sulfur Emissions, Rensselaer Working Papers in Economics 0504.
[76] Stokey, N.L., 1998, Are There Limits to Growth? International Economic Review 39, 1-31.
[77] Tahvonen O. et Kuuluvainen J., 1993, Economic Growth, Pollution and Renewble Resources, Journal of Environmental Economics and Management, 24, 101-118.
[78] Torras, M. et J.K. Boyce, 1998, Income, inequality and pollution: a reassessment of the environment Kuznets Curve, Ecological Economics, 25, 147-160
[79] Wilson, C. et C. Tisdell, 2001, Why farmers continue to use pesticides despite environmental, health and sustainability costs, Ecological Economics, 39, 449-462

[80] WRI, 1996, Pesticide and Immune System: The public Health Risk, World Resources Institute, Washington,DC. In: Mansour S. A., 2004, pesticide exposure – Egyptian scene, Toxicology, 198, 91-115.

[81] Yadav S. N., 1997, Dynamic Optimization of Nitrogen Use When Groundwater Contamination Is Interlised at the Standard in the Long Run, 79, 931-945.

[82] Zanobetti A. et Schwartz J., 2000, Race, gender and Social stutus as modifiers of the effects of PM10 on mortality, Journal of Occupational and Environmental Medecine, 42(5), 469-474.

[83] Zellner A., 1962, An efficient method of estimating seemingly unrelated regression and tests of aggregation bias, American Statistics Associatiation, 57, 348-368

ANNEXE 1

Table 1:descriptive statistics

	MEAN	MIN	MAX	cv	STAND. DEV.	SKEW	KURT	OBS.
GDPCAP	5939,4	99,73	53412	1,3734	8157,8	1,9144	7,0977	679
Pop. growth	0,0194	-0,1971	0,1661	0,8306	0,0161	-2,2498	61,553	679
investment	0,2128	0,0567	0,6092	0,3124	0,0665	0,7493	5,3829	679
school	0,3262	0	0,982	0,8368	0,273	0,5012	2,0105	679
life expect	-2,5463	-3,9572	0,4374	-0,3209	0,8171	0,7091	3,0975	679
CO2GDP	0,4397	0,0204	2,2551	0,8189	0,3601	2,1372	8,9875	557
BODGDP	2,40E-06	1,90E-07	0,000027	1,1607	2,87E-06	4,002	26,884	403
SO2GDP	8,59E-09	2,46E-12	2,99E-07	2,8684	2,46E-08	8,8461	91,842	668
IMDPT	0,6901	0,01	0,99	0,3717	0,2565	-0,8485	2,6738	444
DOC	0,9743	0,0163	4,12	0,9738	0,9488	1,0777	3,3555	579
FERTILITY	4,184	1,18	8,4944	0,4775	1,9979	0,2137	1,6994	679
Pop. density	196,73	1,0896	5778,1	3,2667	642,68	6,3903	46,157	679
fertilizer	1754,9	0,8964	50876	2,5895	4544,4	6,8872	56,51	669

Table 2 : correlation table among variables

	GDPCAP	Pop. growth	investment	school	life expect	CO2GDP	BODGDP	SO2GDP	IMDPT	DOC	FERTILITY	Pop. Dens
Pop. growth	-0,21***	1,00										
investment	0,16***	-0,13***	1,00									
school	-0,54***	0,48***	-0,29***	1,00								
life expect	0,75***	-0,45***	0,29***	-0,77***	1,00							
CO2GDP	0,21***	-0,12***	0,33***	-0,27***	0,26***	1,00						
BODGDP	-0,43***	0,11**	0,06	0,25***	-0,41***	0,03	1,00					
SO2GDP	-0,16***	0,08**	-0,06	0,15***	-0,22***	0,05	0,17***	1,00				
IMDPT	0,46***	-0,31***	0,26***	-0,59***	0,59***	0,25***	-0,19***	-0,06	1,00			
DOC	0,70***	-0,44***	0,17***	-0,67***	0,84***	0,18***	-0,37***	-0,18***	0,56***	1,00		
FERTILITY	-0,58***	0,59***	-0,37***	0,83***	-0,84***	-0,32***	0,25***	0,23***	-0,65***	-0,73***	1,00	
Pop. density	0,13***	-0,03	0,22***	-0,06*	0,20***	0,12***	-0,07	-0,07*	0,13***	0,03	-0,20***	1,00
fertilizer	0,38***	-0,13***	0,23***	-0,25***	0,34***	0,14***	-0,13**	-0,09**	0,26***	0,27***	-0,32***	0,58***

Table 3: Variables characteristics and sources

Variables	characteristics	sources
GDPCAP	gross domestic product per capita	WDI 2007
BODGDP	Biological Oxygen Demande per GDP	WDI 2007
CO2GDP	Carbon dioxide emission per GDP	WDI 2007
SO2GDP	sulphur dioxide emission per GDP	David Stern
n	Populatioon growth	WDI 2007
Investment	gross fixed capital formation	WDI 2007
school	Percentage of "no schooling" in the total population	Barro and Lee 2000
logitsij	log((1-mij)/mij)	WHO and UNICEF
life expect	-log(80-life expectancy)	WDI 2007
IMDPT	immunization rate (DPT)	WDI 2007
DOC	Physicians per 1000 habitants	WDI 2007
fertility	fertility rate	WDI 2007
inequality	income inequality	university of Texas income inequality
popdens	Population density	WDI 2007
fertilizer	fertilizer use	WDI 2007

Table 4: list of countries

Argentina	Japan
Australia	Kenya
Austria	Korea, Rep.
Belgium	Kuwait
Benin	Sri Lanka
Bangladesh	Lesotho
Bahrain	Mexico
Bolivia	Mali
Brazil	Malta
Botswana	Mozambique
Central African Republic	Mauritius
Canada	Malawi
Switzerland	Malaysia
Chile	Niger
China	Nicaragua
Cameroon	Netherlands
Congo, Rep.	Norway
Colombia	Nepal
Costa Rica	New Zealand
Cyprus	Pakistan
Germany	Panama
Denmark	Peru
Dominican Republic	Philippines
Algeria	Papua New Guinea
Ecuador	Poland

Egypt, Arab Rep.	Portugal
Spain	Paraguay
Finland	Rwanda
Fiji	Senegal
France	Singapore
United Kingdom	Sierra Leone
Ghana	El Salvador
Gambia, The	Sweden
Greece	Swaziland
Guatemala	Syrian Arab Republic
Guyana	Togo
Hong Kong, China	Thailand
Honduras	Trinidad and Tobago
Haiti	Tunisia
Hungary	Turkey
Indonesia	Uganda
India	Uruguay
Ireland	United States
Iran, Islamic Rep.	Venezuela, RB
Iceland	South Africa
Israel	Congo, Dem. Rep.
Italy	Zambia
Jamaica	Zimbabwe
Jordan	

Received: 18.09.2009 Accepted: 24.02.2010 Open for discussion: 1 Year