ECONOMIC RESEARCH FORUM

منتدى البحوث الاقتصادية

2011

working paper series

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Working Paper No. 646

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October 2011

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First published in 2011 by
The Economic Research Forum (ERF)
21 Al-Sad Al-Aaly Street
Dokki, Giza
Egypt
www.erf.org.eg

Abstract

The concept of sustainable development requires countries all over the world to use their natural resources rationally while pursuing their economic development, and at the same time to consider the quality of environment as a determinant of their societies' welfare. First, the method of principle component analysis and composite indicators are adopted to construct an overall sustainable development index and resource intensity measure using Millennium Development Goals (MDG) and World Development Indicator Data. Second, this paper applies an integrated paradigm to investigate the relationship between natural resource availability, economic growth, and the environment using a panel of 62 countries over the period 1990-2007. This interlocking relationship is analyzed through estimating the Resource Curse Hypothesis model and the Environmental Kuznets Curve model simultaneously while taking into consideration an important dimension—namely institutional quality. The results suggest that the way countries are dealing with sustainability in the context of MDG is negatively affecting the quality of the environment. Moreover, it proposes that countries with good institution quality are not taking the environmental problems seriously.

ملخص

يتطلب مفهوم التنمية المستدامة أن تستخدم مختلف البلدان في جميع أنحاء العالم الموارد الطبيعية بعقلانية مع السعي إلى تحقيق تنميتها الاقتصادية مع الاخذ فى الإعتبار ان نوعية البيئة تعد عاملا محددا لرفاهية مجتمعاتهم. و قد استندت الدراسة أولا، على طريقة تحليل العنصر الأساسي والمؤشرات المركبة لبناء المؤشر العام للتنمية المستدامة وقياس كثافة استخدام الموارد من خلال الأهداف الإنمائية للألفية (MDG) وبيانات المؤشر العالمي للتنمية. ثانيا، تطبق هذه الورقة نموذج متكامل لدراسة العلاقة بين توافر الموارد الطبيعية ،و النمو الاقتصادي، والبيئة بإستخدام جدول مكون من 62 بلدا خلال الفترة من 1990-2007. ويتم تحليل هذه العلاقة المتشابكة من خلال تقدير نموذج مبنى على فرضية مؤشر الموارد ونموذج منحنى كوزنتس البيئي في وقت واحد مع الأخذ فى الاعتبار النوعية المؤسسية. وتشير النتائج إلى أن الطريقة التي تتعامل بها البلدان مع الاستدامة في سياق الأهداف الإنمائية للألفية تؤثر سلبا على نوعية البيئة. وعلاوة على ذلك، فإنها تقترح أن البلدان ذات النوعية الجيدة من المؤسسات لا تأخذ المشاكل البيئية على محمل الجد.

1. Introduction

In the developing world, there is a clear trade-off between economic growth and environmental security. In the early stages of development, sustainability is difficult to maintain as countries try to achieve capital accumulation, with basic human needs being prioritized over environmental protection. Later, as development is attained, human capital, wealth and strong institutions mean that the industrial processes are likely to use fewer natural resources and produce less pollution. Following the approach of Costantini and Monni (2008), this paper revisits the relationship between natural resource availability, economic growth and the environment, using an integrative paradigm and a panel of 62 countries during the years 1990 to 2007. This is implemented through combining the Resource Curse Hypothesis model (RCH), which focuses on the impact of resource abundance on economic growth, with the Environmental Kuznets Curve (EKC), which considers the effect of economic growth on environment. Moreover, institutional quality is considered as an extra aspect in the system of equations.

The RCH literature is based on the empirical model proposed by Sachs and Warner (1997). This model was based on endogenous growth theory with a Dutch disease feature. Sachs and Warner (1997) stressed the idea that a negative relationship between natural resource abundance and economic growth imposed a conceptual puzzle, as it was expected that resource abundance should increase investment and thereby growth rates. However, what was noticed was that resource-poor economies were the world's star performers like Korea, Taiwan and Hong Kong, while many resource-rich economies underwent adverse reactions in growth during the 1970s and 1980s. Other authors built on this model by adding or altering different independent variables and different econometric methodologies. Therefore, the RCH model's structure is based on growth rate of per capita income as a dependent variable and independent variables such as initial per capita, trade policy, government efficiency, and investment rates. On the other hand, the theory suggests that EKC has an inverted U-shape curve relating economic growth to environmental degradation such as air pollutants, river quality, carbon emissions, and deforestation. Different studies could not establish the hypothesized inverted U-shaped relationship for all kinds of indicators.

This paper aims at extending the study implemented by Costantini and Monni (2008) that relates the three above mentioned dimensions within a cross-country framework to a simultaneous panel equation construction. These empirical results will provide further means of recognizing the interrelation between natural resources, economic growth and the environment and the importance of understanding these links for sustainable development. Moreover, it provides input for policy debates over sustainable development paths that satisfy countries' needs while preserving the environment for future generations for developing countries. The remainder of the paper is organized as follows. Section 2 first sheds light on RCH and EKC literature. Section 3 portrays the research methodology. In section 4, the data used is described and the construction of indices measuring the dimensions of sustainability and resource intensity is illustrated. The estimation results are presented in section 5. Section 6 concludes while offering some policy recommendations.

2. Literature Review

2.1 Role of natural resources in growth models

Natural resources were seen to be of unlimited supply throughout the history of economic thought (Auty and Mikesell 1998). The main focus was on capital and labor. By the end of the nineteenth century, conventional economists believed that natural resources can be excluded from being a constraint by increasing capital and technological progress. On the other hand, by the late nineteenth and early twentieth century, the conservationists had opposed this idea and advocated the wise use of resources. Barnett and Morse (1963) were the first to theoretically analyze natural resource scarcity and its impact on growth. Following World War II, an emerging interest in the economic growth of developing countries led to the formulation of a number of growth models based on the production function, such as Cobb-Douglas and Harrod-Domer functions. Still, natural resources were not dealt with in these growth models due to the belief that natural resources wouldn't hinder world growth. In the early 1970s, the rapid increase in the price of minerals and oil made professional economists realize that natural resource scarcity can be a constraint on economic growth. In modern world economy, prices of natural resources are determined by international markets. Scarcity or abundance is not the only factor that affects growth of a certain country but also the prices of the natural resources. Therefore, growth in resource-based countries could be explained in terms of natural resource prices in domestic and world markets, the quantity demanded by world countries, and movements in real exchange rates (Auty and Mikesell 1998). A resource-abundant country can face lower economic growth compared to a resource-scarce country if a distortion in these factors occurs.

In the twentieth century, the resource curse phenomenon was established as an important empirical finding in environmental and natural resource economics. It puts forward that natural resource-abundant economies have a tendency to grow more slowly than economies without considerable resources (Sachs and Warner 1997; Sachs and Warner 2001; Auty 2001; Atkinson and Hamilton 2003; Gylfason and Zoega 2002). Even so, the availability of natural resources does not necessarily imply a resource curse, but on average resource-abundant countries lag behind countries with fewer resources. Over the last four decades, for example, the Organization of Petroleum Exporting Countries (OPEC) as a whole experienced a negative growth rate of per capita gross domestic product (GDP) (Gylfason 2001).

During the past six decades, numerous empirical works have accumulated on the RCH. These studies used different functional forms to scrutinize the phenomena of resource curse. Table 1 summarizes some of the work done on RCH modeling. As may be seen from the table, growth modeling was adopted in diverse research applying various econometric techniques. In most cases cross-country data was analyzed (Sachs and Warner1997; Atkinson and Hamilton 2003; Costantini and Monni 2008). Further studies used regional data to prove the existence of resource curse in specific countries like Indonesia and China (Komarulzaman and Alisjahbema 2006; Shuai and Zhogying 2009). Others focused on adopting the same model introduced by Sachs and Warner (1997), but the main interest was testing if different resource intensity measures could affect the significance of the curse. Variables such as gross fixed capital formation, inflation rate, education expenditure and institution quality were employed as conditioning variables representing other macroeconomic aspects that have an effect on economic growth. The results obtained showed that there is a significantly negative relationship between natural resource abundance and economic growth which proved that the resource curse exists. In spite of the results reached, further studies are needed to identify better indicators to measure resource intensity, human capital accumulation and sustainability. In addition, testing different econometric techniques—such as investigating the endogeneity of some variables that affect unbiasedness and consistency of the coefficients in the estimated model—is called for.

2.2 Environmental Kuznets curve (EKC) model

Environmental Kuznets Curve (EKC) model is an empirical relationship between per capita income and indicators of environmental degradation. Grossman and Krueger (1991, 1995) were the first to notice this relationship when they were investigating the effect of the North American Free Trade Agreement (NAFTA) on the environment. It was named Kuznets curve after Kuznets (1955), since it resembles the hypothesized inverted U-shape relationship between economic growth and income inequality. Hence, a quadratic functional form is required in order to capture the EKC shape. The theory behind the model is based on the transition that occurs to countries as they move along the different stages of development. At the early stages of development, as income per capita increases, the level of pollutants rises. Institutions and households are interested more in consumable goods rather than environmental quality, so there is more pressure on natural resources. Whereas at higher levels of development, the pollutants level decreases with the increase in economic growth, given that the income directed to environment quality increases. At this stage governments impose environmental policies which lead to improvement in environment quality (Dasgupta et al. 2002).

A couple of new empirical studies have tried to model EKC using various functional forms. Table 2 summarizes these studies that investigate the existence of an inverted U-shaped curve using different environmental indicators (Costantini and Monni 2008; Gürlük 2009). Costantini and Monni introduced a modified functional form of the EKC model. It is used to measure macroeconomic sustainability using negative value of genuine saving per capita (GS) as a dependent variable and a group of control variables such as institution quality, human development, trade openness, and manufacturing. Conversely, Gürlük (2009) explained EKC as a relationship between biological oxygen demand (BOD) as a type of industrial pollution and per capital income as indicator of income and modified human development indicator (MHDI). Low BOD concentrations negatively affect ecosystems. The results of the two studies support the existence of a significant nonlinear relationship between pollution and per capita income. For an extensive literature survey of EKC studies see Dijkgraaf and Vollebergh (2005), Nahman and Antnobus (2005), Tamazian and Rao (2010), and Zaim and Taskin (2000).

3. Empirical Framework

Chevallier (2009) criticized the fact that economic literature deals with RCH and EKC as two separate issues, even though there is an interlocking relationship between natural resource abundance, economic growth, and the environment. Exploring the relationship between these three variables is a new field, and identified as an integrated paradigm for sustainable development. Thereby, this paper focuses on developing an empirical framework following the approach of Costantini and Monni (2008) to further study RCH and EKC models simultaneously. The main addition is that panel data is used to investigate this interlocking relationship. This setting has several advantages over cross-sectional data. The first reason is that a panel dataset provides larger data points which in return increases the degrees of freedom and reduces the colinearity among the explanatory variables. Hence, the efficiency of the econometric estimates is improved. Second, it allows the construction and testing of more complex behavioral models than purely cross-sectional or time series models. Last but not least, the fundamental advantage of panel data is that it focuses on heterogeneity across units, which allow greater flexibility in modeling the differences in behavior across countries (Greene 2008; Hsiao 2003).

Though this integrated strategy offers a more complete picture of the triangular relationship it however entails some major tradeoff. For instance, there are major methodological advances in the RCH literature that are difficult to account for in the integrated approach. As in Collier and Goderis (2008) where how the curse happens, and the distinctions between the short and long-run effects are studied.

3.1 Simultaneous equations system

A general framework, including a growth equation, an institution quality equation, and environmental Kuznets curve model, is adopted. This empirical framework is based on estimating a simultaneous equations system using panel data based on the following h^{th} equation that can be represented as:

$$\boldsymbol{y}_{\boldsymbol{h}_{NT\times 1}} = \left(\boldsymbol{Y}_{\boldsymbol{h}_{NT\times(g_h-1)}} \middle| \boldsymbol{X}_{\boldsymbol{h}_{NT\times k_h}}\right)\binom{\gamma_h}{\beta_h} + \boldsymbol{\varepsilon}_{\boldsymbol{h}_{NT\times 1}} \quad (1)$$

$$= \boldsymbol{Z}_{\boldsymbol{h}_{NT\times(g_h-1+k_h)}}\boldsymbol{\delta}_{\boldsymbol{h}(g_h-1+k_h)\times 1} + \boldsymbol{\varepsilon}_{\boldsymbol{h}_{NT\times 1}} \quad \boldsymbol{h} = 1,2,\ldots,\boldsymbol{g}$$

Where $\boldsymbol{y}_{\boldsymbol{h}}$ is the column vector of data on the dependent endogenous variable, $\boldsymbol{Y}_{\boldsymbol{h}}$ is the matrix of data on the $g_h - 1$ explanatory endogenous variables, $\boldsymbol{X}_{\boldsymbol{h}}$ is the matrix of data on the included exogenous variables, $\boldsymbol{\delta}_{\boldsymbol{h}}$ summarizes all the coefficients to be estimated in the equation and $\boldsymbol{NT}$ is the number of observations where $\boldsymbol{N}$ represents the number of countries included in the analysis and $\boldsymbol{T}$ is time. The $\boldsymbol{\varepsilon}_{\boldsymbol{h}}$ is an NT×1 vector of error terms,

$$\boldsymbol{\varepsilon}_{\boldsymbol{h}} = (\boldsymbol{I}_{\boldsymbol{N}} \otimes \boldsymbol{\iota}_{\boldsymbol{T}})\boldsymbol{\alpha}_{\boldsymbol{h}} + \boldsymbol{u}_{\boldsymbol{h}} \quad (2)$$

with $\boldsymbol{\alpha}_{\boldsymbol{h}} = (\boldsymbol{\alpha}_{\boldsymbol{1h}}, \ldots\ldots\ldots\ldots, \boldsymbol{\alpha}_{\boldsymbol{Nh}})'$ and $\boldsymbol{u}_{\boldsymbol{h}} = (\boldsymbol{u}_{\boldsymbol{11h}}, \ldots\ldots\ldots, \boldsymbol{u}_{\boldsymbol{1Th}}, \ldots\ldots\ldots\ldots \boldsymbol{u}_{\boldsymbol{NTh}})'$ where $\boldsymbol{\alpha}_{\boldsymbol{h}}$ denotes the unobservable individual specific effect, $\boldsymbol{u}_{\boldsymbol{h}}$ denotes the remnant disturbance, $\boldsymbol{I}_{\boldsymbol{N}}$ isan N dimension identity matrix, $\boldsymbol{\iota}_{\boldsymbol{T}}$ is a vector of ones of dimension T and $\otimes$ denotes Kronecker product.

The objective of using simultaneous equations model is to explain the potential endogeneity of several explanatory variables. Endogeneity of the right-hand regressors is a serious econometric problem. It leads to the inconsistency and bias of the usual ordinary least squares (OLS) estimates, since OLS doesn't differentiate between which of the explanatory variables in the equation are endogenous and which are exogenous. The problem evolves when applying least squares directly to estimate this equation using explanatory endogenous variables Y_h which are correlated with the stochastic disturbance terms ε_h, even in probability limit. If these variables could be replaced by appropriate instruments, (i.e., related variables that are uncorrelated) in the probability limit, with the stochastic disturbance terms, the resulting estimator would be consistent. It is often difficult to find such instruments, however, the two-stage least squares (2SLS) method accomplishes this by replacing explanatory endogenous variables with their estimated values. It can be noticed that 2SLS distinguishes between explanatory endogenous variables Y_h and included exogenous variable X_h. The significance of 2SLS could be tested using Hausman test, where Y_h is exogenous under the null hypothesis. If 2SLS is utilized in the case of cross-section regression, the estimated parameters are consistent, but not efficient. At this point, the results of the analysis obtained from 2SLS needs to be improved; the three stage least squares (3SLS) method can be adopted. The 3SLS technique is an improvement over 2SLS. While both are consistent, 3SLS is asymptotically more efficient than 2SLS. Since, the basic rationale for 3SLS, as opposed to 2SLS, is its use of information on the correlation of the stochastic disturbance terms of the structural equations in order to improve asymptotic efficiency (Maddala 1992; Intriligator et al. 1996; Greene 2008; Wooldridge 2002; Gujarati 2003; Verbeek 2008; Wooldridge 2009). On the other side, the estimation of simultaneous equations using panel data is considered a weighted combination of between cross-section, between time-period and within simultaneous equations system estimates (Baltagi 2008; Baltagi and Liu2009). Baltagi (1981) derived simultaneous panel data models, named as simultaneous equations with error components. Baltagi (1984) proved that simultaneous equations with error components has efficiency gains in terms of the mean squared error when performing error component two-stage least squares (EC2SLS) and error component three-stages least squares (EC3SLS) over the standard simultaneous equation counterparts, 2SLS and 3SLS, respectively. Therefore, this paper utilizes three different econometric techniques namely between regression, group means regression, error components two stage least squares, and error components three stage least squares as potential estimation techniques for the simultaneous equations, along with various dummy variables to capture the effect of regional factors such as the MENA region.

3.2 Integrated model

The unambiguous model specification of equation (1) that will be adopted, allowing the interrelationship of RCH and EKC is described in equations (3a) and (3c), respectively. Equation (3b) is incorporated to allow measuring the effect of institutional quality.

Economic growth= β_0 + β_1 *Initial level of GDP* + β_2*Institution quality* + β_3 *Human capital accumulation* + β_4 *Resource intensity index*+ β_5 *Terms of trade* + β_6 *Trade openness* + β_7*Gross fixed capital formation* + β_8 *Foreign direct investment* + β_9 *Regional variables* (3a)

Institution quality= β_0 + β_1 *Initial level of GDP* + β_2 *Human capital accumulation* + β_3 *Terms of trade* + β_4 *Trade openness* + β_5*Gross fixed capital formation* + β_6 *Foreign direct investment* + β_7 *Regional variable* (3b)

Environment quality= β_0 + β_1 *Final level of GDP* + β_2 *Final level of GDP^2* + β_3*Institution quality*+ β_4 *Resource intensity index* + β_5 *Overall sustainable development index* + β_6 *Regional variables* (3c)

RCH model describes the relationship between economic growth as a dependent variable which is measured by natural logarithmic GDP per capita growth and independent variables such as initial level of GDP, and other conditioning variables representing macroeconomic aspects. The choice of including a variable as conditioning variables depends on what is proposed by RCH literature previously discussed to insure model identification in addition to data availability. The institution quality equation depicts rule of law as a function of GDP, terms of trade, trade openness, FDI and gross fixed capital formation also taking into consideration variables like human development and regional effects. Institutional quality is proxied by the rule of law which is obtained from 1996-2008 Aggregate Governance Indicators, Kaufman et al. (2008). In a first phase of model selection, Hausman test procedure was applied in order to test for variables endogeneity. The test showed that institutional quality is an endogenous explanatory variable, therefore equation (3b) is included to the model. This result is corroborated by the work of Isham et al. (2003), Barro and Sala-i-Martin (2004) and Costantini and Monni (2008). Equation (3c) depicts environment quality measured by the natural logarithm of metric tons of per capita carbon dioxide emissions (CO_2) as a function of a number of explanatory variables such as institutional quality, resource intensity measure, and sustainable development indicator. CO_2 is used as a measure of environment quality since it results from the accumulation of human-made greenhouse gases that damage the environment. In addition, CO_2 is highly correlated with other pollutants such as nitrous oxide and sulphur dioxide (Hoffmann et al. 2005) and is considered the primary source of global warming. Moreover, reliable data on CO_2emissions is available and most commonly used by EKC literature (Dasgupta et al. 2002; Nahman and Antnobus 2005). Consequently, there is sufficient evidence for the use of CO_2as a valid and reliable proxy for environmental quality.

In passing, note that not each and every variable needs to appear in each equation of the system described in equations 3a-3c. As a matter of fact, some variables need to be excluded in order to ensure identification. Furthermore, equations 3a-3c is estimated using group means regression, EC2SLS, and EC3SLS. The Hausman test is also used to aid in model selection on the basis of consistency and efficiency of the estimators.

4. Data Sources and Indicator Construction

The previous section portrayed the empirical framework estimated in the following section. Equation 3a-3c highlights the variables required for the estimation. This section deals with the necessary data for model estimation. The data used includes 62 countries covering the years 1990 to 2007. Data was acquired from four different sources: the 2009 World Development Indicators (WDI), Millennium Development Goals (MDGs) data, Human

Development Report, and Aggregate Governance Indicators 1996-2008 compiled by Kaufman et al. (2008). The variable description is recapitulated in table 3. It starts off by a set of regional dummies where the 62 countries are grouped to six different regions (details on how the countries are grouped is in the Appendix). The remainder of this section is split into two-subsections. The former describes the principal component analysis applied in the construction of the indicators measuring sustainability and resource intensity. The latter, describes the developed indicators.

4.1 Principal component analysis (PCA)

Sustainable development was first introduced by the Brundtland Commission in 1987. It is a three dimensional concept describing development from economic, environmental, and social aspects. A modified version of the sustainable development indicator constructed by Adler et al. (2009) is compiled using MDGs database. This is because Adler et al.'s (2009) indicator suffers from a serious drawback—the inclusion of GDP as one of its components leads to misleading results. Since GDP takes into consideration all the produced commodities in a given country but doesn't measure welfare means it can't be used to assess sustainable development (Levett 1998; Bregar et al. 2008). It should also be noted that the human development indicator (HDI) suffered from the same problem when it included the GDP as one of its components (Kelley 1991; Lind 1992; McGillivray1991; Srinivasan 1994).The Principal Component Analysis (PCA) and MDG data for the 62 sample countries are employed to construct factors measuring economic, environmental, and social dimensions. Moreover, WDI is used to obtain an indicator for resource intensity.

PCA is a statistical technique which uses the linear transformation of interrelated variables with the aim of reducing the extended original set to a smaller set of linear combinations that accounts for most of the variations existing in the former set. It can also be viewed as a data reduction technique. Let us consider the variables $X_1, X_2, ...X_p$. A PCA of this set of variables can generate p new variables, known as the principal components, $PC_1, PC_2, ...,PC_p$ and the bs are the principal component coefficients. The principal components can be expressed as follows:

$$PC_1 = b_{11}X_1 + . . . + b_{1p}X_p = Xb_1$$

:

:

$$PC_p = b_{p1}X_1 + . . . + b_{pp}X_p = Xb_p$$

or, in matrix notation as,

$$PC = Xb \quad (4)$$

PCA requires two stages, specifically factor extraction and factor rotation. The primary objective of the first stage is to form an initial decision about the number of factors underlying a set of measured variables. The principal components are then extracted for the factors that have Eigen values greater than one, given that the first principal component denoted by PC (1) accounts for the largest variation in the data. The goal of the second stage is twofold: (1) to rotate factors in order to make them more interpretable and (2) to take a final decision on the number of underlying factors (Johnson and Wichern 2002; Jolliffe 2002).

In general, PCA performs well in relation to removing weaknesses of regression analysis such as multicollinearity. Since most economic indicators suffer from multicollinearity, PCA will provide better indicators to be used in the analysis (Khatum 2009).

4.2 Developed indicators

So far no consensus has been reached on the correct approach to measure sustainable development due to the complexity and multidimensional nature involved (Bregaret al.2008; Kuliget al.2010). According to neo-classical economic assumptions of capital theory, there are two types of sustainability. First, weak sustainability which is based on the substitution assumption between natural capital and manufactured capital; an economy is considered sustainable if it uses its natural capital provided that manufactured capital substitutes for the consumed natural capital. Genuine savings is an example of this kind of sustainable development indicator. Second, strong sustainability is based on the idea that these two kinds of capital are complementary. Therefore, natural capital has to be preserved. Ecological footprints indicator is an example of strong sustainable indicators. In principle, strong sustainable indicators are difficult to obtain because there is no clear way of measuring the degradation of natural capital (Chiesura and Groot 2003). With the use of PCA, the developed indicator will measure weak sustainability in the context of MDGs.

As illustrated in table 4, economic dimension is calculated using one retained PC explaining 82.95% of the total variance. This factor measures poverty reduction across countries of the world as it is a function of three variables: percentage of population below $1 corrected for purchasing power parity (PPP) per day (pop1), percentage of population below the national poverty line (povline), and percentage of poverty gap ratio (povgap) at $1 a day (PPP). Second, social dimension is deliberated using three retained PCs (socidim1, socidim2, and socidim3) explaining 86.49% of the total variation. Human capital accumulation is represented by the first PC of social dimension. Variables like total net enrolment ratio in primary education (totenrol), percentage of literacy rates of 15-24 year olds (litboth), gender parity index in primary level enrolment (genindpr), gender parity index in secondary level enrolment (genindse), gender parity index in tertiary level enrolment (genindte), and average fertility rate (fert)(i.e., total number of births per woman). The *socidim2* measures the health status which corresponds to the percentage of people living with HIV for age interval between 15-49 years old (hivpeop),and Tuberculosis death rate per year per 100,000 people (tuberdeath). The last PC of this dimension symbolizes government effort to enhance education through average public spending on education as a percentage of GDP (eduper). Environmental dimension is the last indicator for measuring sustainable development and is calculated using two retained PCs (envdim1 and envdim2) explaining 87.8 % of the total variance. Carbon dioxide emissions (CO_2) and energy use, represented by kilogram oil equivalent per $1,000, are exploited to obtain *envdim1*and are denoted as co2ppp and enrguse, respectively. The *envdim2* is measured by consumption of all ozone-depleting substances (ozodep).

Turning to the resource intensity indicator, it is assessed by two PCs (resdim1 and resdim2) explaining 73.64% of total variance. Ore and metal exports (oresexp), and mineral depletion (mindepl) characterized the first PC, and this gives an idea about how countries make use of their minerals. Fuel exports (fuelexp) variable is the *resdim2*.

After the stage of calculating factors for each distinct dimension of sustainability, the Bregar et al. (2008) methodology is adopted to compile the development index for each dimension. It is based on using the weighted mean of the retained PCs as follows:

$$\mathbf{I_P} = \frac{\sum_{i=1}^{m} \mathbf{F_{pi}} * \boldsymbol{\lambda_i}}{\sum_{i=1}^{m} \boldsymbol{\lambda_i}}$$

Where,$\mathbf{I_P}$represents the development index, that is calculated as a weighted mean of m values of PCs for unit p.$\mathbf{F_{pi}}$ stands forthe value of the i^{th}PC for unit p. Whereas, $\boldsymbol{\lambda_i}$corresponds to the Eigen value of the i^{th} PC.

Thereafter, the overall sustainability index is calculated as an arithmetic mean of the three indices of development (economic, environmental, and social index), because the sustainable development concept is based on equal importance of the three dimensions (Bregar et al. 2008). The calculation equations for these indices are as follows:

Social dimension = (4.80963*socidim1 +1.9288* socidim2+ 1.0454* socidim2)/ 7.78383

Environmental dimension = (1.62253*envdim1 + 1.01159*envdim2)/2.63412

Resource intensity dimension = (1.4303*resdim1 +1.11892*resdim2)/2.20924

Overall sustainable development index = 1/3 *(economic + social + environment)

5. Estimation Results

The simultaneous equation system illustrated in equations 3a-3c is estimated using between regression, EC2SLS, and EC3SLS. Furthermore, the Hausman test is used to investigate which method of estimation provides consistent and efficient estimators. Results of this test leads to the rejection of the null hypothesis, asserting that the differences in coefficients are not systematic at a one percent level of significance. Therefore, between3SLS (BE3SLS) technique is an enhancement over between2SLS (BE2SLS). This finding supports the existence of an interlocking relationship between economic growth, institution quality, and the environment quality. Hence, they should not be treated separately as proposed by Costantini and Monni (2008). However, the Hausman test rejects the hypothesis indicating that EC3SLS is more efficient than EC2SLS. Baltagi (1981) demonstrated that EC3SLS reduces inefficiency in the EC2SLS if the disturbances of the different structural equations are uncorrelated with each other. This is different from the equivalence conditions between 2SLS and 3SLS in the classical simultaneous equations model (Baltagi, 2008).

The estimated models use the panel data described in the previous section. The economic growth equation is based on GDP per capita growth as a function of initial GDP, institution quality, life expectancy at birth, education subsidies, gross fixed capital formation, foreign direct investment, resource intensity index, merchandize trade and regional dummies. Institution quality equation is a function of GDP, education subsidies, fertility rate, merchandize trade and regional dummies. Finally, environmental quality is calculated using metric tons of CO_2 per capita as a dependent variable and GDP, square value of GDP, institution quality, resource intensity index, sustainable development indicator and regional dummies. Resource intensity index, sustainable development indicator and the regional dummies are time invariant covariates. Variables like fertility rate, and terms of trade are dropped from the growth model because they jointly have an insignificant effect. Some other variables such as life expectancy at birth, resource intensity index, gross fixed capital formation, and foreign direct investment are dropped from institution quality equation since they do not show any significant effect. Despite the fact that inflation rate was proposed by the RCH literature (Barro 1991; Barro and Sala-i-Martin 2004) and industry value-added was used by the EKC models (Costantini and Monni, 2008), they appear with no significant effect and for that reason they areexcluded from the estimated systems of equations. Discussion on the obtained results of the preferred model namely, EC2SLS is provided below.

In EC2SLS, lagged GDP is added to the growth equation as proposed by the neoclassical theory of the long run growth model as it represents conditional rate of convergence (Barro 1991; Barro 1998; Barro and Sala-i-Martin 2004; Carlin and Soskice 2006, and Islam 1995). This kind of convergence highlights the fact that countries are not expected to converge to the same living standards unless they have similar important aspects such as saving rate and population growth. This implies that poor countries will not catch up and achieve the living standards of rich countries unless the former are able to change the determinants of their steady state (Carlin and Soskice 2006). The lagged GDP per capita estimate was insignificant. However, adding the GDP growth dummy—that estimate the impact of poor performance countries—and a dummy for the last three years in the time coverage, it turned out to be significantly positively correlated with GDP growth. The marginal value of lagged GDP per capita is equal to -1.892559 given all other variables remaining constant. The GDP per capita has a positive significant impact on the institutional quality. Human capital is measured by three variables: life expectancy, fertility rate and education subsidies. Education subsidies variable is used to measure how much governments spend on education to enhance the human capital of the country. Life expectancy at birth is adopted to assess the health status of citizens of each country. Fertility rate determines population growth. The impact of these variables varies in the two equations of growth and institution quality. First, the negative sign of education subsidies gives an idea that governments are not putting enough investment in education. Therefore, growth is negatively affected (Blankenaua and Simpson 2004; Stone at el. 2010). Second, in the institution quality equation, education subsidies have a positive significant effect. Both gross fixed capital formation and foreign direct investment are positively affecting growth.

In the environment quality equation, GDP and GDP squared are used to test whether the inverted U-shaped curve of EKC exists significantly. According to our results, both variables have a significant effect and the expected sign of coefficients. Hence the EC2SLS method of estimation embraces the existence of EKC. The constructed resource intensity index is used to test the existence of the resource curse. According to the literature the sign and significance of the variable coefficient measuring resource intensity suggests the existence of a curse or a blessing (Sachs and Warner 1997; Sachs and Warner 2001; Auty 2001; Atkinson and Hamilton 2003; Gylfason and Zoega 2002). According to the results in table 6, resources are exploited and are only negatively affecting environment quality, which opposes the literature. Overall the sustainable development index is positively correlated with environmental degradation. This means that sustainable development, according to the MDGs definition, is negatively correlated with environmental quality. The construction of this index is based on the theory of weak sustainability in which natural capital is substituted by manufactured capital; as long as there is a balance between manufactured and natural capital, an economy is considered sustainable (Chiesura and Groot 2003).

The classification of countries across regions was based on the work of Atkinson and Hamilton (2003). Countries were distributed into six regions: Latin America, MENA, Sub-Saharan Africa, Asia, Central America, and Europe and North America. The effect of regional dummies in the three equations have given a better picture concerning the performance of each region with regards to the interlocking relationship of economic growth and the environment given the endogeneity of institution quality. This is explained as follows: All regional dummies share the same coefficient signs; they are positively correlated with growth and environment degradation while negatively affecting institution quality except for Europe and North America where they do not have a significant effect on the rule of Law. Moreover, Sub-Saharan African countries do not contribute to environmental degradation as compared to other regions. The dummies have similar values of coefficients in the growth equation while Latin America, Europe and North America have larger influences on environmental degradation.

6. Conclusion and Policy Recommendations

In this paper, the growth-environment relationship is analyzed. The main conclusion is that an interlocking relationship exists between natural resource availability, economic growth, and the environment. The results support the idea proposed by Giddings et al. (2002) that these three dimensions have to be represented as three interconnected rings that are all needed to reach sustainable development.

However, the concept of sustainable development paths that satisfy countries' needs while preserving the environment for future generations is not met. In addition, a resources curse seems to exist, which negatively affects environment quality. The curse arises from both mineral and fuel exports. The paper also finds evidence that countries are focusing on sustaining the social and economic dimension of sustainable development without taking the environmental dimension seriously. Therefore, an empirical framework that takes into consideration economic growth and environment quality, given the quality of institution, is essential. Given the analysis, the following country level policies may be suggested. Countries have to focus on having a better rule of law in order to improve institution quality. However, a warning should be given to countries with good institution quality since the analysis revealed that they are not taking environment quality seriously.

Another important result is that education subsidies have a direct impact on institution quality and low investment in education negatively affects growth. Therefore, it is recommended that governments spend more on education in order to accumulate human capital for the future. Moreover, the investment rate and foreign direct investment are found to directly force higher level of economic growth. Consequently, countries must have higher levels of gross capital formation and encourage foreign capital investment to take place using local resources. Last but not least, after the analysis of the results, we urge future studies to take into consideration the endogeneity problem and adopt panel datasets in order to improve the efficiency of econometric estimates.

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Table 1: Various Resource Curse Hypothesis Models

Author	Dependent variable	Independent variable	Econometric model used
Sachs and Warner (1997)	Real per capita growth rate of GDP	Initial GDP per capita, share of primary exports, open economy index, investment ratio, bureaucratic efficiency index, external trade index, ratio of income share, African countries dummy, Asian countries dummy, and Latin American countries dummy	OLS method using cross-country data
Atkinson and Hamilton (2003)	Per capita growth rate of GDP	Initial GDP per capita, years of attainment in school, investment ratio, resource rent, Sub-Saharan Africa dummy, Central America dummy, Latin America dummy, Middle East and North Africa dummy, and East Asia dummy	OLS method using cross-country data
Costantini and Monni (2008)	Per capita growth rate of GDP	Initial GDP per capita, trade, foreign direct investment, GDP deflator, life expectancy, secondary education, diffuse resources, point resources, and institution quality	Simultaneous equation of cross-country analysis
	Institution quality	Initial GDP per capita, trade, foreign direct investment, GDP deflator, life expectancy, secondary education, diffuse resources, and point resources	
Shuai and Zhogying (2009)	Per capita growth rate of GDP	GDP per capita income lagged one, energy exploitation intensity, fixed assets investment, enrolled students in higher education, research and development, trade, and institutions index	Random and fixed effect panel data analysis

Source: Authors' summary on some of the recent work on RCH modeling.

Table 2: Diverse Environmental Kuznets Curve Models

Author	Dependent variable	Independent variable	Econometric model used
Costantini and Monni (2008)	Negative value of genuine saving per capita (GS)	Trade, industry value added, modified human development index, square value of modified human development index, and institution quality	OLS method using cross-sectional data
Gürlük (2009)	Amount of oxygen needed by bacteria in order to dissolve waste (BOD)	Gross domestic product per capita, square value of modified human development index, and modified human development index	OLS method using time series data

Source: Authors' summary on the work done on EKC modeling.

Table 3: List of Variables

Variable name	Variable description	Variable name	Variable description
GDPgro~h	Natural logarithmic GDP per capita growth	Mena	Dummy variable for the MENA region
GDP	GDP per capita, PPP (constant 2007 international $)	Latinam	Dummy variablefor Latin America
Mtrade	Merchandise trade (% of GDP)	Asia	Dummy variable for Asia
du_rg_lGDP~h	Dummy variable for economic growth less than 1.5	centralam	Dummyvariable for Central America
du_GDP_s	Dummy variable for the last three year (2005, 2006, 2007)	Europe	Dummy variable for Europe and North America
co2	Natural logarithm of Carbon dioxide emissions (CO2), metric tons of CO2 per capita	Subsah	Dummy variable for sub-Saharan countries
Edu	Natural logarithm of Average Public spending on education, total (% of GDP)	IQ	Institution quality
Inv	Natural logarithm of Gross capital formation (% of GDP)	resourc~m	Resource intensity index compiled using PCA
Fdi	Natural logarithm of Foreign direct investment, net inflows (% of GDP)	susdeve~p	Overall sustainable development index calculated using PCA
termst~e	Net barter terms of trade (2000 = 100)	Life	Life expectancy at birth
Ferti	Average fertility rate, total (births per woman)		

Table 4: Developed Dimensions Using Method of PCA

Dimensions	Number of factors obtained	Used variables	Total variance
Economic dimension	one	PC1(pop1, popline, povgap)	0.8295
Social dimension	three	socidim1 (totenrol, litboth, gendindpr, gendindse, gendindte, fert), socidim2 (hivpeop, tuberdeath) and socidim3 (eduper)	0.8649
Environment dimension	two	envdim1 (co2ppp, enrguse) and envdim2 (ozodep)	0.878
Resource intensity	two	resdim1 (oresexp, mindepl) and resdim2 (fuelexp)	0.7364

Source: Authors' calculation using PCA method, and MDGs and WDI data.

Table 5: Estimated Model Using between Regression

Model	**Between regression**					
Estimation method		**BE2SLS**			**BE3SLS**	
Equation	**Economic growth**	**Rule of law**	**Environment quality**	**Economic growth**	**Rule of law**	**Environment quality**
GDP (YR1990)	0.0303028			0.0288539		
GDP (YR2007)		0.0253851	0.7723238		0.0321552	0.7432016
GDP^2(YR2007)			-0.0708145			-0.0694109
IQ (YR2007)	-0.0128246		1.134417***	-0.030656		1.147274***
Life	0.0006636			0.0008762		
Edu	-0.0039295	0.5050576*		-0.009251	0.4921309*	
Ferti		-0.025156			-0.0261663	
Inv	0.3988328**			0.4082407***		
Fdi	0.0535406			0.0612672		
Mtrade	-0.0000192	0.009661**		0.0001267	0.0097346**	
termstr~e		-0.003553			-0.0035847	
resourc~m	-0.0258696		0.0131761	-0.026441		0.0158009
susdeve~p			0.2030262			0.2133896
Mena	1.698119**	-1.916312*	-1.176061	1.647731**	-1.923518*	-1.03941
Latinam	1.584808**	-1.951311*	-0.8108509	1.529288**	-1.959935**	-0.6841643
Asia	1.721798**	-1.260308	-1.513982	1.678413**	-1.270515*	-1.398397
Centralam	1.663804**	-2.018746**	-1.093023	1.603358**	-2.024678**	-0.9687839
Subsah	1.580131**	-2.381226**	-2.805209	1.523518**	-2.385964**	-2.683644
Europe	1.703046**	-0.593031	-1.345461	1.674339**	-0.6030675	-1.238924
N	62	62	62	62	62	62
F-statistic	2296.61***	7.93***	15.64***	2966.43***	9.64***	19.06***
Hausman test for significance of BE2SLS and BE3SLS:				chi2(34) = .66	with Prob>chi2 =	0.999

Source: Authors' estimation. * indicates significance at the 10 percent level, ** indicates significance at the 5 percent level, and *** indicates significance at the 1 percent level.

Table 6: Estimated Model Using Random Effects Regression

Model	**Random-effects regression**					
Estimation Method		**EC2SLS**			**EC3SLS**	
Equation	**Economic growth**	**Rule of law**	**Environment quality**	**Economic growth**	**Rule of law**	**Environment quality**
GDP (lagged)	0.0001551**			0.0001463**		
GDP		0.0000375*	0.0014257**		0.0000425*	0.0013303**
GDP^2			-1.48E-06***			-1.46E-06**
du_GDP_s	0.2831539**	0.0174833		0.2748811**	0.0359206	
du_rg_lGDP~h	-2.175868***	-0.136374**	0.3336317	-2.124261***	-0.1335398**	0.6586343**
IQ	0.4585984		3.947869***	0.8049446*		6.319042***
Life	0.0006861			0.0006275		
Edu	-0.102332*	0.056835***		-0.1182034**	0.028331*	
Ferti		-0.00054			-0.0052778**	
Inv	0.3161963***			0.32674***		
Fdi	0.0565661**			0.0583515**		
Mtrade	-7.26E-05	0.0002442		-0.0002103	0.0005274**	
resourc~m	-0.228705		0.7266449**	-0.2204236		0.809759**
susdeve~p			0.2302002***			0.2403852***
Mena	2.386417***	-0.171159**	0.7436401***	2.405459***	-0.0953155*	0.7635613***
Latinam	2.272562***	-0.19639***	0.907375***	2.301497***	-0.1314846**	1.024784***
Asia	2.357145***	-0.107221**	0.6073937***	2.352492***	-0.0430938	0.5227849***
Centralam	2.332444***	-0.18956***	0.5114388***	2.359733***	-0.1238393**	0.6269291***
Subsah	2.309541***	-0.22188***	-1.416928***	2.350004***	-0.1503191***	-1.24462***
Europe	2.305572***	-0.019	1.535529***	2.272309***	0.0430437	1.20882***
N	1054	1054	1054	1054	1054	1054
F-statistic	3031.32***	18.2***	131.35***	3079.9***	18.92***	140.55***
Hausman test for significance of EC2SLS and EC3SLS:				Chi2(36) =82.82 with	Prob>chi2 =	0.0000

Source: Authors' estimation. * indicates significance at the 10 percent level, ** indicates significance at the 5 percent level, and *** indicates significance at the 1 percent level.

Appendix

Classification of Countries According to Regions of the World

Latin American countries	MENA countries	Sub-Saharan African countries	Asian countries	Central American countries	European and North American countries
Argentina,	Afghanistan,	Angola,	Azerbaijan,	Costa Rica,	Albania,
Bolivia,	Algeria,	Benin,	Bangladesh,	Dominican	Armenia,
Brazil,	Bahrain,	Botswana,	Bhutan,	Republic,	Australia,
Chile,	Djibouti,	Burkina Faso,	Cambodia,	El Salvador,	Austria,
Colombia,	Egypt,	Burundi,	China,	Guatemala,	Belarus,
Ecuador,	Iran,	Cameroon,	Hong Kong	Haiti,	Belgium,
Guyana,	Iraq,	Cape Verde,	Special	Honduras,	Bosnia and Herzegovina
Mexico,	Israel,	Central African	Administrative	Jamaica,	Bulgaria,
Paraguay,	Jordan,	Republic,	Region,	Nicaragua,	Canada,
Peru,	Kuwait,	Chad,	India,	Panama,	Croatia,
Suriname,	Lebanon,	Comoros,	Indonesia,	Saint Kitts and	Cyprus,
Uruguay, and	Libyan Arab	Congo,	Japan,	Nevis,	Czech Republic,
Venezuela	Jamahiriya,	Democratic	Kazakhstan,	Saint Lucia, and	Denmark,
	Mauritania,	Republic of the	Korea,	Trinidad and	Estonia,
	Morocco,	Congo,	Kyrgyzstan,	Tobago	Finland,
	Oman,	Cote d'Ivoire,	Lao People's		France,
	Qatar,	Eritrea,	Democratic		Georgia,
	Saudi Arabia,	Ethiopia,	Republic,		Germany,
	Sudan,	Gabon,	Malaysia,		Greece,
	Syrian Arab	Gambia,	Maldives,		Hungary,
	Republic,	Ghana,	Mongolia,		Ireland,
	Tunisia,	Guinea,	Nepal,		Italy,
	United Arab	Guinea-Bissau,	Pakistan,		Latvia,
	Emirates, and	Kenya,	Papua New Guinea,		Lithuania,
	Yemen	Lesotho,	Philippines,		Luxembourg,
		Liberia,	Singapore,		Netherlands,
		Madagascar,	Sri Lanka,		New Zealand,
		Malawi,	Tajikistan,		Norway,
		Mali,	Thailand,		Poland,
		Mozambique,	Timor-Leste,		Portugal,
		Namibia,	Turkmenistan,		Republic of Moldova
		Niger,	Uzbekistan, and		Romania,
		Nigeria,	Viet Nam		Russian Federation
		Rwanda,			Slovakia,
		Senegal,			Slovenia,
		Sierra Leone,			Spain,
		South Africa,			Sweden,
		Swaziland,			Switzerland,
		Togo,			Macedonia,
		Uganda,			Turkey,
		United Republic			Ukraine,
		of Tanzania,			United Kingdom,
		Zambia, and			and United
		Zimbabwe			States