IBIMA Publishing
Journal of Economics Studies and Research
http://ibimapublishing.com/articles/JESR/2017/947798/
Vol. 2017 (2017), Article ID 947798, 18 pages
DOI: 10.5171/2017. 947798

Research Article

Dynamic Panel Data Analysis of CO_2 Emissions Driving Forces

Saoussen Aguir Bargaoui[1] and Fethi Zouheir Nouri[2]

[1] Business School of Management - IHE Sousse, LARMA, Boukhzar University Campus, Elriadh City, Sousse ,TUNISIA

[2]High School of economic sciences and commercials, Tunis University,LARMA, Montfleury, TUNISIA

Correspondence should be addressed to: Saoussen Aguir Bargaoui; aguir_saoussen@yahoo.fr

Received date: 15 March 2017; Accepted date: 19 June 2017; Published date: 10 August 2017

Academic Editor: Imen Gam

Abstract

Interaction between human beings and their natural environment has led to threats to ecosystems. To study this relationship, several sociological theories have been developed, among them treadmill of destruction, world system position, ecological modernization, human ecology, treadmill of production and metabolic rift theories. Research studies in this field used the STochastic Impacts by Regression on Population, Affluence and Technology model. The present work tries to verify these theories via a panel data analysis of 114 countries during the period 1980-2010 to study the driving forces of environmental impact approximated by CO_2 emissions. The originality of this research consists in the attempt to spot the maximum of CO_2 emissions driving forces knowing that some driving forces were studied only for ecological footprint as environmental impact indicator. Findings support the fact that our human society cannot be optimistic about achieving sustainability since the current economic growth deteriorates environmental quality, even if we try to dematerialize our economies or to make changes at the institutional level.

Keywords: Dynamic panel data, CO_2 emissions, human ecology, ecological modernization, treadmill of destruction, treadmill of production, metabolic rift

Introduction

A large literature is assent on the fact that human activities gluttonous in fossil energy are the major cause of climate change (IPCC, 2001). These changes are attributed to the increase in the concentration of greenhouse gases, including carbon dioxide which is the most harmful pollutant. To recognize the relationship human / nature, several theories in economics and sociology have been developed trying to study the quality of the environment, including: ecological modernization theory, treadmill of production theory, treadmill of destruction theory, metabolic rift theory, World-System theory, and human ecology theory.

Inspired by previous empirical works, we proceed with reconcilable approach that seeks to validate all of these theories by

Cite this Article as: Saoussen Aguir Bargaoui and Fethi Zouheir Nouri (2017), "Dynamic Panel Data Analysis of CO_2 Emissions Driving Forces ", Journal of Economics Studies and Research, Vol. 2017 (2017), Article ID 260450, DOI: 10.5171/2017.947798

estimating the contribution of the most influential factors. Empirical validation of hypotheses is based on the popular STIRPAT model (Stochastic Impact by Regression on Population, Affluence, and Technology) by recourse to the dynamic panel data analysis.

More precisely we will attempt to validate empirically the ecological modernization theory, the hypothesis of Environmental Kuznets curve, the treadmill of production theory, the World-System theory, as verified by York et al. (2003). In addition to the mentioned theories, we are motivated to deepen the work of Jorgenson and Clark (2011) in a first empirical test of the theory of treadmill of destruction using CO_2 emissions as a proxy of environmental quality since this empirical aspect has not been the subject of previous work. We will be able to present an empirical validation of the World-System and treadmill of destruction theories using also CO_2 emissions as an impact factor. Thus, we will be capable to present a guide to decision makers containing the influencing factors and their evolution in time. These factors must be taken into account in policy development to be undertaken to address environmental issues.

This paper contributes to the existing environmental economics literature by two ways: (i) this paper tries to verify several theories simultaneously in the same work using the data for 114 developing and developed countries since the environmental problem is a universal one, (ii) verifying the ecological modernization theory, the treadmill of production theory, treadmill of destruction and the World-System theory using CO_2 emissions as a proxy of environmental impact instead of ecological footprint.

In these purposes, our methodology is crystallized in four parts: the first focuses on the existing literature concerning different theories related to studies of environmental impact factors. The second relates to the presentation of our methodology. The third is to present and to discuss the results of our estimates. The fourth is used to conclude and suggest the main theoretical implications.

Literature Review

Treadmill of Production theory

The Treadmill of Production theory focuses on the description of the process of degradation of natural resources by capitalist mode of production, which is a complement of the Marxist philosophy. In fact, Gould et al. (2004: 297) defined the theory of Treadmill of Production as: «*economic change theory, but that has direct implications for natural resource extraction as well as for the opportunity structure for workers*». Thus, it shows the market economies as a «*treadmill*» that creates constantly ecological and social damage through a self-reinforcing powered by increasing the production and consumption mechanism (Schnaiberg, 1980, 1994). Indeed, the producers are trying to increase their production and to make profits through investment in technologies with higher yields per labor unit. Therefore, the adoption of these technologies induces increased unemployment, which restricts the number of consumers with purchasing power.

Therefore, governments and employees continuously support the growth of production to avoid unemployment and problems that may affect tax revenues. The continuing expansion of greedy energy industries deepens the negative environmental impacts following the increased demands for natural resources and significant quantities of resulting waste.

Hence we obtain the first contradiction of capitalism: a demand crisis in which production and consumption are unbalanced.

The expansion of markets is a solution to this first crisis. However, expansion is limited by the number of markets and natural resources that are limited. This leads according to O'Connor (1994) to the second contradiction of capitalism:

Increasing production depletes natural resources needed to support production which leads to an increase in costs and therefore a reduction in benefits.
Given the finite nature of resources, their continued use can lead to an environmental crisis. Thus, the theory of treadmill of production claims that the social and environmental radical improvement is mainly the result of breaks with this mode of production rather than implementing reforms and moderating adjustments (Gould et al., 1996).

Quantitative and comparative tests of this theory are very difficult because of the complexity of the theory of treadmill of production because of the dynamic interaction between the state, the production system and the labor force as consumers and employees (Schainberg, 1980). Therefore, to test this theory, research studies have focused on contextual descriptions via proxies such as gross domestic product (GDP).

The Metabolic Rift theory

Capitalism is based on the ceaseless accumulation of capital, which produces a specific order of social metabolism that is increasingly separated from the natural metabolism, producing metabolic disruptions in natural cycles and processes. The progress of ecological degradation is observed at two levels: the first consists in weakening cycles and natural processes; the second is that this rupture of natural systems leads to the accumulation of waste and emissions.

The metabolic rift analysis illuminates the disruption of social/Natural relations associated with economic growth. Two types of metabolic rift were distinguished in the literature: the intensive and extensive rift. Regarding the extensive rift, it stems from geographic expansion due to the increasing demand for natural resources by capitalists.

Indeed, the concentration of people in cities and agricultural production in rural areas «*disturbs the metabolic interaction between (people) and the earth, that is to say, it prevents the back ground of its components consumed by (people) in the form of food and clothing; therefore it prevents operation of the eternal natural condition for sustainable soil fertility* » (Marx, 1976, p 637).

As for intensive rift, it results from the increased speed of the use of natural elements in the capitalist production process. Capitalists seek to increase profits by reducing the amount of time required for the production of their products through the increased use of natural resources.

Currently, human society is trying to dematerialize and ecologically modernize their production methods that attempt to transform the industrial economy to a functional or service economy to make economies more environmentally sustainable.

The ecological modernization theory

Several studies have investigated the existence of an environmental Kuznets curve (EKC) which consists in a relationship between pollution and income that has the form of an inverted U-shape. Results concerning the verification of the Kuznets hypothesis are heterogeneous. This contradiction has been attributed to the use of inappropriate techniques and omitted variables. Thus, some researchers postulate that economic growth causes the degradation of environmental quality. This finding was justified by the fact that the use of energy and materials is more important and worker productivity will be higher in a context of economic growth. While others argue that the fastest way to improve environmental quality is to realize economic growth. In such context, citizens of most high-income countries will have a great demand to environmental standards respect. In this sense, Beckerman (1992) found that «*the surest way to improve your environment is to become rich*».

The non-monotonic relationship between economic growth and the degradation of environmental quality has been proven by some empirical studies in the 1990s

(Grossman and Krueger, 1995; Panayotou, 2000). In fact, environmental quality is deteriorating at an early stage of economic growth and improves from a certain threshold gradually as income level increases. This finding is supported by the hypothesis of structural change. Indeed, the first stage is generally characterized by an economy based on agriculture, which entails a high level of resources extraction. Then emerges an economy based on a highly polluting industry, characterized by an accelerated depletion of resources and emission of wastes. The final stage comes when growth reaches a certain threshold, improvement of environmental quality can be found following the structural change from an industry to services based economy.

The Structural Human Ecology theory

Based on an ecological basis, the theory of Structural Human Ecology (SHE) attempts to identify anthropogenic factors causing environmental impacts through the development of a relationship between social systems and the environment at macroeconomic level via four interrelated components of the human ecosystem which are: population, social organization, environment and technology, Dietz and Rosa (1994). Moreover, the key role exerted by socio-structural factors on the environment as well as the ecological factors such as climate and biogeography has been highlighted by Dietz and Rosa (2003). Indeed, climatic factors influencing the consumption of natural resources are increasing in countries with cold climate. As for biogeography, it deals with the extent of the influence of the density and the availability of resources on the levels of their consumption.

Thus, in addition to biophysical, climatic (latitude,..) and biogeographic factors (arable land, land area ..) (Dietz and Rosa, 1994; Rosa and Dietz, 1998), and in accordance with the ideas of the Neo-Malthusian School of thought that stipulate that size, growth, density and structure of the population explain environmental impacts (Dietz and Rosa, 1994).

Economic Policy Perspectives

World-system theory

The World-system theory is mainly based on the fact that the core countries representing producers and dominant consumers of natural resources are exporting waste and releases to the periphery. These facts were supported by previous studies that have proven the positive effect of the position of the world-system on the ecological footprint, perceived as an environmental impact indicator. Thus, differences in consumption between core and peripheral countries were supported by these results (Burns et al., 2001; Hornborg, 2001).

Therefore, core and productive economies with articulated markets consume more against more extractive economies with disarticulated markets in peripheral and semi peripheral countries with higher levels of industrialization dependent and underdeveloped (Boswell and Chase-Dunn, 2000 ; Bunker, 1985; Kentor, 1998). The population in core regions has economic advantages enabling them to buy and consume larger amounts of natural resources and products relatively to non-core countries (Hornborg, 2001).

Several attempts to operationalize the position in the world-system have been conducted in previous studies that used a wide variety of indicators. Among these indicators, we can mention: the part of a nation in world trade, stability of trade, GDP per capita relative to world GDP, military power, urbanization and diplomatic relations. In this sense, York et al. (2003) developed a new measure based on the dependence on foreign aid and found that the position of a country in the world-system has no statistically significant effect. In addition, Jorgenson (2005) found that the position in the world-system (2000) increases the ecological footprint per capita. Given that a substantial literature has been devoted to the position in the world-system, Kentor (2000) justifies the inclusion of urbanization as an intermediate variable by the fact that it represents one of the factors explaining the position in the world-system.

Urbanization

The concerns of urbanization in environmental issues were seen early in the works of Frederick Engels in 1892 in his book « *The Condition of the Working Class in England*» which examined the environmental conditions in the companies of the industrial cities of England in his studies on environmental justice in urban areas.

Based on the arguments of the urban political economy and previous cross-national surveys, the study of the environmental impacts of urban populations seems crucial. Indeed, the concentration of the population in large cities creates significant environmental problems. In fact, Gonzalez (2005) showed that urban areas are mass consumption centers, whether products or services. The production of industrial products and articulated consumption markets makes it more convenient to access raw materials in urban areas and generate more gluttonous consumption of natural resources. In fact, Bornschier and Chase-Dunn (1985) advanced that the highly urbanized areas contain production economies of scale that support big businesses and the spatial concentration of economic and industrial activities.

With the exception of some theoretical and empirical work (Jorgenson, 2003; Jorgenson, 2005; Hooks and Smith, 2004, 2005), research that addressed the study of the impact of military activities on the environmental quality is almost non-existent.

The treadmill of destruction theory

Grimes (1999) advanced that it is crucial to incorporate military behaviors and institutions in studies that address the environmental damage given that the activities of military institutions generate strong demand of natural resources for purposes of research and development, maintenance and operation of their infrastructure and equipment, even in the absence of armed conflict (Sidel and Shahi, 1997) and produce large amounts of toxic substances and wastes (Ward, 1999). In this sense, production, testing, maintenance and conventional wars, biological, chemical and nuclear arms generate toxic and radioactive substances that contaminate the air, water and soil (Davis, 2002; Renner, 1991).

Transnational research by York et al. (2003) carried on the environmental impacts of military personnel and used as a proxy for the size of military personnel against the use of military expenditure in the work of Jorgenson (2005). Following the work of Jorgenson and Clark (2011), we consider that it is essential to assess environmental impacts by using these two approximations simultaneously.

Methodology

2.1. STIRPAT Model (Stochastic Impact by Regression on Population, Affluence, and Technology)

Over the past three decades, some researchers have postulated that the growth of population, affluence and technology are jointly responsible for the environmental impact. Mathematical formalization of this relationship is based on a simple model known as IPAT identity (Impact on Population, Affluence and Technology) developed in the work of Ehrlich and Holdren (1971) and Commoner (1972). Research results of Ehrlich and Holdren suggest that population growth has a negative and disproportionate impact on the environment and that wealth is one of the main drivers of CO_2 emissions.

In addition, Dietz and Rosa (1997) considered human activities as the essential driving force of CO_2 emissions. This model comes from ecology and is amenable to economic analysis that has been successfully used for the analysis of factors causing environmental impacts. For this, they have divided human activities into three anthropogenic forces that are:

$$\boldsymbol{I} = \boldsymbol{P} \times \boldsymbol{A} \times \boldsymbol{T} \qquad (1)$$

Where I: the impact on the environment, P: population; A: Affluence and T: Technology.

Several research studies such as Dietz and Rosa (1994), Dietz and Rosa (1997) and York et al. (2003) used this simple formulation that is subject of several reproaches concerning the statistical relationship that does not indicate the cause and effect connection and does not take into account possible non-monotonic or non-proportional effects of variables. To overcome these drawbacks, the development of a stochastic regression impact on the population, affluence and technology (STIRPAT) by Dietz and Rosa (1997) suggests the possibility of hypothesis testing and has none proportional impact of different factors. The environmental impact model allows the representation of all human activity effects in the following form:

$$\boldsymbol{I_i = \alpha P_i^{\beta} A_i^{\gamma} T_i^{\delta} \varepsilon_i} \quad (2)$$

Where P, A and T represent the population, affluence and technology and α, β, γ and δ are the exponents of P, A, and T and represents the parameters to be estimated (the IPAT model in equation (1) assumes that α = β = γ = δ = ε = 1). The error term for any unexplained variances of the model, denoted ε. i represent countries and indicate that the amounts of P, A, T and ε varies across the country.

Adding the temporal dimension and applying the natural logarithm (ln) of the two sides of the above equation to allow for hypothesis testing, the equation will be presented by:

$$\boldsymbol{lnI_{it} = \alpha_0 + \beta lnP_{it} + \gamma lnA_{it} + \delta lnT_{it} + \mu_{it}} \quad (3)$$

Where $\boldsymbol{\alpha_0 = ln\alpha}$ et $\boldsymbol{\mu_{it} = ln\varepsilon_{it}}$

Ultimately, this formalization allows expressing the contribution of anthropogenic factors in the environmental impact in the form of elasticity and adding other control variables by introducing them into the basic formulation if they are conceptually consistent with the multiplicative specification of the model (York et al., 2003).

Previous research has highlighted the negative impact of population on environmental quality. Indeed, using the STIRPAT model on data concerning 111 countries, Dietz and Rosa (1997) found that a growth rate of 1% of the population causes a damage of 1.15% in terms of dioxide of carbon. From their side, Hamilton and Turton (2002) crowned their studies with conclusions that present the income per capita and population growth as the two main factors increasing carbon dioxide emissions in OECD countries against their reduction with the decrease in energy intensity.

In fact, Bruvoll and Medin (2003) have shown that structural change explains the increase in energy intensity over the period 1913-1970 while technical evolution from the 1970s has reduced the energy intensity. Thus, the results of their estimates permitted to conclude that the elasticity of the population is slightly greater than one, the urban population increase CO_2 emissions, and income per capita has a more than proportional effect on emissions, while increasing energy efficiency reduces the emissions proportionately.

Using data for 93 countries during the period 1975-1996, the causal relationship between the population and CO_2 emissions was also studied by Shi (2003) who concluded that the change in the overall population during the past two decades was associated more than proportionally to the growth of carbon dioxide emissions. In the same vein, Cole and Neumayer (2004) considered 86 countries during the period from 1975 to 1998 and found a positive relationship between CO_2 emissions population, urbanization rate, the energy intensity and household size.

The results of the study of Rosa, York and Dietz (2007) noted a relatively small impact of urbanization, and age structure of the population in the deterioration of environmental quality against the most important role of the population and consumption.

In the same context, Jamel and Derbali (2016) proved empirically the evidence of bidirectional linkage between environmental degradation and energy consumption, economic growth, and financial development in the case of the Asian countries.

Heryadi and Hartono (2016) estimated a fixed effect panel model on the impact of energy efficiency and RE on CO2 in G20 countries in 2000-2013 and found that the energy efficiency and renewable energy reduce emissions and that income (GDP per capita) and population generate additional emissions.

In summary, the emissions of carbon dioxide were decomposed into scale, composition and technique effects. Scale effects are measured by variables such as income level and population, composition effects refer to changes in the mix of inputs and outputs related to the production process and technical effects are approximated by the intensity of energy and advances in technology.

2.2. Research Hypotheses

In order to verify the presented theories we will try to test the following hypotheses.

H_1: The basic STIRPAT model is verified: to validate this hypothesis, we must obtain a positive coefficient for population, GDP and industry, and a negative coefficient for energy efficiency.

H_2: The environmental Kuznets curve is verified: the validation of this hypothesis requires obtaining a positive coefficient for GDP and negative for the squared GDP.

H_3: Verification of the treadmill of destruction hypothesis: the spending and military personnel raise the level of CO_2 emissions.

H_4: The position in the world-system increases CO_2 emissions.

H_5: Biogeographical and demographic factors affect negatively the environmental quality as suggested by the theorists of human ecology.

To validate this hypothesis, we used the proxy arable land that the coefficient must be positive and the areas of land whose coefficient must be negative.

H_6: The ecological modernization of the economy reduces environmental impacts. In addition to checking the hypothesis of Environmental Kuznets, the empirical validation of the hypothesis of ecological modernization involves checking the following three assumptions:

<u>Hypothesis 6.1</u>*:* The expansion of political rights improves environmental quality.

<u>Hypothesis 6.2</u>*:* The expansion of civil liberties improves environmental quality.

<u>Hypothesis 6.3</u>*:* Raising the level of economic freedoms that promoted capitalism leads to the improvement of environmental quality.

To validate our research hypotheses, we estimated several models whose equations are as follows:

<u>Model1</u>: $$lnCO_{2it} = \alpha_i + \lambda_t + \beta_1 lnCO_{2it-1} + \beta_2 P_{it} + \beta_3 lnGDP_{it} + \beta_4 EE_{it} + \beta_5 I_{it} + \nu_{it} \quad (4)$$

<u>Model2</u>: $$lnCO_{2it} = \alpha_i + \lambda_t + \beta_1 lnCO_{2it-1} + \beta_2 P_{it} + \beta_3 lnGDP_{it} + \beta_4 lnGDP_{it}^2 + \beta_5 EE_{it} + \beta_6 I_{it} + \nu_{it} \quad (5)$$

<u>Model3</u>: $$lnCO_{2it} = \alpha_i + \lambda_t + \beta_1 lnCO_{2it-1} + \beta_2 P_{it} + \beta_3 lnGDP_{it} + \beta_4 lnGDP_{it}^2 + \beta_5 EE_{it} + \beta_6 I_{it} + \beta_7 MS_{it} + \beta_8 AF_{it} + \nu_{it} \quad (6)$$

<u>Model4</u>: $$lnCO_{2it} = \alpha_i + \lambda_t + \beta_1 lnCO_{2it-1} + \beta_2 P_{it} + \beta_3 AP_{it} + \beta_4 lnGDP_{it} + \beta_5 lnGDP_{it}^2 + \beta_6 EE_{it} + \beta_7 I_{it} + \beta_8 U_{it} + \beta_9 WSP_{it} + \beta_{10} EFI_{it} + \nu_{it} \quad (7)$$

Model5: $lnCO_{2it} = \alpha_i + \lambda_t + \beta_1 lnCO_{2it-1} + \beta_2 P_{it} + \beta_3 AP_{it} + \beta_4 lnGDP_{it} + \beta_5 lnGDP_{it}^2 + \beta_6 EE_{it} + \beta_7 I_{it} + \beta_8 U_{it} + \beta_9 LA_{it} + \beta_{10} AL_{it} + \nu_{it}$ (8)

Model6: $lnCO_{2it} = \alpha_i + \lambda_t + \beta_1 lnCO_{2it-1} + \beta_2 P_{it} + \beta_3 AP_{it} + \beta_4 lnGDP_{it} + \beta_5 lnGDP_{it}^2 + \beta_6 EE_{it} + \beta_7 I_{it} + \beta_8 S_{it} + \beta_9 A_{it} + \beta_{10} U_{it} + \beta_{11} PR_{it} + \beta_{12} CL_{it} + \beta_{12} Kyoto_{it} + \beta_{13} EFI_{it} + \nu_{it}$ (9)

Model7: $lnCO_{2it} = \alpha_i + \lambda_t + \beta_1 lnCO_{2it-1} + \beta_2 P_{it} + \beta_3 AP_{it} + \beta_4 lnGDP_{it} + \beta_5 lnGDP_{it}^2 + \beta_6 EE_{it} + \beta_7 I_{it} + \beta_8 S_{it} + \beta_9 A_{it} + \beta_{10} U_{it} + \beta_{11} PR_{it} + \beta_{12} CL_{it} + \beta_{13} EFI_{it} + \beta_{14} LA_{it} + \beta_{15} AL_{it} + \beta_{16} MS_{it} + \beta_{17} AF_{it} + \beta_{18} WSP_{it} + \beta_{19} Kyoto_{it} + \nu_{it}$ (10)

Where $\boldsymbol{\alpha_i}$ and $\boldsymbol{\lambda_t}$ are specific effects of studied country and year that allow controlling for unobservable country-heterogeneity and common time-varying effects that could affect emissions. $\boldsymbol{CO_2}$: CO_2 emissions, *P:* Population, *AP:* Active population, *GDP:* Affluence, *EE:* Energy efficiency, *I:* Industry, *MS:* Military spending, *AF:* Armed forces, *U:* Urbanization, *WSP:* World-system position, *EFI:* Economic Freedom Index, *LA:* Land Area, *AL:* Arable Land, *PR:* Political Rights, *CL:* Civil liberties, *Kyoto:* Kyoto Protocol ratification, *S:* Service sector, *A:* Agriculture, $\boldsymbol{\nu_{it}}$: error term.

Despite the fact that the fixed-effects (FE) and random effects (RE) models are two methods that aim to correct the bias problem of heterogeneity and have gained popularity in the various fields of sociology, the dynamic panel data models are recognized by researchers as more efficient. In this context, the dynamic panel model is obtained by introducing the lagged dependent variable which is the CO_2 emissions delayed for estimating environmental impact function. However, the introduction of this variable causes the correlation between the delayed dependent variable and the error term. To overcome the problems of simultaneity bias, reverse causality and omitted variables, Arellano and Bond (1991) developed the Generalized Method of Moments (GMM) estimator. This method consists of two steps: The first one removes the individual and time-specific effects by rewriting the model in first difference. The second step is to integrate the lagged level values of two or more periods as instruments for the explanatory variables in first differences, assuming that the errors of the level equation are not serially correlated.

However, the effectiveness of this instrumentation technique has been criticized by some researchers and it is in this context that Blundell and Bond (1998) proposed the GMM-system model that is crystallized around a system of two equations: the first equation is a first difference equation in which the lagged variables in levels of at least one period are used as instruments of the equation allowing the removal of the unobserved time and invariant individual characteristics. The conditions to fulfill are the absence of correlation of the error terms and the endogenous variables with low explanatory power. The second equation of the model is a level equation in which the variables in first differences delayed by at least one period are used as instruments for the level equation.

To estimate the different models and validate the hypothesis, we use GMM System estimation developed by Blundell and Bond (1998) by using the STATA software (version 12).

Data

To validate these hypotheses and to determine the causes of the deterioration of environmental quality, we opted for carbon dioxide emissions as a dependent variable. In fact, greenhouse gases are composed of several components such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3), dioxide sulfur (SO_2). We restrict our analysis to a single environmental impact indicator which is carbon dioxide measured in kilo tones because it is argued in studies of the World Bank that this pollutant is the determining cause of climate change.

Moreover, there is a clear consensus that it is the most concentrated gas in the atmosphere, playing an important role in the vital processes of plants and animals, such as photosynthesis and respiration.

The validation of the different theories is conducted through their approximations by variables (See appendix 1 that presents the different variables used in this article).

Our panel data present a panorama of 114 developed and developing countries over the period 1980- 2010. This choice can be justified by the fact that climate change is a global problem that affects all countries of the world. The limitation of the study to this number is justified by the unavailability of data regarding different variables for all countries of the world.

Results

The results of the dynamic estimates of the different models are shown in Table 2.

Before interpreting the results, tests of validity of our estimates are required in advance. The first, Sargan test, allows verifying the validity of the instruments and is useful when employing a number of instruments (p) exceeds the number of explanatory variables. The statistics of the test varies between 35.44454 and 111.0571 for the different estimated models follow the Chi-square Law [p - (k + 1)] degrees of freedom whose corresponding threshold is 352.42. Therefore, we accept the null hypothesis and conclude the validity of the chosen instruments.

The second statistical test is the Arellano-Bond relative to the null hypothesis of no first order autocorrelation, i.e those of the first order errors: AR (1). The test of the AR (1) process in first differences rejects the null hypothesis with p-values <5%. This result is plausible, considering the delay of recurrence of the error terms:
$\Delta e_{it} = e_{it} - e_{it-1}$ et $\Delta e_{it-1} = e_{it-2} - e_{it-1}$.

The third test is the autocorrelation of the Arellano-Bond errors. The results build on the lack of second order autocorrelation AR (2), with p-values> 5%.

In the light of the validation of results' authentication tests, our interpretations are certified. The coefficients of the lagged CO_2 emissions are positive and this for different estimated models, which is consistent with results of Agras and Chapman (1999), Martínez-Zarzoso and Bengochea-Morancho (2004, 2003), Aldy (2006), Egli and Steger (2007), Martínez-Zarzoso et al. (2007) Morrero (2009), and Martinez-Grenewald Zarzoso (2009, 2011) and Kinda (2011). The impact of the last year level of emissions is very important with respect to the emissions of the year that follows it.

DOI: 10.5171/2017.947798

Table1: Estimation of dynamic panel models for different theories validation

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
CO_2 Emissions (t-1)	0.67536 (107.2)***	0.67295 (370.7)***	0.643531 (282.6)***	0.683641 (48.5)***	0.66933 (73.85)***	0.678713 (50.37)***	0.60198 (20.06)***
Population	0.14315 (14.10)***	0.137794 (11.34)***	0.18153 (11.10)***	0.28662 (4.20)***	-0.17518 (-4.31)***	0.343893 (6.21)***	0.679268 (1.59)
Active population				-0.20024 (-0.72)	-0.08598 (-2.47)**	-0.048221 (-0.49)	0.821135 (1.35)
Land area per capita					-0.40465 (-14.2)***		0.49707 (1.62)
Arable land					0.084101 (8.28)***		0.0337 (0.75)
GDP per capita	0.55404 (98.44)***	1.64167 (96.97)***	1.75564 (48.49)***	2.23983 (6.44)***	1.72389 (22.8)***	1.867964 (12.08)***	1.3775 (1.13)
GDP per capita squared		-0.060859 (-47.4)***	-0.06138 (-31.1)***	-0.09499 (-4.4)***	-0.06113 (-13.1)***	-0.06792 (-7.43)***	-0.03056 (-0.41)
energy efficiency	-0.5536 (-128.7)***	-0.58575 (-68.5)***	-0.85983 (-194.6)***	-0.67848 (-32.9)***	-0.65601 (-73.4)***	-0.653971 (-49.1)***	-0.86999 (-19.9)***
Industry	0.02674 (6.29)***	-0.01474 (-3.66)***	-0.09567 (-17.7)***	-0.03904 (-3.24)***	-0.04992 (-14.5)***	-0.015909 (-0.86)	-0.04282 (-0.32)
Service						-0.03319 (-1.40)	-0.119421 (-0.97)
Agriculture						0.035225 (3.28)***	0.137163 (2.94)***
Urbanization				0.12805 (0.56)	0.123848 (1.49)	0.411213 (2.60)***	0.202832 (0.25)
Military spending			-0.02339 (-17.5)***				0.000269 (0.03)
Armed forces			-0.05396 (-35.2)***				-0.02502 (-1.94)**
World-System position							
Corel							0.060288 (1.07)
Peripheral				0.029293 (0.45)			
Semi- peripheral				-0.00895 (-0.13)			0.05329 (2.34)**
Political rights							
Free						0.027504 (3.50)***	
Partially free						0.047694 (6.79)***	0.074576 (3.56)***
Not free							0.019323 (0.56)
Civil liberties							
Free							0.033797 (1.54)
Partially free						-0.028613 (-5.63)***	0.00933 (0.54)
Not free						-0.059486 (-9.92)***	
Kyoto Protocol ratification						-0.0077 (-5.27)***	-0.012237 (-1.95)**
Economic Freedom Index				-0.030428 (-1.28)		-0.017934 (-4.35)***	0.14124 (2.60)***

Constant	-3.01472 (-20.59)***	-7.48533 (-30.9)***	-8.38058 (-40.0)***	-11.7979 (-3.77)***	0.398 (0.35)	-13.28869 (-9.93)***	-23.099 (-2.02)**
Sargan Test	110.7126 (1.0000)	111.0571 (1.0000)	100.2214 (1.0000)	56.15546 (1.0000)	99.91761 (1.0000)	73.99261 (1.0000)	35.44454 (1.0000)
Arellano-Bond Test AR(1)	-3.0553 (0.0022)	-3.0614 (0.0022)	-2.2836 (0.0224)	-2.4812 (0.0131)	-2.8139 (0.0049)	-2.5935 (0.0095)	-1.6391 (0.1012)
Arellano-Bond Test AR(2)	-1.3228 (0.1859)	-1.3386 (0.1807)	-1.0126 (0.3112)	-1.4126 (0.1578)	-1.4966 (0.1345)	-1.3501 (0.1770)	-1.0754 (0.2822)
Observations	2391	2391	1578	1180	2147	1808	725
Nations	114	114	105	61	103	84	55

Source: the authors

*The Students T are provided in parentheses: ***, ** and * represent statistical significance at 1%, 5% and 10%, respectively. The instruments used in our regressions are valid because the Hansen test does not reject the hypothesis of validity of lagged variables in levels and differences. §The peripheral category is the reference for the world-system theory, the not free category is the reference for political rights, and free category is the reference for civil liberties.*

Regarding the first empirical application, allowing the confirmation of STIRPAT model, the results confirm our initial hypothesis. The increase in population, affluence and the share of industry in economic activities significantly increase CO_2 emissions while improving energy efficiency produces the opposite effect. These results are in accordance with the findings of Aguir bargaoui et al. (2014) et Heryadi and Hartono (2016).

The second empirical application validates the Environmental Kuznets hypothesis, as a result of the significance of the effects of the positive and statistically significant coefficient of GDP per capita and the negative coefficient of squared GDP. Improving environmental quality is ensured both through energy efficiency and industrial sector. The first result is endorsed by several previous research studies except that the second is questionable given that the industrial sector is recognized to be environmentally destructive whether in terms of natural resources usage, gas emissions or toxic waste. Our results contradict those of Morrero (2009) concerning the verification of EKC.

In fact, studying 27 European countries during the period 1990-2006, this researcher has not verified the environmental Kuznets curve. By contrast, our verification of this hypothesis is supported by Grunewald and Martínez-Zarzoso (2009) who used the data for 123 countries over the period 1975-2004 and Mazzanti and Musolesi (2009) who studied the problem in the case of 109 countries during the period 1960-2001.

With regard to the third model, the coefficients related to military spending and armed forces are highly significant with negative signs. This result leads us to strongly reject the hypothesis of treadmill of destruction as these two variables are expected to put pressure on the environment by contributing to the increase of the latter. The sign and significance of the other variables remain unchanged.

The fourth model, results indicate that belonging to core, semi peripheral or peripheral countries, has no influence on the level of emissions because of the non-significance of related coefficients. Subsequently, we reject the World-System theory. These findings are in accordance with the results of York et al. (2003) who approximated environmental impact by ecological footprint. The economic freedom index, urbanization and active population have no impact on environmental quality. As for the other variables included in this model, they maintain their significances and signs.

The fifth model deals with the theory of human ecology. It allowed us to conclude that the relationship between the level of CO_2 emissions and land area per capita is negative which means that when the available land of a nation per capita is larger, the CO_2 emissions will be reduced. Thus, the availability of resources influences the level of emissions. While arable land increases the level of emissions, land cultivation deteriorates environmental quality. As a result, we can confirm the hypothesis of human ecology which is consistent with the results of York et al. (2003). GDP per capita contributes to an increase in CO_2 emissions and squared GDP cause their decline leading to the validation of the hypothesis of Environmental Kuznets. The variables population, active population, energy efficiency and industrial activity allow reducing the level of emissions. As for the level of urbanization, it appears to have no impact on CO_2 emissions.

The sixth model that aims to examine the ecological modernization theory allowed us to conclude that the structure of the economy does not have a statistically significant effect on the level of emissions unless the share of agriculture in the economy that reduces the environmental quality is consistent with the results of the theory of human ecology where the decline of arable land appears as a cause of environmental degradation. In terms of population, it adheres to the increase of emissions levels. As for political rights, free and partly free countries hinder environmental quality. While countries with partial or without civil liberties, participate in reducing the level of emissions. Concerning the economic freedom index and the ratification of the Kyoto Protocol, they appear as factors that reduce CO_2 emissions.

These results are conventional to those of Grenewald and Martinez-Zarzoso (2010) who estimated the models with dynamic panel data for 213 countries over the period 1960 to 2009. They found that the Kyoto obligations have a measurable effect on CO_2 emissions reduction. The same ascertainment was found in the work of Mazanti and Musolesi (2009), which focused on the group of northern European countries. In terms of the size of the population and CO_2 emissions, our results are in conformity with those of Grenewald and Martinez-Zarzoso (2010) who found that these factors lead to an increase in the level of emissions.

Finally, the results of the latest model that simultaneously captures all the theories indicate that the world system theory, treadmill of destruction theory and the Kuznets hypothesis are rejected. Political and civil freedoms have no impact on the level of emissions except for the partly free countries about their political rights that increase the level of emissions. Energy efficiency and Kyoto Protocol ratification reduce CO_2 emissions. Population, active population and urbanization have no statistically significant impact. The impact of the economy's structure remains similar to the previous estimate. Finally, the economic freedom index increases the level of emissions. Therefore, capitalism deteriorates environmental quality which confirms the hypothesis of metabolic rift.

3. Conclusion and policy implications

This article attempted to present and verify the literature regarding different theories related to the relationship between the evolution of human society and environmental sustainability. The empirical validations of some of these theories manifest shortcomings in the literature.

For this, we have tried to estimate the dynamic panel models to explain the level of CO_2 emissions by interaction with a variety of key variables. The subject of theoretical consensus, this range of explanatory variables allow verification of theories presented, and they serve as a benchmark to decision makers facing identifying factors that reduce the environmental impact by focusing their actions on the factors that actually help reduce emissions.

The estimation results have allowed us to advance four crucial findings for directing decision makers. First, the emission level of the previous year increases emissions of the current one. Thus, the level of emissions is a cumulative phenomenon and the actual control of emissions will improve the environmental quality of tomorrow. Secondly, energy efficiency helps reduce emissions with a coefficient of elasticity quite significant. Decision makers need to invest in research and development to develop more energy-efficient technologies. Third, Economic Freedom Index, presented as a proxy of capitalism, increases the level of emissions. Subsequently, the think back for a new mode of production is highly stressed to trigger a production system more respectful of environmental quality.

Fourth, the role of the ratification of the Kyoto Protocol as a factor reducing the level of emissions but in a small portion is open to criticism. Indeed, focusing on the position in the world system, we noticed that the semi-peripheral and partly free countries have a negative impact on the environment. This finding is due to one of the protocol flexibility mechanisms, the Clean Development Mechanism, which is the fact that industrialized countries subsidize projects that reduce emissions in the least developed countries and are rewarded with carbon credits.

Developing countries benefit for free from advanced technologies that allow their plants to operate more efficiently. Except it should be noted that most of these countries are not industrialized, meaning that although using the cleaner technology investments entails emissions increasing of these underdeveloped countries. Thus, it should be noted here that the reduction of emissions from the ratification of the protocol is camouflaged, as the pollution problem is outsourced from highly industrialized countries to developing and emerging countries that didn't have quantified obligations in terms of emissions reductions.

Acknowledgment

I would like to thank the editor and anonymous reviewers for their supportive comments and suggestions.

Funding

The authors received no direct funding for this research.

References

1. Agras, J and Chapman, D. (1999), 'A dynamic approach to the Environmental Kuznets Curve hypothesis', *Ecological Economics*, 28, 267–277.

2. Aguir Bargaoui, S., Liouane, N. and Nouri,FZ. (2014), 'Environmental Impact Determinants: An Empirical Analysis based on the STIRPAT Model', Procedia - Social and Behavioral Sciences, 109, 449-458.

3. Arellano, M and Bond, S. (1991), 'Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations', *The Review of Economic Studies*, 58 (2), 277-297

4. Beckerman, W. (1992), 'Economic development and the environment: conflict of complementarity?',*Policy Research Working,* Paper Series 961, World Bank.

5. Blundell, R and Bond, S. (1998),'Initial conditions and moment restrictions in dynamic panel data models, *Journal of Econometrics,* 87, 115-143.

6. Bornschier,V and Chase-Dunn, C.(1985), 'Transnational Corporations and Underdevelopment', New York: Praeger.

7. Boswell, T. and Chase-Dunn, C. (2000), The Spiral of Capitalism and Socialism: Toward Global Democracy. Boulder, CO: Lynne Rienner Publishers.

8. Bruvoll, A and Medin, H. (2003), 'Factors Behind the Environmental Kuznets Curve: A Decomposition of the Changes in Air Pollution', *Environmental and Resource Economics,* 24, 27-48.

9. Bunker, SG. (1985), Under developing the Amazon: Extraction, Unequal Exchange, and the Failure of the Modern

State. Urbana: University of Illinois Press.

10. Burns, T.J., Byron L.D., Jorgenson, A.K., and Kick, E.L.(2001), Assessing the Short- and Long-Term Impacts of Environmental Degradation on Social and Economic Outcomes', Presented at the annual meetings of the American Sociological Association, Anaheim, CA.

11. Cole, MA and Neumayer, E. (2004), 'Examining the impact of demographic factors on air pollution', *Population Environment*, 26 (1), 5-21.

12. Commoner, B. (1972), The Environmental Cost of Economic Growth, in Population, Resources and the Environment.Washington, DC: Government Printing Office, 339-363.

13. Dietz, T and Rosa, EA. (1997), 'Environmental Impacts of Population and Consumption', Pp. 92-99 in P.C Stern, T. Dietz, V. Ruttan, R.H. Socolow and J. Sweeney (eds.). Environmentally Significant Consumption: Research Directions. Washington DC: National Academy Press

14. Dietz, T and Rosa, EA. (1994), 'Rethinking the Environmental Impacts of Population, Affluence and Technology', *Human Ecology Review*, 1(2), 277-300.

15. Ehrlich, PR and Holdren, JP. (1971), 'Impact of Population Growth', *Science,* 171, 1212-1217.

16. Grossman, GM and Krueger, AB. (1995), 'Economic Growth and the Environment', *The Quarterly Journal of Economics*, 110 (2), 353-377.

17. Gonzalez-Benito, J and Gonzalez-Benito, O.(2005). 'Environmental proclivity and business performance: An empirical analysis', *The International Journal of Management Science*,33, 1-15.

18. Gould, KA., Weinberg, AS. and Schnaiberg, A. (1996). Local environmental struggles: Citizen activism in the treadmill of production. Cambridge, UK: Cambridge University Press.

19. Gould, KA., Pellow, DN. and Schnaiberg, A. (2004), 'Interrogating the treadmill of production', *Organization & Environment*, 17 (3), 296-316.

20. Grimes, PE. (1999), 'Recent Research on world Systems', 29-55, in 'A World System Reader: New perspectives on Gender, Urbanism, Cultures', *Indigenous Peoples, and Ecology*, edited by Tom Hall. New York: Rowman and Littlefield.

21. Grunewald, N and Martínez-Zarzoso, I. (2009), Driving factors of carbon dioxide emissions and the impact from Kyoto protocol, CESifo working paper N° 2758, Retrieved from http://hdl.handle.net/10419/30507

22. Grunewald, N and Martínez-Zarzoso, I. (2011), How well did the Kyoto Protocol work? A dynamic-GMM approach with external instruments, Discussion Papers N° 212, retrieved from http://wwwuser.gwdg.de/~fjohann/paper/DB212.pdf

23. Hamilton, C and Turton, H. (2002), 'Determinants of emissions growth in OECD countries', *Energy Policy*, 30 (1), 63–71.

24. Heryadi, MD and Hartono, D. (2016), 'Energy Efficiency, Utilization of Renewable Energies, and Carbon Dioxide Emission: Case Study of G20 Countries International', *Energy Journal*, 16, 143-152.

25. Hooks, G and Smith CL. (2005), 'Treadmills of Production and Destruction: Threats to the Environment Posed by Militarism', *Organizations and Environment*, 18, 19-37.

26. Hooks, G and Smith, CL. (2004), 'The Treadmill of Destruction: National Sacrifice Areas and Native Americans', *American Sociological Review*, 69, 558-76.

Saoussen Aguir Bargaoui and Fethi Zouheir Nouri (2017), Journal of Economics Studies and Research,
DOI: 10.5171/2017.947798

27. Hornborg, A. (2001), The Power of the Machine: Global Inequalities of Economy, Technology, and Environment. Walnut Creek, CA: Alta Mira Press.

28. IPCC, Climate Change, (2001), The Scientific Basis, Contribution of the working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge: Cambridge University Press.

29. Jamel, L and Derbali, A. (2016), 'Do energy consumption and economic growth lead to environmental degradation? Evidence from Asian economies', *Cogent Economics & Finance*, 4: 1170653.

30. Jorgenson, AK and Clark, B. (2011), 'Societies consuming nature: A panel study of the ecological footprints of nations, 1960–2003', *Social Science Research*, 40 (1), 226–244.

31. Jorgenson, AK. (2003), 'Consumption and Environmental Degradation: A Cross- National Analysis of the Ecological Footprint, *Social Problems*, 50, 374–94.

32. Jorgenson, AK., Rice, J. and Crowe, J. (2005), 'Unpacking the Ecological Footprint of Nations', *International Journal of Comparative Sociology*, 46, 241-260.

33. Kentor, J. (1998), 'The Long Term Effects of Foreign Investment Dependence on Economic Growth:1940– 1990.' *American Journal of Sociology*, 103, 1024–1046.

34. Kentor, J. (2000), Capital and Coercion: The Economic and Military Processes That Have Shaped the World-Economy, 1800–1990. New York: Garland Press.

35. Kinda, SR. (2011), Democratic Institutions and Environmental Quality: Effects and Transmission Channels, Proceedings of the German Development Economics Conference, Berlin 2011, N° 46.

36. Marrero, GA. (2009), 'Greenhouse gases emissions, growth and the ebergy mix in Europe: A dynamic panel data approach', Focus-Abengoa Forum energy and climate. http://www.fedea.es

37. Martinez-Zarzoso I. and Bengochea-Morancho. (2004), 'A Pooled mean group estimation of an environmental Kuznets curve for CO_2', *Economics Letters*, 82, 121-126.

38. Martínez-Zarzoso, I. (2009). A general framework for estimating global CO2 emissions, Oxford Business & Economics Conference Program.

39. Marx, K. 1976. Capital I. Translated by Ben Fowkes. London: Penguin Books.

40. Mazzanti, M and Musolesi, A. (2009), Carbon Kuznets Curves: Long-Run Structural Dynamics and Policy Events, FEEM Working Paper N° 87.2009. Retrievedfrom http://ssrn.com/abstract=1512564 or http://dx.doi.org/10.2139/ssrn.1512564.

41. O'Connor, J. (1994), Is capitalism sustainable? In O'Connor M. (Ed.), Is Capitalism Sustainable? Political Economy and the Politics of Ecology, Guilford, New York.

42. Panayotou, T., Peterson, A., and Sachs, J. (2000), Is the Environmental Kuznets Curve Driven by Structural Change?What Extended Time Series May Imply for Developing Countries, CAERII, Discussion Paper N° 80, Consulting Assistance on Economic Reform II.

43. Renner, M. (1991), 'Assessing the Military's War on the Environment', 132- 152, in State of the World, edited by Linda Starke. New York, NY: WW Norton & Company.

44. Rosa, EA and Dietz, T. (1998), 'Climate Change and Society: Speculation,

Construction and Scientific Investigation', *International Sociology*, 13, 421-455.

45. Schnaiberg, A and Gould, KA. (1994), Environment and society: The enduring conflict. New York: Cambridge University Press.

46. Schnaiberg, A.(1980), The environment: From surplus to scarcity, New York: Oxford University Press.

47. Shi, A. (2003), 'Tthe impact of population pressure on global carbon dioxide emissions, 1975-1996: evidence from pooled cross country data', *Ecological Economics*, 44, 29-42.

48. Sidel, V and Gurinder S. (1997), The Impact of Military Activities on Development, Environment, and Health." Pp. 283-312 in International Perspectives on Environment, Development, and Health: Toward a Sustainable World, edited by Gurinder Shahi, Barry Levy, Al Binger, Tord Kjellstrom, and Robert Lawrence. New York, NY: Springer Publiching Company.

49. Ward, C. (1999), Canaries on the Rim: Living Downwind in the West. London: Verso.

50. York, R and Rosa, EA. (2012), 'Choking on Modernity: A Human Ecology of Air Pollution', *Social Problems*, 59, 282-300.

51. York, R., Rosa, EA. and Dietz, T. (2003), 'STIRPAT, IPAT and ImPACT: analytic tools for unpacking the driving forces of environmental impacts', *Ecological Economics*, 46, 351-365

52. York, R., Rosa, EA. and Dietz, T. (2001), The Population and Affluence Elasticity of environmental Impacts, paper presented at the annual meeting of the Pacific Sociological Association, San Francisco, CA.

53. York, R., Rosa, EA. and Dietz, T. (2003), 'Bridging Environmental Science with Environmental Policy: Plasticity of Population, Affluence, and Technology', *Social Science Quarterly*, 83, 18-34.

Appendix: Definition of used variables

Theory	Variable	Description	Scale and source
Structural Human Ecology	Population	Total number of inhabitants of a nation	number WDI (2011)
	Active population	Percentage of people whoses ages is between 15 and 64 years with respect to total population	number WDI (2011)
	Arable land per capita	Arable land in hectares per capita	Hectars / capita WDI (2011)
	Land area per capita	weighted productivity zones used to indicate both the biocapacity of the earth, and the demand for biocapacity. The global hectare is normalized to the weighted average of productivity in their area of biologically productive land and water in a given year.	Hectars / capita Global Footprint Network, 2012.
Ecological modernization	GDP per capita	GDP per capita in constant 2005 dollars based on purchasing power parity (PPP)	Dollars WDI (2011)
	Squared GDP per capita	GDP per capita squared	Dollars WDI (2011)
	Energy efficiency	GDP per unit of energy use is the GDP in PPP per kilogram of oil equivalent of energy use. GDP in PPP is gross domestic product (GDP) converted to international dollars using the rate parity purchasing power (PPP).	Dollars WDI (2011)
	Urbanization	Percentage of people living in urban areas compared to total population	Pourcentage WDI (2011)
	Kyoto Protocol ratification	This variable takes the value of 1 from the date of ratification of the protocole for each country, otherwise takes the 0 value.	Dummy;United Nations frame on climate change
Structure of the domestic economy	Service sector	Percentage of service sector in GDP measured by value added of services (% of GDP)	Pourcentage WDI (2011)
	Industrial sector	Percentage of manufactural sector in GDP measured by value added in industry (% of GDP)	Pourcentage WDI (2011)
	Agricultural sector	Percentage of agriculture in GDP measured by value added in agriculture (% of GDP)	Pourcentage WDI (2011)
World-System theory	World-system position	Measure based on the official development assistance and official aid that a nation gives or receives. Dummy variable coded into three categories: core = nations that are not net beneficiaries of aid; semiperiphery = Nations that are net beneficiaries but help is less than 5% of GDP, and the periphery = All other nations.	Dummy variable WDI (2011)
Capitalism	Political rights	Reflects if a nation is governed by democratically elected and has représnetant inclusive elections, fair and open. The original index is a scale of 7 points. While the dummy variable coded into three categories: (1-2): free, (3-5): partly free, (6-7): not free.	Dummy variable Freedom House (2011)

	Civil liberties	Reflects the existence of freedom of the press, freedom of assembly and demonstration, general personal freedoms, freedom of private organizations, and property rights within a nation. The original index is a scale of 7 points. While the dummy variable coded into three categories: (1-2): free, (3-5): partly free, (6-7): not free.	Dummy variable Freedom House (2011)
	Economic liberties	The economic freedom index measures the degree to which the policies and institutions of countries are supportive of economic freedom. The cornerstones of economic freedom are personal choice, voluntary exchange, freedom to compete and security of private property. Forty-two variables are used to build this composite index to measure the degree of economic freedom in five broad areas: (1) size of government; (2) the legal system and property rights; (3) sound money; (4) freedom of international trade; and (5) regulation.	Scale of 10 points Fraser Institute (2011)
Treadmill of destruction theory	Military expendit ures	Includes all current and capital expenditure of the armed forces, including peacekeeping forces; defense ministries and other government agencies engaged in defense projects, paramilitary forces and military activities in space.	(% of GDP) WDI (2011)
	Armed forces	The active duty military, including paramilitary forces if their training, organization, equipment and control allows them to be used to support or replace regular military forces divided by the total population.	(% of total population) WDI (2011)

Source: the authors