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The Impact of Population Growth on Environmental Quality and Gross Domestic Product (GDP): GMM System Analysis

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Abstract

This paper aims to assess the impact of population growth on GDP and environmental quality. For this, we use the generalized moments in system method (GMM) with dynamic panel data for ten countries over the period 1980-2013. The main results of this study are: (i) the population have a positive and significant impact on economic growth while the capital has a positive but no significant effect on economic growth. (ii) For the environment, population growth has a positive and significant effect on CO_2 emissions, the urbanization is negatively and significantly contributed to CO_2 emissions, but trade openness has no effect on CO_2 emissions. What is concluded that the effect of the population depends on other factors such as aging, hierarchical structure and the economic level of the country?

Keywords: CO_2 emissions, Economic Growth, Population Growth, Panel data, GMM system.

JEL classification: D62 - H2 – Q28- Q25 – Q54

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Introduction

Degradation of the environment has been the subject of debate for decades of years; research into the causes of this degradation was the top scientific preoccupations. According to the previous studies, economic activity is the main cause of environmental problems. Looking some non-industrialized we see the intensity of CO_2 emissions is high. In this context, several researchers focus on the impact of population on environmental problems, others studying the effect of population on economic activities. The empirical relationship between economic growth and environmental quality (quality of air, water quality, etc.) has been widely debated in recent years. The results obtained on this relationship to define economic and appropriate environmental policies to improve well-being.

In the literature, this debate boils down to be the discussion of the existence of an inverted U-shaped relationship, called the Environmental Kuznets Curve. The latter states that, at the macroeconomic level, environmental degradation is accentuated for low-income levels and then it declines to a certain threshold given income (reversal point). Holtz-Eakin and Selden (1995) studied the reduced form of the relationship between CO_2 emissions and real GDP per head for a sample of 130 countries during the period 1951-1986. They found a Kuznets curve; in fact, this curve is almost linear and growing for the entire sample but with a turnaround point outside the sample, equal to $ 35,428. Grossman and Krueger (1993, 1995) studied the effect of GDP per head on various environmental quality indicators using a model with individual random effects. For most environmental quality indicators - sulfur dioxide concentration (SO_2), suspended particles, biological oxygen demand, chemical oxygen demand and arsenic in rivers - an inverted U curve appears. Selden and Song (1994) also studied the relationship between GDP per head and four air pollutants (SO2, nitrogen oxides (NOx), carbon monoxide (CO)) using the same data source; Grossman and Krueger (1993, 1995). Selden and Song (1994) showed the existence of a Kuznets curve for all these pollutants.

Other studies have shown the existence of an environmental Kuznets curve for several pollutants[2]. For example, Kaufmann et al. (1998) have used panel models with fixed and random effects with a quadratic function for a sample of 23 countries between 1974 and 1989 and obtained the type inverted U of relationship, that is to say, a Kuznets curve describing the relationship between atmospheric concentration of SO_2 and the spatial intensity of economic activity. However, Kaufman et al. (1998) also showed that there is a U-type relationship between the concentration of SO_2 and GDP per capita, contrary to the Kuznets curve. Azomahou and Nguyen Van (2001) used a nonparametric model and various specification tests. The result is a complex relationship, despite its monotonous between CO_2 emissions and GDP per capita.

The demographic variables also require special attention because the population is recognized as a major cause of environmental degradation (see, eg, Ehrlich and Ehrlich, 1981)[3]. According to the World Bank (1992), population growth leads to increased

[2] See the special issues of journals Environment and Development Economics 1997 and Ecological Economics 1998. See, also Stern (1998) for a review of the literature.
[3] See also Robinson and Srinivasan (1997) for a synthesis of the literature on population growth, economic development, natural resources and the environment.

demand for goods, services and livelihoods, which degrade the environment and exerts pressure on natural resources. Population growth can pose a direct threat to the local environment and reduce the natural assimilative capacity of the environment.

It is important to note that the impact of population on the environment can be modified by economic growth and the state of technology (Cropper and Griffiths, 1994). So, for example, increased income can direct the energy needs to other sources than fuel wood; of same, clean water is improved. The adoption of modern technology in agriculture reduces the conversion of arable land to forests as it can achieve a high return on a limited area of cultivated land (intensive agriculture).

The main objective of this paper is to examine the effect of population growth on gross domestic product (GDP) and CO_2 emissions by using a panel data of 10 countries (United Kingdom, United States, Canada, Brazil, India, China, France, Germany, Italy, and Japan) during 1990-2013 periods. To analyze this effect, first, we check that the series are stationary or not. Then we use the two cointegration tests to check the variables are cointegrated or not (either in level or in first difference). Finally, we apply the estimator of GMM system on a set of dynamic panel data.

The rest of this article is organized in the following way: In Section 2 we present a first part in a review of empirical literature on the role of population growth in economic growth and the environment. In section 3 we present the research method and the data sources. In section 4 we present the estimation results and interpretation. Finally, we conclude the results of paper.

Literature review

Population growth and Economic Growth

Several researches on the causal relationship between population growth and economic growth provided mixed results. For example, Simon (1981) found that population growth may have a positive impact on GDP per capita growth in the long-run. Kelley (1988) and Kelley and McGreevey (1994) examined the history of population and of economic development. Kelley and McGreevey showed that high population growth rates in developing countries since the middle of the twentieth century have had little effect on per capita GDP growth. Peng (2002) examined the relationship between population growth, transaction efficiency and economic development in selected Asian countries, using in framarginal analysis framework, which differs from the marginal analysis within neoclassical framework. The results show that there exist a positive relationship between population and economic growth.

By using the Granger causality analysis and the Generalized Impulse-Response Function, Climent and Meneu (2003) examined the link between demographic population and economic growth in Spain during the period 1960-2000. The empirical evidence on causality reported that fertility responds directly to economic growth and Infant Mortality does not cause total fertility.

In China and India, Lozeau (2007) found that a large population can result in having a large workforce. Several key economic factors contributed to the way the Chinese and Indian populations have grown and what different effects that growth had on their developing economies. Similarly, Afzal (2009) examined the relationship between population growth and economic growth in Pakistan during the period 1981-2005. Their results demonstrate that rapid population growth is a real problem because it contributes to lower investment growth and diminishes the savings rate.

Furuoka (2009) analyzed a long-run relationship between population growth and economic development in Thailand, employing the augmented Dickey-Fuller (ADF) unit root test, the bounds test for cointegration, and the Granger causality test. The results show that population growth has a positive impact on economic development. Also, the results show that there exists a unidirectional causality from population growth to economic development.

In some cross country studies, for instance, Headey (2009) investigated the effect of population growth on economic growth in developing countries. It demonstrated that population growth had a significant negative effect on economic growth. Shahbaz et al. (2009) examined the link between population growth, population density and economic growth in Pakistan during the period of 1972–2006. Their findings indicate that the diminution in infant mortality rate and total fertility contribute to accelerate the pace of economic growth in a positive direction. In Singapore, Furuoka and Munir (2011) investigated how the population growth contributes to economic development in Singapore. They use ordinary least squares, fully modified ordinary least squares, and dynamic ordinary least squares. The results of Granger causality revealed that exist a bidirectional relationship between population and economic growth.

More recently, Adediran's study (2012) is the only one that investigated the effect of population growth on economic development for the Nigeria for the period 1981-2007. The results revealed that population growth has a positive and significant impact on GDP per capita. By using ARDL technique, Ali et al. (2013) analyzed the impact of population growth on economic development in Pakistan during the period 1975-2008. The empirical results indicate that the impact of population is positive and significant for economic development but negatively affected by the unemployment rate.

In the case of Kenya, only a few studies had examined the causal relationship between population growth and economic growth over the period 1963-2009. Thuku et al. (2013) show that population growth and economic growth are positively correlated and that an increase in population will impact positively to the economic growth in the country. Further, Furuoka (2014) examined causal link between population growth and economic development in Sarawak and Malaysia. The empirical results show that there is no statistically significant long-run relationship, but a causal relationship between population growth and economic development in Sarawak. The results also indicated that income expansion caused the population expansion in Sarawak and Malaysia.

By using Johansen co-integration test and vector error correction model Mahmud (2015) found out whether the relationship between population growth and economic growth in India during the period 1980-2013. The results show that there is a positive relationship between population growth and economic growth in short and long-run**.** In addition, the result of Granger causality test also shows that there is a unidirectional relation running from economic growth to population growth.

Population growth and CO_2 emissions

The relationship between population and the environment has become a major issue found in the recent literature on sustainable development. Many studies have been carried out to show how the population affects the environment. For instance, by using a data set of 93 countries, Shi (2001) analyzed the impact of population on CO_2 emissions for the period 1975-1996. Their findings indicated that the population increases the carbon emissions in the last twenty years. In addition, the increase in levels of income has been linked to a change monotonically with rising of CO_2 emissions.

On the other hand, Morancho et al. (2006) explored the impact of population growth on carbon dioxide emissions for European Union countries over the period 1975-1999. Their findings show that the impact of population growth on CO_2 emissions is more than proportional for the countries.

In other studies, Zhu and Peng (2012) analyzed the effect of population (size and structure) on carbon dioxide emissions in China during 1978–2008. Their empirical results show that the population plays a major role on the environment. Ohlan (2015), using annual data for the period 1970–2013, investigated the impact of population density, energy consumption, economic growth and trade openness on CO_2 emissions for the India. The results indicate that population density; energy consumption and economic growth have statistically significant positive effect on CO_2 emissions both in the short-run and long-run.

Research method

Presentation of the basic model

The model of Solow (1956) considers the rate of investment, population growth and technological progress as exogenous. The two inputs, capital and labor are compensated their marginal productivities. We will follow the process of Demetriades and Law (2004), to study the effects of population growth on CO_2 emissions and economic growth. We assume a Cobb-Douglas production function, the production at the time (t) is given by:

$$Y_t = A_t L_t^{\alpha} K_t^{\beta} \quad (1)$$

With, $0 < \alpha < 1$ *and* $0 < \beta < 1$, Y, L, K, A denote the production, labor, capital and the level of technology. The parameter A reflects the effectiveness of the factors α and β designate the elasticity of output with respect to labor and to capital respectively. By introducing the neutral technical progress in the model (1) we obtained:

$$Y_{it} = A_{it} L_{it}^{\alpha} K_{it}^{\beta} PG_{it}^{\delta} CE_{it}^{\theta} e^{\gamma t} \quad (2)$$

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Where i = 1,….., N represents countries observed over the periods t = 1,……, T. Y is the gross domestic product (GDP); L represents the labor; K is the capital stock; PG represents the population growth, and EC represents CO_2 emissions. The coefficient $e^{\gamma t}$ describes the evolution of neutral technical progress during the period γ is the rate of neutral technical progress. The linear transformation of the model (2) reduces the following specification for the estimate:

$$LnY_{it} = LnA_{it} + \alpha LnL_{it} + \beta LnK_{it} + \delta LnPG_{it} + \theta LnCE_{it} + Lne^{\gamma t} + \varepsilon_{it} \qquad (3)$$

Model (3) is modeled keeping technology constant ($LnA_{it} = a$). Then, it is as follows:

$$LnY_{it} = a + \alpha LnL_{it} + \beta LnK_{it} + \delta LnPG_{it} + \theta LnCE_{it} + \varepsilon_{it} \qquad (4)$$

With, Ln represents the natural logarithm. ε_{it} is the error term that is supposed to be independent and identically distributed (iid). α, β, δ and θ represent the elasticity of labor, capital, population growth, and CO_2 emissions respectively. In addition, LnY_{it} represents the logarithm of GDP per capita; LnL_{it} represents the logarithm of labor; LnK_{it} represents the logarithm of capital; $LnPG_{it}$ represents the logarithm of population growth; and $LnCE_{it}$ represents the logarithm of the CO_2 emissions.

Estimation procedure

Our study uses a sample of 10 countries during the period 1980-2013. The empirical analysis consists on System Generalized Method of Moments (GMM) estimator developed for dynamic models. For a comprehensive analysis of the impact of population growth on economic growth and environmental quality were performed a series of models by adding or excluding explanatory variables.

Starting from the equation (4), our model is dynamic panel; we use the GMM system: we introduce the delayed endogenous variable as an explanatory one. The general specification of the model that we considered in order to identify the effect of population growth (PG) on economic growth (Y) and the CO_2 emissions (CE) can be written as follows:

$$LnY_{it} = \alpha_0 + \alpha_1 LnY_{it-1} + \alpha_2 LnPG_{it} + \alpha_3 LnCE_{it} + \sum_{j=1}^{3} \varphi_j Control_{i,j} + \varepsilon_{i,t} \qquad (5)$$

$$LnCE_{it} = \beta_0 + \beta_1 LnCE_{it-1} + \beta_2 LnPG_{it} + \beta_3 LnY_{it} + \sum_{j=1}^{3} \varphi_j Control_{i,j} + \varepsilon_{i,t} \qquad (6)$$

Where, LnY_{it}, $LnCE_{it}$, represent, respectively, the natural logarithm of GDP per capita, and the natural logarithm of the CO_2 emissions of the country i in time t. α_0 and β_0 are the parameters to be estimated; LnY_{it-1} and $LnCE_{it-1}$ represent the logarithm lagged dependent variables. $Control_{it}$ represents the control variables used in both models, for the GDP model (capital stock (K), labor force (L), and financial development (FD)) and for the CO_2 model (foreign direct investment (FDI), trade openness (T), and urbanization (UR)). Finally, ε_{it} is the errors term.

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The model (5) is an analysis of the impact of population growth (PG), CO_2 emissions (CE), financial development (FD), capital (K) and labor (L) on economic growth (Y) (for example, Headey, 2009; Huchet-Bourdon et al. 2011; Adediron, 2012; Busse and Königer, 2012; Greenwood et al. 2013; Ejuvbekpokpo, 2014; Furuoka, 2013; Hassen, 2014; Mahmud, 2015). In addition, the model (6) assumes that CO_2 emissions (EC) can be influenced by economic growth (Y), population growth (PG), foreign direct investment (FDI), trade openness (T) and urbanization (UR) (for example, Marancho et al. 2006; Zhu and Peng, 2012; Ohlan, 2015; Saidi and Hammami, 2016).

Method of dynamic panel

A dynamic model is a model in which one or more delays in the dependent variable are included as explanatory variables. Unlike the dynamic GMM, standard econometric techniques such as OLS do not provide efficient estimates, due to the presence of the lagged dependent variable on the right of the equation.

The advantage of GMM is that solves the problems of simultaneity bias, reverses causality and omitted variables that weakened the results of previous studies. It also helps treat the endogeneity problem of all the explanatory variables, which arises when studying the relationship between social capital and economic growth.

There are two variants of the GMM estimator in dynamic panel: the first difference GMM estimator and the GMM estimator system. The first difference GMM estimator of Arellano and Bond (1991) is to be taken for each period the first difference of the equation to estimate to remove the specific effects of the country, and then instrumented explanatory variables in the equation in first differences by their delayed values of a level period or more. The GMM system estimator of Blundell and Bond (1998), is to combine the equations in first differences with the level equations where the variables are instrumented by their lagged level values of at least one period.

Two tests are associated with the estimator of GMM dynamic panel: the over-identification test Sargan/Hansen, which can test the validity of the lagged variables as instruments, and autocorrelation test Arellano and Bond where the null hypothesis is the absence of autocorrelation of the first order errors in the level equation.

Descriptive statistics and correlations

Descriptive statistics

Observing the graph of the GDP evolution in the period 1990-2013, we note that for India and China, GDP is evolving at a low rate. For the other countries have the same trend and the growth rate is constant during the study period. We can say that these countries have the same economic weight.

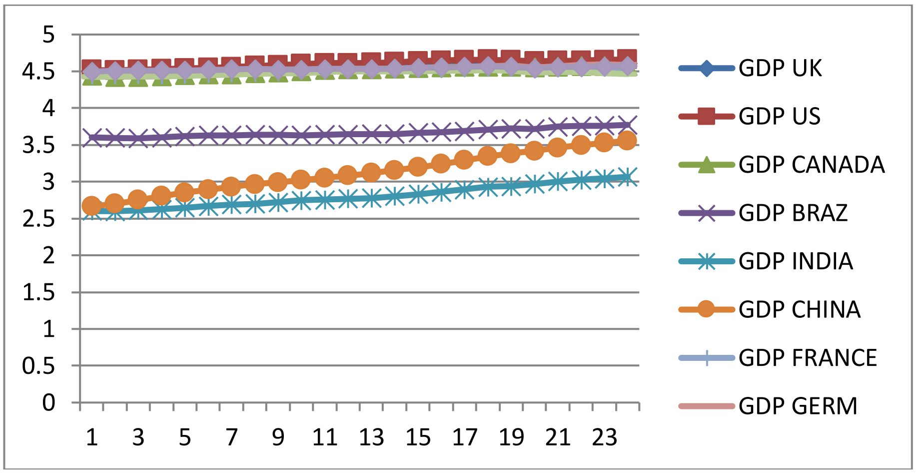

Figure 1. Evolution of GDP between 1990 and 2013

The evolution of CO_2 during the period of study, the curves don't have the same trends; for the United State, Canada, Japan, United Kingdom, Italy and France they have the same tendency, the evolution of CO_2 is constant and by 2011 it decreases. For India and Brazil, the CO_2 level is growing at a low rate, by cons, CO_2 levels in China from 2003 increases of 0.4%.

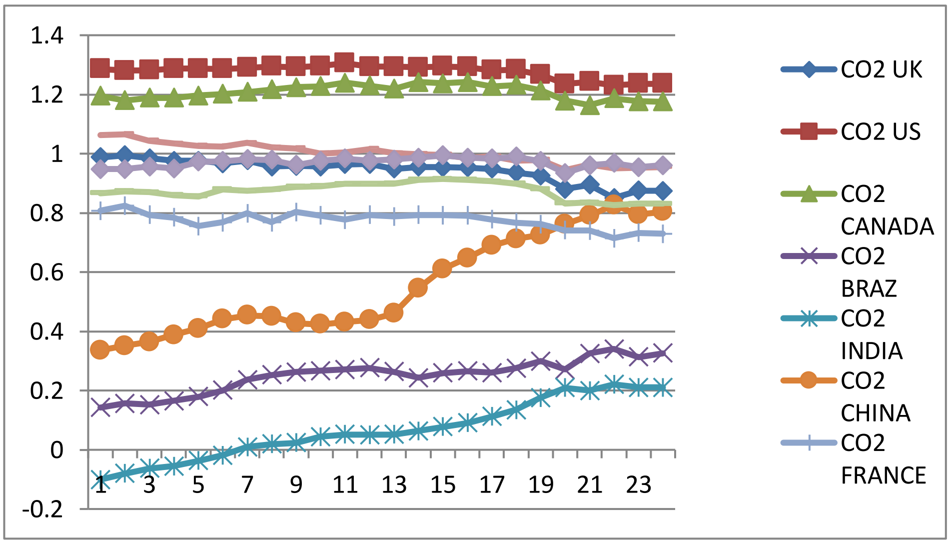

Fig.2 Evolution of CO_2 emissions between 1990 and 2013

This study uses annual data covering 1990 to 2013, collected from the World data bank, World Development Indicators database, for United Kingdom, United States, Canada, Brazil, India, China, France, Germany, Italy, and Japan. The variables of the per capita real Gross Domestic Product (GDP) and environmental quality (CO_2 emissions) used are commonly found in the literature related to the subject. The control variables: population growth (PG), capital (K), labor force (L), financial development (FD) is proxied by access to domestic credit of private sector per capita, foreign direct investment, trade openness (T) which is obtained by dividing the sum of exports and imports by GDP and urbanization (UR) is urban population as share of total population.

Table 1 shows the descriptive statistics of the variables. As can be seen, the average of economic growth of the sample over the study period (1990-2013) is 24669.42; the average minimum of growth is registered in India (675.2188), while the maximum is in Japan (313545.0). Regarding the variables of population, India recorded the maximum values for the growth of the population (1.690723). The lowest population growth recorded in Japon (0.140512). Regarding the variable of the environment, its lowest average value is obtained in the India (1.196099) and United States recorded the highest value (18.98182).

Correlations

In order to detect the relationship between the variables, we will present the different correlation coefficients in the following table to test the correlation between them.

- A high correlation (close to 1 in absolute value) indicates a strong correlation between the variables used.

- A low correlation (close to 0) indicates a weak correlation between the variables used.

Generally, the values are greater than or equal to 0.5 indicates that the variables are strongly correlated positively or negatively according to the account in variable effect on the other.

The results of the correlations between variables are presented in Table 2. Regarding the correlation between variables, two findings deserve to be made: First, there is a positive and significant correlation at the 5% threshold in most cases between variables and economic growth. Also, the correlation between other variables is also often significantly positive and strong. For cons, the population growth variable is negatively correlated with CO_2 emissions and economic growth.

From the chart representing the various correlation coefficients, there is a strong positive correlation between economic growth and CO_2 emissions (0.763342), and other correlations that are weakly correlated, for example, capital, FDI. Also, there are negative correlations between dependent and independent variables.

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Table 1. Descriptive statistics

		CE	FD	FDI	Y	K	L	PG	T	UR
United Kingdom	Mean	8.826488	144.5850	3.506969	35621.79	378011.9	30211575	0.485369	53.90064	79.49608
	Std. Dev	0.774090	38.17032	2.901383	4810.753	64010.13	1379236.	0.217307	5.067646	1.330124
	Maximum	9.870362	215.0548	10.44479	41543.50	478074.3	32772204	0.787033	63.00590	82.09200
	Minimum	7.085732	103.1710	0.628500	27821.08	262435.5	28641172	0.239745	44.03445	78.11200
United States	Mean	18.98182	196.6348	1.395255	40170.64	237309.4	1.47E+08	1.036084	24.42394	78.87325
	Std. Dev	0.971188	30.09692	0.776792	4592.879	51590.43	10414343	0.189252	3.596602	1.815093
	Maximum	20.20761	235.7177	3.123781	45660.73	304611.7	1.60E+08	1.386886	30.88516	81.27700
	Minimum	17.02022	145.2208	0.302938	32537.69	148276.8	1.28E+08	0.756558	19.73551	75.30000
Canada	Mean	16.16800	150.0767	2.673760	32896.27	6.04E+10	16841277	1.041686	66.85102	79.27167
	Std. Dev	0.902416	37.86230	2.208963	3924.485	1.21E+11	1673211.	0.167597	9.243583	1.575179
	Maximum	17.46386	214.2259	8.944987	37756.65	3.11E+11	19516479	1.493593	83.17568	81.47200
	Minimum	14.58905	100.9123	-0.072789	26810.20	137239.2	14720716	0.796845	49.36948	76.58200
Brazil	Mean	1.793577	85.56192	2.261204	4673.948	4.74E+10	87432602	1.347993	22.32003	80.74892
	Std. Dev	0.226991	26.04001	1.419247	627.3828	6.35E+10	13639696	0.268326	4.581218	3.464809
	Maximum	2.191394	180.0440	5.001248	5926.879	1.50E+11	1.08E+08	1.738052	29.67825	85.17100
	Minimum	1.388940	54.92754	0.182961	3886.192	136845.2	62785855	0.913688	15.16176	73.92200
India	Mean	1.196099	56.67761	1.075499	675.2188	376105.7	4.19E+08	1.690723	33.01320	2.668000
	Std. Dev	0.278200	11.11791	0.877789	241.0660	267344.4	52663049	0.252757	13.76496	0.157061
	Maximum	1.662873	77.15084	3.545983	1164.343	908517.6	4.88E+08	2.073448	55.54501	3.025237
	Minimum	0.793218	42.85788	0.026756	398.3536	105631.2	3.29E+08	1.251191	15.23902	2.392264
China	Mean	3.851949	120.6872	3.708076	1588.023	347115.2	7.31E+08	0.805974	43.75996	38.69800
	Std. Dev	1.555567	23.27057	1.264717	971.0264	231618.1	50601734	0.312417	11.01437	8.385958
	Maximum	6.710302	157.6492	6.212820	3619.446	905908.3	8.02E+08	1.467303	64.76946	53.16800
	Minimum	2.167703	87.22194	0.971382	464.8720	102103.1	6.37E+08	0.479150	29.61548	26.44200
France	Mean	5.962390	113.5818	2.040846	32724.64	431564.9	27883087	0.520572	50.18008	76.37796
	Std. Dev	0.371761	20.26330	0.945290	2872.591	64960.50	1475505.	0.166320	6.116423	1.577962
	Maximum	6.670624	147.8064	3.865317	36073.52	528077.3	30030773	0.753806	59.20038	79.05500
	Minimum	5.185043	97.15220	0.682308	28200.14	340371.5	25769792	0.079445	39.57153	74.05600
Germany	Mean	10.07569	130.1972	1.597653	33946.24	564233.6	40770236	0.175176	62.07339	73.54550
	Std. Dev	0.798959	16.97814	2.184054	3131.536	38731.01	1152064.	0.638341	15.49941	0.545847

	Maximum	11.62265	164.7976	10.77387	39372.51	629470.7	42755645	2.100157	85.88923	74.89000
	Minimum	8.803955	98.89390	-0.347714	28791.57	491943.1	37331150	-1.691349	40.64431	73.06400
Italy	Mean	7.523422	111.0389	0.708056	29927.77	340466.4	23881492	0.253999	46.97013	67.49754
	Std. Dev	0.483882	30.80026	0.590742	1999.782	42168.62	804282.1	0.287011	6.708320	0.635972
	Maximum	8.216487	177.2370	2.007018	32830.73	410977.0	25474177	1.159251	56.13591	68.68600
	Minimum	6.702558	83.71776	-0.397191	26476.76	273343.9	22756086	0.001589	33.97007	66.70600
Japon	Mean	9.336669	301.0585	0.128464	313545.0	34469.64	66584677	0.140512	23.71483	83.05783
	Std. Dev	0.332849	28.67335	0.144347	363081.4	1823.219	1007932.	0.170462	6.391820	5.574356
	Maximum	9.856908	366.5330	0.507814	997325.0	37573.37	68023400	0.381790	35.22832	92.49100
	Minimum	8.598622	253.7523	-0.055016	100703.9	31174.96	63776258	-0.200321	15.92399	77.33900
Panel	Mean	8.371610	141.0100	1.909578	24669.42	1.08E+10	1.59E+08	0.749809	42.72072	66.02347
	Std. Dev	5.533203	69.76141	1.887818	15176.52	4.76E+10	2.24E+08	0.578897	17.78021	24.69843
	Maximum	20.20761	366.5330	10.77387	45660.73	3.11E+11	8.02E+08	2.100157	85.88923	92.49100
	Minimum	0.793218	42.85788	-0.397191	398.3536	100703.9	14720716	-1.691349	15.16176	2.392264

Notes: ***CE***= CO_2 *emissions;* ***FD***= *financial development;* ***Y***= *economic growth;* ***FDI***= *foreign direct investment;* ***K***= *capital stock;* ***L***= *labor force;* ***PG***= *population growth;* ***T***= *trade openness;* ***UR***= *urbanization.* ***Std. Dev***=*Standard deviation.*

Table 2. Correlation between the variables

	CE	Y	PG	K	L	FD	FDI	T	UR
CE	1.000000	-	-	-	-	-	-	-	-
Y	0.763342	1.000000	-	-	-	-	-	-	-
PG	-0.212124	-0.555728	1.000000	-	-	-	-	-	-
K	0.030254	-0.031957	0.224804	1.000000	-	-	-	-	-
L	-0.409981	-0.721100	0.319238	-0.117729	1.000000	-	-	-	-
FD	0.500086	0.589697	-0.443055	-0.020968	-0.230891	1.000000	-	-	-
FDI	-0.035549	-0.083013	0.057732	-0.005819	0.208552	-0.166020	1.000000	-	-
T	0.198726	0.320815	-0.348620	-0.011968	-0.152860	-0.107538	0.338767	1.000000	-
UR	0.543843	0.718820	-0.492029	0.122928	-0.734715	0.510313	0.013375	0.128096	1.000000

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Estimation results and interpretation

Unit root test in panel

To present the unit root tests, we are building on the work of Hurlin and Mignon (2005); Guillaumant (2008); Araujo (2004) and Banerjee and Zanghieri (2003). The unit root tests in panel were inspired by the Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003). Also, the central hypothesis of these tests is based on the concept of independence between individuals of the panel. In the following we try to present the various tests in the following table.

Table 3. Results of unit root test

Variables	LLC		IPS	
	Level	First difference	Level	First difference
CE	-2.71377 (0.0033)***	-7.43771 (0.0000)***	1.82938 (0.9663)	-5.28402 (0.0000)***
FD	3.73878 (0.9999)	-7.29153 (0.0000)***	1.53885 (0.9381)	-5.26563 (0.0000)***
FDI	-2.36403 (0.0090)***	-11.4879 (0.0000)***	-3.71972 (0.0001)***	-7.15867 (0.0000)***
Y	5.72665 (1.0000)	-3.09645 (0.0010)***	1.85694 (0.9683)	-5.50413 (0.0000)***
K	1.92066 (0.9726)	-8.94705 (0.0000)***	0.13837 (0.5550)	-5.50360 (0.0000)***
L	5.20031 (1.0000)	-3.99695 (0.0000)***	0.77598 (0.7811)	-4.68292 (0.0000)***
PG	-1.53908 (0.0619)*	2.82166 (0.0024)***	0.98868 (0.8386)	-7.35374 (0.0000)***
T	3.32176 (0.9996)	-9.23747 (0.0000)***	1.47641 (0.9301)	-6.61106 (0.0000)**
UR	4.46110 (1.0000)	-0.49977 (0.0030)***	2.51979 (0.9941)	-0.28880 (0.0000)***

Notes: LLC, IPS, correspond to the results of tests of Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003), and (.) are the p-value. *** Significance 1%, ** Significance 5%,* Significance at 10%.

The results in Table 3 indicate that most series are non-stationary with both tests. However, the two tests we would bring us to accept the null hypothesis of non-stationarity for the variables (Y, FD, K, L, T, UR) in level, at the risk level of 1 percent and the variable becomes stationary in first difference, while this hypothesis is rejected by the test Levin, Lin and Chu (2002) for the environmental quality variables (EC), foreign direct investment and growth of the population in level risk of 1 percent and 10 percent.

For the result of the IPS test (2003) to accept the null hypothesis of non stationarity for all variables in levels. This implies that all non-stationary variables at the level. Finally, the statistics of IPS (2003) allows rejecting the null hypothesis of stationarity for all variables (EC, FD, FDI, Y, K, L, PG, T, UR) in first difference in risk of 1 percent, while the variables are stationary.

As a conclusion, the results of tests LLC (2002) and IPS (2003) show that the series are non-stationary in level. Acceptance of the unit root hypothesis for all variables in levels leads us to verify whether these variables become stationary in first difference to show the existence of a long-term relationship between economic growth and CO_2 emissions and the control variables.

The results of the tests LLC (2002), and IPS (2003) applied to the series in first differences show that all series are I (1). The verification of stationarity of all panel variables in first difference leads us to study the existence of a long-term relationship between these variables, and hence the existence of a cointegration relationship through the use of tests Pedroni cointegration.

Co-integration test in panel

Then we focus on cointegration tests by relying on the work of Pedroni (1997, 1999). The verification of properties of non stationarity for all variables of the panel leads us to study the existence of a long run relationship between these variables. This is to say, the study of the existence of a cointegration relationship and applying the cointegration test of Pedroni (1997, 1999).

The cointegration test panel based on the residual term, to deal with is that developed by Pedroni (1999, 2004), who proposes 7 cointegration tests for panel data that admit a strong heterogeneity. These tests take into account the heterogeneity at level the cointegration relationship (Each individual admits one or more cointegration relationships that may different between individuals of the panel). The results of Pedroni cointegration test estimates are presented in Table 4.

Table 4: Result of the cointegration test of Pedroni

	Test	Value	P-value
Within-dimension	Panel v-Statistic	4.536958	(0.0000)***
	Panel rho-Statistic	2.151990	(0.0984)*
	Panel PP-Statistic	-2.693406	(0.0035)***
	Panel ADF-Statistic	-1.615444	(0.0531)*
Between-dimension	Group rho-Statistic	2.620895	(0.0000)***
	Group PP-Statistic	-2.332923	(0.0098)***
	Group ADF-Statistic	-1.570826	(0.0581)*

Notes: *** Significance 1%, ** Significance 5%,* Significance at 10%.

According to the results of Pedroni cointegration tests, we notice that the majority of statistics allows us to accept the existence of assumption of cointegration relationship between economic growth and CO_2 emissions and the other variables of controls at the risk of 1 percent and 10 percent. In addition, the results of cointegration test of Pedroni show that the majority of these statistics indicate that there is a long-term relationship and consequently a cointegration relationship between these variables.

In conclusion, from the results of cointegration tests in panel Pedroni (1999, 2004) one can conclude that there is a cointegration relationship between economic growth, CO_2 emissions and the others control variables the study period and as a result we can say that there is an important relationship.

Kao (1999) proposes to test the presence of cointegration while using the ADF test types. It presents the cointegration tests in panel based on the regression residuals. The particularity of this model it tests the presence of cointegration for each cross section of the panel uses under the assumption of independence between the groups. The ADF test is built from the regression differentiated residues. The null hypothesis of no cointegration for every i value assessed by the average individual ADF tests. The results of Kao cointegration test are presented in Table 5.

Table 5: Result of the co-integration test of Kao

	t-Statistic	Prob.
ADF	-3.963898	0.0000

Note: **** indicates statistical significance at the 1% level.*

The results of Kao's (1999) reject the null hypothesis of no cointegration at the 1% significance level. Then, we conclude that the existence of a long-term panel equilibrium relationship between these three variables, which means that GDP, the EC and the PG move together in the long term.

The generalized method of moments (GMM) in system

The method of Arellano and Bond (1991) provides an estimator "GMM" more efficient, allowing to verify the absence of autocorrelation of first and second order take account of the heterogeneity. The GMM estimator in first differences presents certain insufficiencies since the lagged variables on level are not good instruments of the variables in first differences. Arellano and Bover (1995) and Blundell and Bond (1998) proposed another estimator system GMM based on the initial conditions and taking into account the moment conditions, to combine the first difference equations with on level equations and the variables in first differences as instruments. Based on the results presented in the table (6), the test Hansen (p = 1.000) for both model and Arellano and Bond in second difference on the errors of autocorrelation (p = 0.131, p = 0.190) does not reject the validity of the lagged variables and no autocorrelation hypothesis mistakes.

Table 6: Results of GMM system

Variables	Economic growth (Y)		CO_2 emissions (CE)	
	Model (1)		Model (2)	
	Coefficient	P-value	Coefficient	P-value
Y(-1)	0.9744	(0.000)***	-	-
Y	-	-	0.0596	(0.047)**
CE(-1)	-	-	0.8034	(0.000)***
CE	-0.0817	(0.043)**	-	-
PG	0.0129	(0.020)**	0.0240	(0.086)*
K	0.0013	(0.574)	-	-
L	0.0236	(0.033)**	-	-
FD	0.0567	(0.058)*	-	-
FDI	-	-	0.0017	(0.006)***
T	-	-	0.0018	(0.618)
UR	-	-	-0.0046	(0.097)*
Cons	-12.432	(0.068)*	0.4330	(0.055)**
Sargan Test	93.86	(0.000)	77.25	(0.002)
Hansen Test	8.62	(1.000)	4.63	(1.000)
AR(1)	-2.32	(0.020)	-1.23	(0.022)
AR(2)	-2.16	(0.131)	1.31	(0.190)

Notes: **** Significance 1%, ** Significance 5%,* Significance at 10%. The statistics of AR1 and AR2 represent the autocorrelation test of order 1 and 2. The values in parentheses are the p-value.*

Empirical results estimated for the two specifications introduced in the table (6) confirm the existence of a positive and significant effect exerted by the endogenous variable lagged one period. First of all, for the model (1), the results show that labor and financial development has a positive and significant effect on economic growth at 1 percent threshold and 10 percent. This implies that 1 percent increase of the labor and the financial development causes increase in economic growth of 0.0236 and 0.0567, respectively. Thus, the improvement of financial development that resulting by an increase of bank deposits, liquidity in the economy and credit facilities to private agents, is positively associated with economic growth prospects in these countries. The countries in this study have the advantage of having common economic, financial development can promote the consolidation of the banking sector, increase trade and transactions between agents and countries, and finally promote economic growth. These results remain very close to those obtained by Levine et al. (2000), Beck et al. (2000) and Rioja and Valev (2004) which provide a positive impact of financial development on economic growth. The capital coefficient is positive but not significant. The CO_2 emissions have negative effects and significant on economic growth at 5 percent threshold. This means that the increase in emissions will decrease economic growth of 0.0817. These results are the same as for Jayanthakumaran et al. (2012) for China and India; Saidi and Hammami (2015) for 58 countries. Finally, the population growth (PG) induces a positive and statistically significant effect on economic growth at the 5 per cent threshold. Thus, an increase of the population growth of 1 percent increases the growth of 0.0129. The result is in line with that of Ali et al. (2013). We conclude that the direct effect of population growth is positive on economic growth but reverse is the case when indirect analysis is made and leading to unemployment. Now, on one hand it increases the growth, but on the other hand, it creates a problem of unemployment and leads to lack of educational establishments and health.

Regarding the model (2), the findings suggest that population growth has a positive effect on CO_2 emissions at the 10 per cent threshold; the CO_2 emissions increase of 0.0240, when the growth of the population increases by 1 percent. Our results are confirmed with results of Martínez-Zarzoso et al. (2007). In addition, foreign direct investment has a positive and significant effect on CO_2 emissions at 1 percent level. So an increase of 1 percent in FDI increases CO_2 emissions of 0.0017. Our result is consistent with results of Merican et al. (2007), Chandran and Tang (2013), Seker et al. (2015). Economic growth has a positive and significant effect on CO_2 emissions to level 5 percent in all countries, indicates that these countries would be in the ascending phase of the Environmental Kuznets Curve. An increase of CO_2 emissions of 0.0596 leads increases a per capita GDP of 1 percent. The coefficient of urbanization is negative (-0.0046) indicating that an increase of 1 percent of this variable will decrease CO_2 emissions of 0.0046. This is the same result found by Martínez-Zarzoso and Maruotti (2011) but it is different to the result of Sadorsky (2014). Finally, the coefficient of trade openness is positive but not significant. A clearer understanding of how urbanization affect of CO_2 emissions is essential in a sustainable development perspective.

Conclusion

World population explosion has effects on the economy, the rate of population growth exceeds that of the economic growth which can cause adverse effects; the level of consumption beyond the level of productivity and this contributes negatively on economic growth. In our study we examine the impact of population growth on economic growth and CO_2 emissions, using the GMM system. In order to see this effect we study the case of 10 countries that approximate in their economic weight but their population growth varies from one country to another. The results obtained show that the effect of population on economic growth and CO_2 emissions is positive and significant. The effect of the population is significant and positive but with small contribution to economic growth. Capital has an insignificant effect on economic growth also the labor contributes positively and significantly to economic growth.

The population growth is not a problem that hinders economic growth and contributes to pollution of the environment; it is influenced by other factors for example the country's economic policy and social hierarchy such as aging and also skilled labor. The environment can be influenced indirect by the population, the economic activities are the most important that affected the environment. This can be treated in another study; we focus on the interaction between population growth, economic growth and CO_2 emissions.

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