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Analyses on the Causality in Carbon Emission with respect to Economic Growth and Education

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Abstract

This paper investigates the association between the level of carbon emission (CO2), economic growth and scholarly education levels in the countries chosen according to some specific characteristics using multivariate time series approach. It considers the impact of GDP and education enrollment, as a proxy of human capital, on the level of CO2 for the countries classified according to their economic developments and regional distribution. The analyses are assessed in three different cases two of which consider the structural breaks for certain periods. The paper enables policy makers to consider the influence of education level and GDP in CO2 issues.

1. INTRODUCTION

The industrial development, dependence on natural energy sources contribute to pollution in the world. However, the awareness in environmental issues through all channels of education is expected to bring more caution to reduce the pollution, for instance CO_2 emission. According to the United States Environmental Protection Agency [7], the economic activities that release GHG are energy supply (%25), industry (21%), land use, land-use change and forestry and agriculture (24%), transportation (14%), commercial and residential building (6%) and other energy related operations (10%). Many of these activities result from government policies, economic developments, financial markets and social and industrial needs. In light of developments in last decades, the association between CO_2 emission and these activities can mainly be categorized in terms of the economic development which triggers the use of sources contributing to the carbon emission, whereas the level of awareness in reducing its effects on the environment. For this reason, an important indicator of the economic development, GDP, and the awareness on the impact of carbon emission on the environment gain importance. Decision makers, strategy developers, producers and consumers in every economy act according to their level of education. The main expectation is that more educated population leads to a faster economic development, and hence, more awareness to the environmental issues. Regarding to the differences in educational systems and strength on economic growth, it gains importance to observe if (i) the increase in education level and enrollment come up with the environmental awareness, (ii) the economic strength (emerging or developed economy) has an impact on CO_2 emission, (iii) the geo-location makes a difference on CO_2 level, (iv) the education has impact on economic strength.

The studies on investigating the interrelation between education and economic growth, and CO_2 and economic indicators are various. [24] utilizes the endogenous growth model to explore the effect of school enrolments and public investments on economic growth in East Asian countries. A causal relation between higher education and economic growth in Sweden, Japan, France and the U.K are studied by [23] using cointegration and causality methods. The connection between private enterprise, international trade, higher education and economic growth in China, the association between human capital and economic growth in

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Greece, the linkage between education levels and economic growth for some OECD countries and less developed countries are analyzed in detail by [6; 1; 28; 39], respectively. The relation between various levels of education and economic growth in Japan using VAR analysis under certain structural breaks, the effect of education and technical progress on the economic growth in Taiwan, the interrelation between the education and the economic growth in India using Granger causality test, households' resources and the demand for education in Vietnam using panel data analyses are examined in literature ([32; 23; 33; 12]). The dependence between labor productivity and investment in education at African countries, identification of the effects of education on the economy in Portugal using VAR, the determination of the impact of school enrolment on GDP using cointegration and causality tests also show the importance of the education on economic indicators ([25; 26; 31]). All literature reviewed conclude that there exists positive influence of the education, especially higher education level on economic growth.

The literature on determining the connection between economic growth and carbon dioxide emission presents many remarkable studies such as [2; 3; 4; 5; 10; 15; 16; 17; 29; 34; 37; 38]. Their results conclude that there exists a causal relation between CO2 and GDP by using different methodologies. [36] investigate the association between economic growth, CO2 emissions and energy consumption by modified granger causality test illustrating that there is no causal link between the economic growth and carbon emission based on the occurrences between 1960-2000. Also, the study done by [14] indicate bi-directional causality between CO_2 and economic growth using ARDL model for the term between 1960 and 2005.

The motivation in this paper is to investigate if an increase in the level of education will decrease the CO_2 emission, as well as increase in the economic welfare. The influence of robust economy and emerging markets are expected to have a reverse effect on carbon emission level. To investigate the contributing factors in carbon emission, this paper aims to expose the relation of the two distinctive variables with CO_2. A comparative study is done by selecting countries from Europe (France, Spain), North Africa (Tunisia, Morocco), Asia (China) and Middle East (Turkey) based on their geological positions, availability of the common time-frame in data set and the similarity in education systems. The data taken from World Bank and UNESCO for the period 1971-2010 which is the common time frame available for the countries selected. For comparative reasons, the time period selected is kept the same for each country.

The organization of the paper is follows. A brief summary on the countries selected is given in Section 2 to explain the reasons of their inclusion in to the study. The method employed is shortly defined in Section 3. Empirical findings and comparative analyses are presented in detail in Section 4. Comments and further remarks conclude the paper.

2. PRELIMINARIES

A brief review on the education system, economic state and the carbon emission facts of the countries selected are summarized to point out the association and the state of these factors. On the evaluation of the education part, the system, the requirements and the regulations having impact on the education system are taken into account on country base. Spain and France represent Europe, whereas Tunisia and Morocco Africa, Turkey Middle East/East Europe and China Far-East in world map. Besides the similarity in educational forms in common, all these countries are located in Mediterranean region resembling the same climate conditions, except China. Tunisia, Morocco and Turkey are chosen due to their mutuality in history and religion. Economically growing power China is taken into consideration due to its position regarding to his environmental policy. Analyses on these countries are expected to give a determining indicator on the influence of economy, education on CO_2 emission.

We briefly outline the characteristics of the countries selected. A Mediterranean country, Spain has preschool education system for 0-6 years old children which is followed by 10 years of mandatory education. Although, higher school education in Spain is not compulsory by 2010, it has 1.9 millions of participants. Spain is the largest fourteenth economy in the world with 1,120,000 billion USD of GDP in 2015. Based on the recent preventions carbon emission of Spain decreased from 353 thousand to 270 thousand kilotons from 2005 to 2010 [41]. In France, the obligatory education age is 6-16 years consisting of primary, secondary and high school educations. The enrollment rates of France by 2010 is as flows: 4.1

million pupils are in primary education, 5.8 millions of students are in secondary school and 2.1 million of participants are in higher education. France is the biggest sixth economy in the world by 2,418,836 million USD of GDP by 2015 while it produces 33 million kilotons of carbon dioxide in 2010 [41]. The establishment of the Turkish education system has origins from the system in France, though it has gone through many regulatory changes in last two decades. The basic education system, which was formerly composed of 5-year primary, 3-year secondary and 3-year high school, has been first changed to a two-level system of 8-year primary, 3-year secondary in the fundamental education in 1997. The last reform has been done in 2012, which categorizes the system as a 4-year first level primary, 4-year second level primary and 4-year secondary education increasing the compulsory education duration from 8 years to 12 years. Based on the recent change, the number of primary schools becomes 32,108 with 11 millions of participants, while the number of secondary school is 9,672 having 5 million registered students by 2012 [38]. The university education in Turkey is highly demanded and competitive in enrollment process. The higher education institutes (university and vocational schools-synonym tertiary) increased from 19 to 170 between years 1981 and 2013, as well as having the enrollment rate increasing from 66 thousand to 1.7 million by 2011. Turkey ranks sixteenth place in the league of world economy by 717.88 million USD of GDP and produces 298 thousand kilotons of CO_2 in 2010 [41]. In Morocco children between the ages of 6-13 should participate in mandatory education, which is composed of pre-school, primary and secondary schools and total number of enrollments in mandatory education is 7 million while enrollment in higher education is 447 thousand by 2010. With a GDP of 100,593 million USD, Morocco is at 60th rank in the world. Morocco has relatively lower carbon dioxide emissions with 55 thousand kilotons in 2010 [41]. Tunisian education system, as in the Morocco education system, is based on French model. It starts with 6 years of primary and 3 years of lower secondary education. At the end of 9 years of education, a comprehensive examination performance is decisive on the continuation to the 4 years of the secondary education while the numbers of participants in the mandatory education is approximately 2.5 million. The admission to the higher education is centrally controlled and the enrolment rate in higher education is approximately 370 thousand. Tunisia has GPD of 43,015 million of US dollars GDP by 2010 and it is ranked on the 85th place. Like Morocco, it has a lower rate of carbon emission by 25 thousand kilotons in 2010 [41]. Chinese education system is composed of compulsory preschool, primary and secondary school with 100 million students in primary and 50 million participants in secondary education. At the end of 9 years of these mandatory educations students should take an exam to continue high school, which also opens gate to the higher education which has 31 million participants by 2010 [40]. China produces the highest carbon emission by 8.7 million kilotons in 2010 and has the second highest GDP by 11,007,721 million of USD in 2015.

A comparative illustration on the factors affecting CO_2 emission is presented in Figure 1. As it can be depicted, France has the highest and stable economic indicator, whereas, China leads in CO_2 emission compared to all other countries. It should be noted that the increase in CO_2 emission in China has parallel improvement on its GDP. Among African countries, Morocco has better economic power as well as higher CO_2 emission. We see the similar increasing rate in both countries. Turkey shows improving GDP over the years, which are taken into account, and does its carbon emission the same. Even though GDP of Spain has a better position compared to Turkey, carbon emission pattern in Turkey has a higher increasing rate.

Regarding to the education systems, we observe that primary (PRM) education show stationarity over the years, African countries show increase in secondary (SCD) education and China, Turkey, Morocco and Tunisia have increase on their higher (TER) education in last decade, at which China shows a recognizable rate of increase.

To determine if these three components have influence on each other or not, we employ auto- and inter-correlated time series methodology on the historical observations.

3. THE VECTOR AUTOREGRESSIVE MODEL

Time series modeling is the most commonly and effectively used approach in econometric analyses. It requires the stationarity of the series in order to come up with reasonable predictions. The stationarity which can be tested by checking if a unit root exists by using the Augmented Dickey Fuller (ADF), Dickey-Fuller

GLS detrended (DF-GLS), KPSS, and Phillips and Perron (PP). These tests help us to determine also the order of the integration [9; 21; 30].

The influence of different series on each other can be examined by Vector Autoregressive (VAR) analysis. The multivariate representation of linear modeling with a structural break is expressed as follows [18]:

$$\boldsymbol{X_t = \mu + \alpha_1 X_{t-1} + \cdots + \alpha_k X_{t-k} + D_t + \varepsilon_t,} \tag{1}$$

where $\{\alpha\}_{i=1,\ldots,k}$ is a m-dimensional vector of coefficients, ε represents the m-dimensional vector of residuals with zero mean and constant variance and D_t is a dummy variable which stands for the structural break appearing at time t.

VAR requires all the variables included in model to be stationary. Employing cointegration with the condition that all variables are integrated of the same order solves this problem. If we rewrite the Equation (1) with a lag operator, L, we have the following compact form:

$$\alpha_p(L)X_t = \mu + D_t + \varepsilon_t, \tag{2}$$

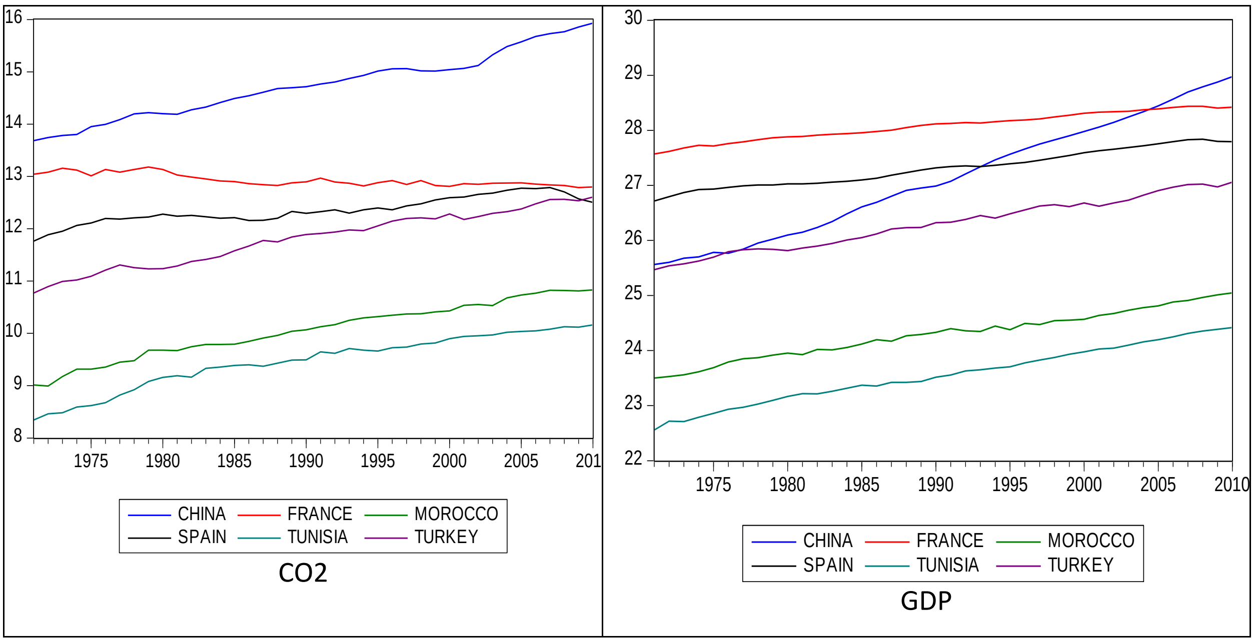
with $\alpha_p(L) = I_k - \sum_i^p \alpha_i L^i$. Equation (2) can be represented by a difference operator, Δ, as:

$$\beta_{p-1}(L)\Delta X_t = \mu - \theta X_{t-1} + D_t + \varepsilon_{t,} \tag{3}$$

where, $\beta_{p-1}(L) = I - \sum_i^{p-1} \gamma_i L^i$ and, $\gamma_j = -\sum_{n=i+1}^{p} \alpha_j$, for i= 1,…,p-1, and θ represents the matrix of the long run relationship. Re-parametrization of the Equation (3) yields [13] and [8] Vector Error Correction Model (VECM) representations given as follows:

$$\Delta X_t = \mu + \pi X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i X_{t-i} + D_t + \varepsilon_t, \tag{4}$$

where, $\Gamma_i = \gamma_j$ and $\pi = \theta$. The rank of π gives the number of cointegration vectors. If the matrix π has a reduced rank r < n, then π can be decomposed to α and β^t, such as $\pi = \alpha\beta^t$, with rank r. Here, the elements of α are the adjustment parameters and the rows of β^t correspond to the cointegration vectors. The number of cointegrated vectors can be found by trace test statistics, J, given in Equation (5) [18]:



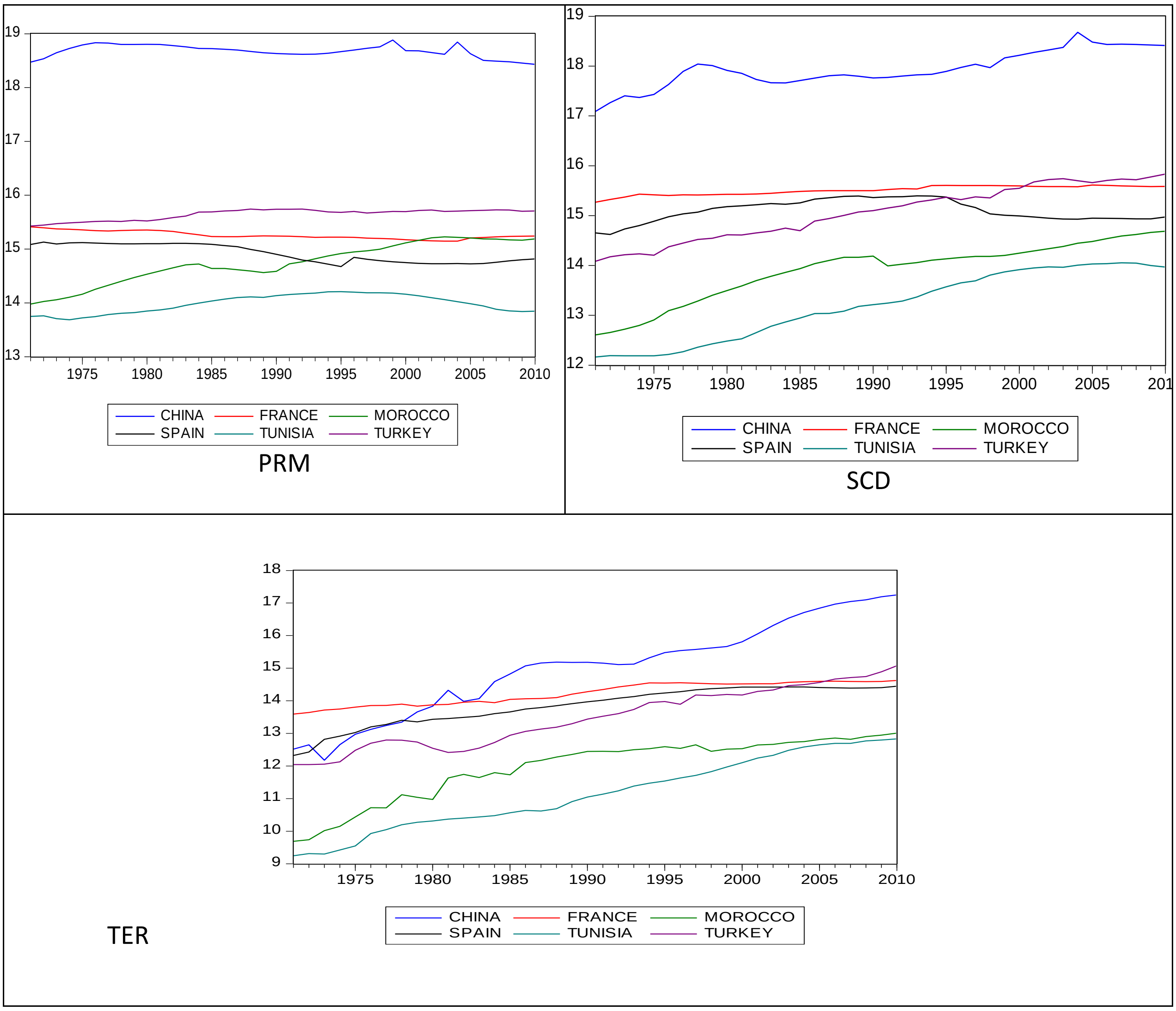


Figure 1. *The log-transformed annual observations for selected countries (1970-2010). (GDP, primary school (PRM), secondary school (SCD), tertiary (TER)*

$$J = -T \sum_{i=r+1}^{n} \left(1 - \tilde{\lambda}_i\right), \tag{5}$$

which has the null hypothesis of r cointegration vectors against n number of cointegration. Here, T denotes the sample size and $\tilde{\lambda}_i$ is the largest canonical correlation [18; 20].

4. EMPIRICAL ANALYSES

The data set consists of annual occurrences on real GDP (in USD), CO_2 emission (in million tons, mt), the number of enrollments in Primary (PRM), Secondary (SCD), university or higher education, called as Tertiary (TER) collected from the sources of World Bank and UNESCO between years 1971-2010 [40; 41]. For comparison reasons, the common time interval at which data for all selected countries can be retrieved is implemented for the proposed study. The analyses are done using Eviews 7.0.

The graphs given in Figure 1 shows that there is a special case in Turkish data which has to be incorporated into the analyses. Among the education components in Turkey case, primary education (PRM) shows sensitivity to the exogenous variables and retreats back by a downward slope between years 1988-1997. The hump at the earlier periods in university education (TER) is caused by the change in the regulations and the transition period to the general examination system. It is expected that the reform in 1997 have an influence on the proceeding education stages. Therefore, we conclude that Turkey appears to be more prone to the influence of regulatory changes compared to the other countries chosen. For this reason, the analyses are performed under three assumptions (namely, Case 1, 2 and 3) at which three steps are involved to assess the information searched for.

Case 1 takes into account the variables having no exogenous influence such as the change in regulations. **Case 2** includes a dummy variable to the model to investigate the impact of educational reform in 1997. **Case 3** considers the existence of a structural break in primary education (PRM) for the periods 1988-1997. The empirical analyses are done in three steps for each case. **Step 1**, identifies the data generating properties of each variable and determine the statistical properties of the log-transformed observations on the time frame selected. **Step 2** investigates the cointegration structure, i.e. the choice of the order, the estimation of the parameters in the vector autoregression structure, and determination of their significance. **Step 3** identifies the casual relation between the variables by Granger causality test.

***Table 1**: Descriptive statistics for the selected countries between years 1971-2010.*

		GDP	PRM	SCD	TER	CO_2
Turkey	Mean	11.8019	26.2975	15.6465	15.0634	13.4785
	Std. Dev	0.5289	0.47005	0.0990	0.5468	0.9143
	Skewness	-0.2341	-0.0304	-0.8989	-0.2212	0.0058
	Kurtosis	1.8439	1.8216	2.2271	1.7383	1.7023
	JB (p-val.)	0.2735	0.3134	0.0411	0.2254	0.2458
France	Mean	12.9338	28.0787	15.2589	15.5096	14.2287
	Std. Dev	0.1152	0.2535	0.0737	0.0902	0.3413
	Skewness	0.7975	-0.2442	0.4672	-0.6401	-0.3048
	Kurtosis	2.2901	1.9436	2.1048	2.5610	1.5189
	JB (p-val.)	0.0788	1.9436	0.2478	0.2173	0.1179
Spain	Mean	12.3527	27.3118	14.9198	15.0971	13.8448
	Std. Dev	0.2488	0.3265	0.1658	0.2181	0.5945
	Skewness	-0.0071	0.1162	0.0352	-0.2155	-0.8623
	Kurtosis	2.5841	1.8086	1.2310	2.1679	2.8642
	JB (p-val.)	0.8653	0.2929	0.0734	0.4811	0.0826
Morocco	Mean	10.0557	24.2926	14.7431	13.9002	11.9453
	Std. Dev	0.5367	0.4358	0.3783	0.59054	0.9683
	Skewness	-0.2653	-0.0904	-0.4023	-0.8383	-1.0190
	Kurtosis	2.0495	2.0738	2.1474	2.6505	2.7921
	JB (p-val.)	0.3725	0.4761	0.3179	0.0868	0.0303
Tunisia	Mean	9.4631	23.5557	13.9850	13.19754	11.14483
	Std. Dev	0.5234	0.5216	0.1699	0.688250	1.119333
	Skewness	-0.6029	-0.0550	-0.2245	-0.2021	-0.0176
	Kurtosis	2.3089	1.9871	1.6153	1.5700	1.8412
	JB (p-val.)	0.1999	0.4209	0.1710	0.1588	0.3263
China	Mean	14.7424	27.1271	18.6773	17.9348	15.0045
	Std. Dev	0.6259	1.0655	0.1159	0.3661	1.4394
	Skewness	0.1444	0.1135	-0.4206	-0.0375	-0.2487

Kurtosis	2.1425	1.7355	2.4694	2.5724	2.1309
JB (p-val.)	0.5055	0.2527	0.4386	0.8547	0.4227

[a,b,c] 1%, 5% and 10% significance levels, respectively.

The summary of basic characteristics on the log-transformed data set is presented in Table 1. The descriptive statistics show that China has the highest average GDP followed by France whose average is very close to Spain. The same order appears in average CO_2 values. Two selected African countries yield the lowest average carbon emission levels, whereas, the rest come up around an average of 14 and over. There exists no significant volatility depicted for each variable. None of the variables exposes either remarkable skewness, or leptokurtic behavior. Except SDC-Turkey and CO_2-Morocco, all variables follow normal distribution, which is a desirable condition to assure the unbiasedness in estimators.

In determining the cointegration structure, the stationary condition in each case is justified through the tests (ADF, DF-GLS, KPSS, PP) and the order of integration is determined for the variables for each country separately (Table A.1). Results of the unit root tests based on ADF indicate that PRM-Turkey, SDC-France, SDC-Morocco, TER-Morocco, CO_2-China are stationary at level, whereas the rest becomes stationary at the first difference. The graph of PRM-Turkey (Figure 1) shows a trend shift for the periods between 1988 and 1997, which is investigated through two structural break tests [27; 42]. Both of the tests suggest that there exists unit root with structural break (p value<0.01). For this reason, as **Case 3**, a dummy variable, D_t, having value 1 for the periods from 1988 to 1997 and zero otherwise is included into the model. In this case, the order of integration in the cointegration analysis is taken to be one.

The VAR system in level given in Equation (1) is estimated with an optimal lag (p=4) according to Akaike information criterion (AIC). The trace test indicates the number of cointegration vectors to be chosen. The critical values based on Giles [11] indicate that there exist structural breaks in the VAR system.

The cointegration analysis indicates the existence of a long run relation or equilibrium between the investigated variables. However, it does not show the direction of the relation. In order to depict the causal relation, we estimate five different VECMs when CO_2 is taken as the dependent variable. Therefore, we define the relation of CO_2 level with respect to the other parameters as follows:

$$\Delta CO2 = \mu + \sum_{i=1}^{p} \sigma_i \Delta CO2_{t-i} + \sum_{i=1}^{p} \alpha_i \Delta GDP_{t-i} + \sum_{i=1}^{p} \beta_i \Delta PRM_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta SEC_{t-i} \ \sum_{i=1}^{p} \delta_i \Delta TER_{t-i} + \sum_{i=1}^{r} \psi_i ECT_{t-i} \ \varphi_1 D_t + \varepsilon_t \,. \quad (6)$$

Here, *ECT* represent the error correction term. It should be noted that two ECT's appear due to the Johansen-Juselus methodology [18] the maximum cointegration rank is one less the number of variables [19].

Tests on the parameters in the Equation (6) determine the short- and long -run impact of variables on CO_2. The empirical results show that in the short-run all education levels result in change in CO_2. However, in the case when GDP is taken as dependent variable, only primary (PRM) and secondary (SCD) educations have impact on GDP.

4.1. Analyses on Case 1

Case 1 exhibits the contribution of all variables in the whole-time span without any structural break assumption. The steps in the analyses are performed to the data set and the optimal lag length for Turkey is determined as 3 and the number of cointegration is remains to be 2 as well as in China and Spain cases. However, France, Morocco end up with an optimal lag of 1, Tunisia with 3 cointegrating vectors (Table 2). For Turkey case, when CO_2 is taken as the dependent variable, all ECTs terms are significant with an adjustment rate of 40% and 18%. In the short-run primary and secondary educations cause CO_2 and in the long run, all education levels and GDP cause CO_2. Only one of the ECT term is significant in the case, when GDP is the dependent variable and it has an adjustment rate of 20% while in the short run only CO_2 cause GDP. The long run results illustrate that again all levels of education and CO_2 cause GDP. However, in the short run there exists a uni-directional causality running from CO_2 to GDP. The long run causal relationship is bi-directional which supports the findings of [14]. The results of Granger causality and diagnostic tests for all countries are given in Table 3 and Table 4 respectively.

In China the higher education (TER) causes CO_2 in short and long run. Interestingly, none of the other variables have influence on GDP. In short and long run, the change in CO_2 has impact on primary and secondary education. France has CO_2 (GDP) emission, which is affected by all education levels and GDP (CO_2) in long run. Similar to China, secondary education is influenced by all other variables in the long run and CO_2 causes secondary education. In Spain, long-run impact of all variables on CO_2 is recognizable whereas in short run only GDP is significant. As in China GDP does not have any impact from all other variables in both runs. Secondary education in Spain follows the same pattern as in France and China. In Tunisia, amazingly, CO_2 is not affected by any of the variables. GDP has an impact in short and long run by CO_2. Surprisingly, primary and higher education are influenced by all others contrary to other countries. In long run, Morocco's CO_2 level has influence on all other variables, GDP is caused only by primary education (PRM). Higher education is affected by all other variables in the long run.

Table 2. *Johansen cointegration test results for each countries.*

Country	**Hypothesis**	**Trace Stat.**	**Critical Value (1%)**	**Eigenvalue**
Turkey	None	103.5069*	76.07*	0.72315*
	At most 1	57.27300*	54.46*	0.55381*
	At most 2	28.22088	35.65	0.35043
France	None	91.4423*	76.07*	0.70138
	At most 1	46.7250	54.46	0.49534
Spain	None	183.9469*	76.07*	0.91648
	At most 1	97.0554*	54.46*	0.75903
	At most 2	47.2476	35.65*	0.58394
Morocco	None	86.4958*	76.07*	0.62183
	At most 1	50.5169	54.46	0.50454
Tunisia	None	117.0793*	76.07*	0.71329
	At most 1	70.85577*	54.46*	0.56089
	At most 2	40.40498*	35.65*	0.43067
China	None	100.7616*	76.07*	0.66529
	At most 1	61.3594*	54.46*	0.59199
	At most 2	29.0866	35.65	0.43699

* 1% significant level.

Table 3. *Granger Causality Test Results for Case 1*

		Short-run (F-statistics)					**Error Correction (Coefficient and t-statistics)**			
	Dep. Var.	ΔCO_2	ΔGDP	ΔPRM	ΔSCD	ΔTER	ECT_1	ECT_2	ΔCO_2	ΔG
Turkey	ΔCO_2		1.8513	5.0256[b]	14.8211[a]	0.1683	-0.4089[a]	-0.1788[b]		3.1
	ΔGDP	4.4600[b]		0.1119	0.9994	4.9676[b]	-0.0393	-0.2104[b]	3.2244[b]	
	ΔPRM	1.1255	0.2228		0.1399	0.0033	0.0197	-0.0449	0.9615	0.6
	ΔSCD	0.9536	2.5770	1.8105		0.0105	-0.2921[b]	0.0719	2.7746[c]	3.2
	ΔTER	0.4489	0.3830	0.7878	1.4821		-0.31042	0.38882	1.0448	1.1
China	ΔCO_2		1.9155	1.3657	1.2898	2.7870[b]	-0.2473[b]	0.0606		1.9
	ΔGDP	0.1307		1.3876	0.2938	0.2308	-0.0345	0.0718	0.6751	
	ΔPRM	3.3013[c]	0.1257		2.3509	0.1406	-0.1397	-0.2831[b]	5.4793[a]	5.6
	ΔSCD	6.8688[b]	5.4269[b]	8.2696[a]		4.1339[c]	-0.3442[a]	0.0636	8.2137[a]	9.1
	ΔTER	0.0008	1.8024	0.2238	0.2390		0.0053	-0.3671	0.3201	0.6
France	ΔCO_2		1.7610	2.1822	0.3982	1.0878	-0.2368[a]			9.5
	ΔGDP	0.3447		0.1672	0.0390	0.9505	-0.0501[b]		6.2306[b]	
	ΔPRM	0.0093	0.6874		1.8155	0.1892	-0.0258		1.4502	1.7
	ΔSCD	3.6628[c]	0.0131	0.9721		3.1064[c]	-0.7520[a]		33.7616[a]	27.4
	ΔTER	0.6897	0.0292	0.0112	0.0112		0.1898[c]		3.7145	3.3
Morocco	ΔCO_2		6.0181[a]	9.7491[a]	0.0020	0.3591	-0.6602[a]			15.2
	ΔGDP	0.4993		2.6729[c]	2.1686	0.6184	0.2752		2.1955	
	ΔPRM	0.3099	0.2598		2.4151	0.9660	0.0118		0.9166	0.7
	ΔSCD	0.4509	0.4603	0.0013		0.0056	-0.1767[c]		1.6031	1.6
	ΔTER	1.9107	0.1168	1.5842	0.1329		0.0445[a]		5.5847[a]	5.2

Table 3. *Granger Causality Test Results for Case 1 (contd.)*

	Dep. Var.	ΔCO_2	ΔGDP	ΔPRM	ΔSCD	ΔTER	ECT_1	ECT_2	ΔCO_2	ΔGDP	ΔP
Spain	ΔCO_2		2.9220[c]	0.5007	0.4236	0.1820	-0.1245[a]	-0.365[a]	-0.0814		9.5
	ΔGDP	0.2923		0.2629	0.0939	0.2459	-0.0470	- 0.0211	-0.0758	2.7125	
	ΔPRM	0.1387	0.0832		1.4846	0.1994	-0.0966	- 0.0431	-0.0972	0.2042	0.9
	ΔSCD	0.0131	0.5466	0.2524		0.0006	-0.0139	- 0.0517	0.2272[a]	4.7629[a]	4.7
	ΔTER	0.2757	0.0188	0.3398	1.3194		-0.1882[b]	- 0.1341	-0.1455	2.3056[c]	2.5
Tunusia	ΔCO_2		0.3112	0.0847	0.0257	0.6940	0.1014	- 0.1737	0.0207		1.2
	ΔGDP	7.1160[a]		0.6348	0.1658	0.4859	-0.0885	- 0.160[b]	0.0693	3.4782[b]	
	ΔPRM	0.0527	2.4476		6.7214[a]	7.2942[a]	0.0686[b]	0.0245	0.4727[a]	8.7127[a]	7.7
	ΔSCD	1.3343	0.3014	0.2623		0.0409	-0.1339[c]	- 0.0563	-0.0779	1.1719	1.1
	ΔTER	1.4511	0.2912	1.9806	2.6664[c]		-0.0941	- 0.370[b]	-0.0912	4.2361[a]	4.4

[a,b,c] 1%, 5% and 10% significance levels, respectively. Short-run blocks represents the F-statistics of the Wald test, coefficient of the ECT with the significant level according to t-statistics. Long-run block represents the joint Wald

Table 4. *Diagnostic Test Results for Case 1*

	Dep. Var.	**Serial Cor.**	**Heteroskedasticity**	**Normality**
Turkey	ΔCO_2	0.913129	0.423698	0.396912
	ΔGDP	0.436718	1.935656	1.443213
	ΔPRM	0.561179	0.684493	0.652099
	ΔSCD	0.118176	0.04365	0.244478
	ΔTER	0.110722	1.181197	2.398783
China	ΔCO_2	0.391355	1.066519	1.546552
	ΔGDP	0.806744	0.062815	14.16100[a]
	ΔPRM	0.086572	4.894182[b]	5.331294[c]
	ΔSCD	1.070370	1.730021	6.275101[c]
	ΔTER	0.653919	2.501511	17.10494[a]
Spain	ΔCO_2	2.734451	0.667326	1.224283
	ΔGDP	2.007711	0.043905	12.19728[a]
	ΔPRM	0.534541	0.000192	419.8296[a]
	ΔSCD	1.394270	0.406008	15.40274[a]
	ΔTER	1.810508	2.095295	15.02032[a]
Tunusia	ΔCO_2	0.437761	2.126292	0.055439
	ΔGDP	1.449038	0.254765	0.641596
	ΔPRM	0.104734	1.938478	3.406205
	ΔSCD	1.016583	0.712459	2.793449
	ΔTER	2.399299	0.180590	1.481678
France	ΔCO_2	1.355809	1.687234	0.750080
	ΔGDP	0.255321	0.144650	4.308503
	ΔPRM	0.438650	0.022302	152.2440[a]
	ΔSCD	2.948378	1.283974	11.12142
	ΔTER	0.223989	0.208132	1.000854
Morocco	ΔCO_2	1.414600	0.447958	0.494308
	ΔGDP	5.779832[c]	0.008765	0.841441
	ΔPRM	1.793621	0.627830	4.980287[c]
	ΔSCD	8.128456	0.001982	226.74[a]
	ΔTER	0.632029	1.277605	11.3414[a]

[a,b,c] 1%, 5% and 10% significance levels, respectively.

The summary of the analyses in Case 1 presented in Table 5. Indicates that the short run impact of GDP on CO2 is detected in selected African countries. However, except China and Tunisia, the long-run impact of GDP on carbon emission exists. Education levels in long and short run in Turkey case are significant, except short-run high-level education. The empirical evidences support results presented by [31]. Also, Granger causality test results on economic growth and carbon emissions confirm the findings of [34] and [14]. Tunisia case depicts no impact of education level on carbon emission, whereas Morocco case shows the influence only on long-run, except in primary school education level. Spain and France illustrate the same behavior, that the long term influence of all education levels on carbon emission. Interestingly, China case indicate only high level education impact on CO_2.

Table 5. *A comparative summary of the cointegration analyses.*

				CO_2			
		Turkey	**China**	**France**	**Morocco**	**Spain**	**Tunisia**
GDP	*Short-run*	No impact	No impact	No impact	Impact	Impact	No impact
	Long-run	Impact	No impact	Impact	Impact	Impact	No impact
PRM	*Short-run*	Impact	No impact	No impact	Impact	No impact	No impact
	Long-run	Impact	No impact	Impact	Impact	Impact	No impact
SEC	*Short-run*	Impact	No impact	No impact	No impact	No impact	No impact
	Long-run	Impact	No impact	Impact	Impact	Impact	No impact
TER	*Short-run*	No impact	Impact	No impact	No impact	No impact	No impact
	Long-run	Impact	Impact	Impact	Impact	Impact	No impact

4.2. Analyses on Case 2 and Case 3

In Case 2 the dummy variable D_t, takes the value unity for the period from 1997 to 2010 to figure out the impact of the education reform on GDP and CO_2, while in Case 3 it takes the value one for the periods 1988 to 1997 to reveal the effects of structural break on the VAR model. Two cointegration vectors in the system are analyzed to determine the causal relationship whose results are presented in Table 6, and diagnostics are employed to check the validity of the model.

Table 6. *Johansen Cointegration Test Results for Cases 2 and 3*

	Null Hypot.	**Trace Stat**	**10%**	**1%**	**Eigenvalues**
Case 2	None	161.9160*	84.48*	97.60*	0.8851
	At most 1	86.1638*	60.36*	71.60*	0.7537
	At most 2	37.1398	40.16	49.70	0.4770
Case 3	None	223.7849*	84.48	97.60*	0.9537
	At most 1	116.1965*	60.36	72.68*	0.8666
	At most 2	45.68749	40.16	49.70	0.5821

* 1% significant level. Critical vales are taken from Giles and Godwin [11].

Granger causality test and the diagnostic test results are given in Table 7 and Table 8, respectively. All dummy variables, seems to be statistically insignificant, this exposes that the education reform in 1997 does not have any significant effect on GDP and CO_2. For this reason, no exogenous variables to the VAR system are introduced to the model.

For the long-term causal relation, the coefficients of the ECM are taken into account. We find at least one significant ECT in all cases, which shows that dependent and independent variables move together in long-run. Also the positive coefficients of the ECT are statistically insignificant so they do not cause any convergence problem in the long run [36].

Table 8. *Diagnostic Test Results for Case 2 and Case 3*

	Dep. Var.	**Serial Cor.**	**Heteroscedasticity**	**Normality**
Case2	ΔCO_2	0.9132	0.4236	0.3969
	ΔGDP	0.4367	1.9356	1.4432
	ΔPRM	0.5612	0.6844	0.6520
	ΔSCD	0.1182	0.0436	0.2444
	ΔTER	0.1107	1.1811	2.3987
	ΔCO_2	0.8943	1.1728	0.3087
Case 3	ΔGDP	0.1075	0.4719	1.0259
	ΔPRM	4.2198	0.8667	0.0340
	ΔSCD	1.0581	0.2881	0.4161
	ΔTER	2.6735	0.4885	1.0709

[a,b,c] 1%, 5% and 10% significance levels, respectively

Table 7. *Granger Causality Test Results for Case 2 and Case 3*

		Short-run (F-statistics)					Error Correction Term (Coefficient and t-statistics)			
Case 2	Dep. Var.	ΔCO_2	ΔGDP	ΔPRM	ΔSCD	ΔTER	ECT_1	ECT_2	ECT ΔCO_2	ECT ΔGDP
	ΔCO_2		0.8265	5.5401^{b}	15.8419^{a}	3.1610^{c}	-0.0229^{c}	-0.2131^{b}		2.2768^{b}
	ΔGDP	1.4084		8.4518^{a}	11.4213^{a}	1.4939	-0.7299^{a}	-0.0385	6.4575^{b}	
	ΔPRM	0.0513	0.0011		0.4935	2.1799	-0.2877^{b}	0.0377	3.6843^{b}	3.2931^{b}
	ΔSCD	1.3837	3.2099^{c}	0.2142		0.3104	-0.2994^{a}	-0.2431^{b}	3.2599^{b}	3.7219^{b}
	ΔTER	0.6979	0.3026	1.0972	1.8349		-0.3964^{b}	0.1933	1.6152	1.6508
Case 3	ΔCO_2		3.4083^{c}	1.7731	9.6614^{a}	0.5580	-1.0409^{b}	0.5637		2.6858^{c}
	ΔGDP	3.2071^{c}		0.2060	2.2772	1.0176	0.1756	-0.6464	1.9611	
	ΔPRM	0.2065	0.0132		0.3157	2.5569	-0.2750^{c}	0.1500	4.5756^{a}	4.3150^{b}
	ΔSCD	1.2877	2.0748	0.2648		0.4301	-0.0278	-0.1647	0.5813	0.9871
	ΔTER	0.1622	0.1962	0.1496	1.4323		-0.3289^{c}	0.1638	1.0732	1.1315

[a,b,c] 1%, 5% and 10% significance levels, respectively. Short-run block represents the F-statistics of the Wald test, Error Correction part rep significant level according to t-statistics. Long-run block represents the joint Wald test statistics of the variables with the ECT.

The coefficients of the significant ECT show the speed of adjustment to equilibrium. When the dependent variable is CO_2 we have a relatively slow adjustment rate of 20% and all independent variables cause CO_2. However, in the case of GDP adjustment is faster with 70% and the causal relation is the same as the case of CO_2, at which all independent variables affect GDP. Some important highlights of VECM are: i) The causal relation between CO_2 and GDP is bi-directional. ii) The relation between education levels and GDP is bi-directional, except the higher-level education (TER); i.e. unidirectional causality runs from TER to GDP. That is, the university level has impact on GDP. iii) The causal relation between CO_2 and education levels are bi-directional, except TER, having unidirectional move from TER to CO_2. These lead us to conclude that there is no any evidence of causal linkage between CO_2 and GDP in the short-run, which agrees with the findings in [35]. Moreover, our result also confirms the conclusion of [14] in the long-run, who proposes bi-directional causality between CO_2 and GDP. To justify the estimated model, diagnostic tests are performed. Existence of no serial correlation, no heteroscedasticity and normality are justified through Breusch-Godfrey serial correlation Lagrange multiplier, ARCH Lagrange multiplier, Jarque-Bera (JB) tests, respectively. Additionally, the stability of these models is tested by the cumulative sum control chart (CUSUM) and CUSUM-squared. Table 8 resents the results of the tests mentioned above which conclude a stable model having not enough evidence to reject the null hypotheses.

5. CONCLUDING COMMENTS

This paper investigates the dependence of GDP and education level on carbon emission under certain characteristics which are defined with respect to geographic location (Africa, Europe and Middle East), regulatory reforms, economic growth (China, Tunisia, Morocco, Turkey as emerging country; France, Spain as developed economies) and school enrollments (primary, secondary, high level education) using multivariate time series analysis. The empirical analyses show that these variables are cointegrated and, their occurrences influence each other in time. Thus, an increase in education enrollments, which can be taken as a proxy of physical human capital ([26]), cause an increase in both economic growth and carbon emissions. The outcomes of the study enlighten the linkage between CO_2 and education levels. The findings enable policy makers to find new strategies to raise consciousness in environmental pollution. It is shown that strategies should be more focused on higher education levels. Policy makers should develop strategies to increase the quality of education, instead enforcing the change in structures of compulsory education levels, i.e. regulatory changes. The analyses illustrate also that, the higher the education level becomes, the more carbon emissions is observed, especially, in China, mostly referring to the increase in the purchasing power parallel to the level of education in the last decades. The outcomes of this study are expected to guide the policy makers and investors to plan strategies in improving the energy sources by taking into account the environmental issues.

CONFLICT OF INTEREST

No conflict of interest was declared by the author.

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Table A.1. *Unit root tests to determine the stationarity and the order of integration (d)*

		ADF	Lag	DF-GLS	Lag	KPSS	PP
Turkey	CO_2	-1.6023	0	1.1832	0	0.7789[a]	-1.7058
	ΔCO_2	-6.0026[a]	0	-4.6609[a]	0	0.2001	-6.0507[a]
	GDP	-0.7242	0	0.5796	0	0.7806[a]	-0.7300
	ΔGDP	-4.4174[a]	0	-5.6309[a]	0	0.0527	-6.3033[a]
	PRM	-2.6551[c]	0	-0.6054	2	0.5826[b]	-2.4343
	ΔPRM	-4.9760[a]	0	-2.8254[a]	1	0.3619[c]	-5.0852[a]
	SCD	-1.3383	1	0.5079	2	0.7965[a]	-2.3371
	ΔSCD	-7.4354[a]	0	-3.3093[a]	1	0.2954	-7.3613[a]
	TER	0.0670	0	0.5655	1	0.7770[a]	-0.0460
	ΔTER	-4.2123[a]	0	-4.0877[a]	0	0.0592	-4.1878[a]
France	CO_2	-1.3722	0	-1.1415	0	0.6244[b]	-1.3722
	ΔCO_2	-7.5039[a]	0	-6.6143[a]	0	0.0630	-7.5516[a]
	GDP	-2.1183	1	0.4833	1	0.7755[a]	-3.0228[b]
	ΔGDP	-4.3554[a]	0	-3.7069[a]	0	0.6756[b]	-4.2422[a]
	PRM	-1.9312	1	-0.8517	1	0.6439[b]	-2.1866
	ΔPRM	-3.6106[a]	0	-3.3963[a]	0	0.3460	-3.5512[b]
	SCD	-3.4541[b]	0	-0.4798	0	0.7406	-3.2558[b]
	ΔSCD	-5.3145[a]	0	-1.5707	2	0.4018[c]	-5.3146[a]
	TER	-2.0488	0	0.2257	1	0.7423[a]	-1.7810
	ΔTER	-4.8209[a]	0	-4.6508[a]	0	0.2465	-4.9224[a]
Morocco	CO_2	-1.8354	0	0.6377	3	0.7781[a]	-2.3145
	ΔCO_2	-6.7315[a]	0	-5.3050[a]	0	0.2539	-6.7126[a]
	GDP	-0.7412	1	0.3145	3	0.7814[a]	-0.5621
	ΔGDP	-10.524[a]	0	-10.2087	0	0.1069	-10.015[a]
	PRM	-1.7776	1	-0.1998	1	0.7396[a]	-2.0402
	ΔPRM	-3.0716[a]	0	-3.0629[a]	0	0.2253	-3.0505[b]
	SCD	-3.4078[a]	0	-0.3748	2	0.7127[b]	-2.7678[c]
	ΔSCD	-2.2217	1	-2.2575[b]	1	0.3889[c]	-3.8166[a]
	TER	-4.5809[a]	2	0.0042	0	0.7054[a]	-4.3678[a]
	ΔTER	-7.0994[a]	0	-7.1257[a]	0	0.6126[b]	-7.0264[a]

Table A.1. *Unit root tests to determine the stationarity and the order of integration (d) (contd.)*

		ADF	Lag	DF-GLS	Lag	KPSS	PP
Tunisia	CO_2	-3.0583[b]	1	0.7318	0	0.7548[a]	-3.9523[a]
	ΔCO_2	-7.1078[a]	0	-2.4563[b]	1	0.5284[b]	-7.0153[a]
	GDP	-1.6040	0	0.2999	2	0.7823[a]	-1.8664
	ΔGDP	-10.119[a]	0	-1.0624	1	0.3005	-9.7925[a]
	PRM	-1.6128	1	-1.2848	1	0.3547[c]	-1.3672
	ΔPRM	-2.2416	0	-2.2461[b]	0	0.4457[c]	-2.2416
	SCD	-1.4600	1	-0.5713	1	0.7496[a]	-1.1670
	ΔSCD	-2.5332	0	-2.5169[b]	0	0.2728	-2.5106
	TER	-1.0703	1	0.2506	1	0.7732[a]	-0.9634
	ΔTER	-4.2864[a]	0	-4.2325[a]	0	0.1159	-4.3187[a]
China	CO_2	0.2233	1	0.7910	1	0.7766[a]	0.3437
	ΔCO_2	-3.7964[a]	0	-3.8438[a]	0	0.1110	-3.8333[a]
	GDP	1.1976	2	0.2428	1	0.7759[a]	2.4645
	ΔGDP	-3.0381[b]	1	-3.3347[a]	0	0.3907[c]	-4.1690[a]
	PRM	-1.9630	0	-1.4984	0	0.3167	-2.1757
	ΔPRM	-6.6005[a]	0	-6.0508[a]	0	0.3462	-6.6121[a]
	SCD	-2.0323	0	-0.2672	0	0.6728[b]	-2.0040
	ΔSCD	-4.9446[a]	0	-2.9315[a]	1	0.1483	-4.9312[a]
	TER	-0.7615	0	1.0323	0	0.7560[a]	-0.7647
	ΔTER	-6.4195[a]	0	-6.5082[a]	0	0.0991	-6.4865[a]

[a,b,c] 1%, 5% and 10% significance levels, respectively