CO_2 emissions, energy consumption and GDP: evidence from Iraq

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Abstract

The relationships between environmental quality, energy use and economic output have created growing attention over the past decades among researchers and policy makers. Focusing on the empirical aspects of the role of carbon dioxide (CO_2) emissions and energy use in affecting the economic output, this paper is an effort to fulfil the gap in a comprehensive case study at a country level using modern econometric techniques. To achieve the goal, this country-specific study examines the short- and long-run relationships among energy consumption (using disaggregated energy sources: petroleum products and the direct combustion of crude oil, and electricity), CO_2 emissions and gross domestic product (GDP) for Iraq using time series analysis from the year 1980–2010. To investigate the relationships between the variables, this paper employs the Augmented Dickey–Fuller (ADF) and the Phillips–Perron (PP) unit root tests for stationarity, the Johansen and Juselius method for cointegration and a vector error correction model (VECM) for both short- and long-run causality among the research variables for the sample. All the independent variables in this study show very strong significant effects on GDP in the country for the long term. The long-run equilibrium in the VECM suggests negative long-run causalities from consumption of petroleum products and the direct combustion of crude oil and the natural gas use to GDP. Conversely, a positive impact of electricity consumption on GDP found to be significant in the long run in Iraq during the period. Overall, this study found that the associations could to be differed by the sources of energy in the case of Iraq over the period 1980–2010.
Keywords: CO_2 emissions, energy consumption, economic growth, cointegration, error correction model, Iraq.

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1 Introduction

Energy is considered as one of the most essential products in modern times whether it does or does not add value to constructive economic capabilities. Energy dominates a principal role in the socioeconomic lifespan in Iraq as well. Iraq is one of the largest exporters of energy globally. But total energy consumption (Kt of oil equivalent) in Iraq was last measured at 40,220 in 2011, according to the World Development Index (WDI) [1]. It is an extremely low measurement compared to other regions in the same year (e.g., 4,487,970 in the upper middle income group; 833,420 in MENA (all income levels); 456,204 in MENA (developing only); 616,096 in the Arab world; 12,715,769 in the world). Based on the data from the same source, Iraq shows CO_2 emissions of 114,667 Kt in 2010. Similar to the energy consumption, it is exceptionally low measurement compared to the other groups in 2010 (e.g., 12,721,087 in the upper middle income group; 2,228,843 in MENA (all income levels); 1,277,891 in MENA (developing only); 1,601,122 in the Arab world; 33,615,389 in the world).

Concerning the circumstances of relatively low energy use and CO_2 emissions in Iraq, this study attempts to examine the influence of energy consumption and CO_2 emissions on economic output. This paper is structured by five parts: this section; Section 2, which briefly review the literature on the nexus of the economic growth, environmental pollution, and energy use; Section 3, which introduces the econometric methods employed in this study and provides a description and sources of data used for this examination; Section 4, which offers the empirical results followed by discussion for the evidence; and Section 5, which ends with the conclusion drawn from the empirical findings and suggests policy implications.

2 Literature review

In a field of energy economics, the connection between energy use and economic activities and the relationship between environmental pollution and economic activities are famous themes and empirically they have been attempted to find the direction of interconnections between them using different techniques. In spite of the relationship between energy consumption and economic growth has been extensively researched over the previous decades, there appears to be no agreement about the direction of causality between economic growth and energy consumption. For example, some authors found bi-directional causality for some countries while the others found unidirectional causality among the variables. For example, in a study of Turkey during 1970–2006 using the Johansen cointegration test and pair-wise Granger causality test, Erdal *et al.* [2] find that there is bidirectional causality running from the energy consumption to the Gross National Product (GNP) and vice versa. Also, by applying techniques of co-integration and Hsiao's Granger causality, Hou [3] found a bidirectional relationship between the economic growth and energy consumption in China from 1953 to 2006. In Karanfil [4]'s study, empirical results for the case of

Turkey over the period 1970–2005 suggest that there is a unidirectional causality runs from official GDP to energy in both short and long runs. Panel studies also show conflicting results. For instance, Huang *et al*. [5] studied 82 countries from 1972 to 2002 using the GMM-SYS and the panel vector autoregressive (VAR) approaches. They discovered: (i) in the lower and upper middle-income groups, economic growth enhances energy consumption; (ii) in the high-income group countries, economic growth harms energy consumption; (iii) in the low-income group, there exists no significant causal relationship between energy consumption and economic growth. Similarly, Rafiq [6] in a panel cointegration and causality study for a group of six emerging economies of Asia found the empirical results based on cointegration and vector error correction modeling show that there exists unidirectional causality from output to energy consumption for Iraq in the short run, unidirectional causality running from energy consumption to GDP for China both in the short- and long- run, whereas bi-directional short-run causality for Thailand. Bowden and Payne [7] conducted a study for the US from 1949 to 2006 using the Toda and Yamamoto [8] technique with disaggregated analysis. Their evidences show that the relationship between energy consumption and real GDP is not uniform across sectors. Bidirectional Granger-causality is present between commercial and residential primary energy consumption and real GDP, respectively while total and transportation primary energy consumption has no significant effect on real GDP. On the other hand, only few studies (Holtz-Eakin and Selden [9], Jalil and Mahmud [10], Farhani *et al*. [11], Jaunky [12]) were conducted on the nexus of CO_2 emissions and economic growth and it is comparatively rare to the nexus between energy consumption and economic growth.

The mainstream literatures approve or disapprove the existence of a relationship between the two factors each: CO_2 emissions and economic growth or energy consumption and economic growth. Further expansion of these studies, there are some studies investigated the nexus among the energy consumption, CO_2 emissions, and economic growth (Ang [13, 14], Apergis and Payne [15], Zhang and Cheng [16], Soytas and Sari [17], Chang [18], Lean and Smyth [19], Wang *et al*. [20], Hossain [21], Fei *et al*. [22], Pao and Tsai [23], Arouri *et al*. [24]). Among the papers investigating the relationships between the three variables some studies predominantly focused on the Middle East and North Africa (MENA) region particularly (Halicioglu [25], Lee [26–29]). Using modern econometric techniques, this paper attempts to link the gap with an effort on identifying country-specific characters in the case of Iraq between 1980 and 2010.

3 Data

Following the literature reviews, this paper empirically investigates the effect of energy consumption and environmental pollution on economic output as follows:

$$GDP_t = f\,(Environmental\ pollution_t,\ Energy\ use_t)$$

The data set that was used for this empirical analysis was collected to examine the relationship between environmental quality, energy use, and economic output at the macroeconomic level. The data scope deliberated for the paper is from 1980 to 2010 by annual base. As a proxy for energy consumption, total three disaggregated energy sources are applied. Data on the consumption of petroleum products and the direct combustion of crude oil are quantified at the rate of a thousand barrels per day. Natural gas is quantified in a billion cubic feet, while electricity is measured in terms of a billion kilowatt hours. An index of gross domestic product (GDP) is measured in constant 2005 US dollars, i.e., the economic output, was used as a proxy for economic output. For a proxy for environmental quality, CO_2 emissions (measured in Kt) are used.

Data on the energy consumption are obtained from the Energy Information Administration (EIA, 2015). The GDP data are collected from the WDI database (World Bank, 2015). Data on CO_2 emissions is also taken from the WDI database. The data used in this paper are annual series between the years 1980 and 2010 and are transformed into natural logarithms. The abbreviations for all the variables are listed in Table 1. Descriptive statistics for Iraq are presented in Table 2.

Table 1: List of variables.

Variables	Depictions	Observations range
lnGDP	Gross domestic product (Constant 2005 US$)	2010–2012
lnCO_2	Carbon dioxide (CO_2) emissions (Kt)	2010–2012
lnCCOIL	The consumption of petroleum products and the direct combustion of crude oil (Thousand Barrels Per Day)	2010–2012
lnCNG	The consumption of natural gas (Billion Cubic Feet)	2010–2012
lnCELEC	The consumption of electricity (Billion kWh)	2010–2012

Table 2: Descriptive statistics.

	lnGDP	lnCO_2	lnCCOIL	lnCNG	lnCELEC
Mean	24.146	11.100	5.962	4.075	3.082
Median	23.942	11.149	6.103	4.152	3.203
Maximum	24.919	11.651	6.518	4.740	3.526
Minimum	23.232	10.330	5.323	2.890	2.284
Std. Dev.	0.471	0.366	0.345	0.591	0.306
Skewness	0.146	-0.357	-0.426	-0.615	-1.189
Kurtosis	1.723	2.357	1.956	2.092	3.863
Observations	31	31	31	31	31

4 Methods

As mentioned above, purpose of this study is to investigate both the short- and long-run associations among macro-economic variables (i.e., the GDP, CO_2 emissions, and energy use). To estimate the objectives, cointegration and VECM methods are applied for this paper. This study begins with the stationarity test of the variables. It is critical to examine the order of integration of the macroeconomic variables (i.e. GDP, CO_2 emissions, and energy use) since most of which are not stationary (Nelson and Plosser [31]). To know the order of integration among variables, the existence of unit roots is examined by conducting the two most popular unit root tests: the Augmented Dickey and Fuller [32] (ADF) test and the Phillips and Perron [33] (PP) test.

To ensure a endorsed VEC model, there should exist one cointegrating vector at least that changes to stationarity (Greene [34]). For cointegration among variables, the Johansen trace test of the Johansen [35] and Johansen and Juselius [36] maximum likelihood procedure was practiced to the model consisting of the five $I(1)$ variables of this study. If the variables integrated with the same order (e.g., I(0) or I(1)), specification of Johansen–Juselius method, which is grounded on the vector autoregression (VAR) model, can be written in the following equation:

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \dots + \beta_p \Delta y_{t-p} + v_t \quad (1)$$

where y_t is (n x i) vector $(y_{1t}, y_{2t}, \dots, y_{nt})'$, δ is (n x i) vector of intercept terms, β_i is coefficients matrix of the lag term of y_t, v_t is an independently and identically distributed (n x i) vector with zero mean and variance matrix.

Accordingly, the null hypothesis that there are *r*, the cointegrating rank, or fewer cointegrating vectors is tested using the trace test statistic. It can be formulated as:

$$Trace \quad Test = -T \sum_{i=r+1}^{M} \ln[1-(r_i^*)^2] \quad (2)$$

Once the test of cointegration proposes that there exists a cointegrating vector, at least, the specification of the VEC models, suggested by Engle and Granger [37] to correct disequilibrium and assess the direction of causations between the variables in the short and long terms, can be expressed as follows:

$$\Delta Y_t = c + \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + u_t \quad (3)$$

where c is a $k \times 1$ vector of constants, Π is $k \times k$ matrix expresses the long-run coefficients, Γ_i is $k \times k$ matrix that articulates the coefficients of the short-run dynamics, μ_t represents a $k \times 1$ vector of residuals, ΔY is a $k \times 1$ vector of variables in their first difference, which are stationary, I(I). Thus, for the error term μ_t to be stationary, Π should be stationary. In fact, in such case, there are three different possibilities. If Π has a reduced rank, that is $(0 < r < 1)$ then there are cointegrating vectors among the variables that are stationary and it supposed that there are r cointegrating relationships. In that case, Π can be written as follows:

$$\underset{(kxk)}{\Pi} = \underset{(kxr)}{\alpha} \underset{(rxk)}{\beta} \quad (4)$$

where the expression ΠY_{t-1} is the error correction term (ECT) and Π can be separated into two matrices α and β, such as $\Pi = \alpha\beta$, where α denotes the vector of error-correction coefficients measuring the speed of convergence to the long-run steady state and β refers the vector of cointegrating parameters.

In keeping with that technique, the associations among the research variables of this study have been established in the ECM procedure are modeled with the next equation:

$$\Delta \ln GDP = \beta_{10} + \sum_{i=1}^{p} \beta_{11i} \Delta \ln GDP_{t-i} + \sum_{j=1}^{q} \beta_{12j} \Delta \ln CO2_{t-j} + \sum_{k=1}^{r} \beta_{13k} \Delta \ln CCOIL_{t-k} + \sum_{m=1}^{t} \beta_{14m} \Delta \ln CNG_{t-m} + \sum_{n=1}^{u} \beta_{15n} \Delta \ln CELEC_{t-n} + \beta_{16} \varepsilon_{t-1} + \mu_{1t} \quad (5)$$

$$\Delta \ln CO2 = \beta_{20} + \sum_{i=1}^{p} \beta_{11i} \Delta \ln CO2_{t-i} + \sum_{j=1}^{q} \beta_{22j} \Delta \ln GDP_{t-j} + \sum_{k=1}^{r} \beta_{23k} \Delta \ln CCOIL_{t-k} + \sum_{m=1}^{t} \beta_{24m} \Delta \ln CNG_{t-m} + \sum_{n=1}^{u} \beta_{25n} \Delta \ln CELEC_{t-n} + \beta_{26} \varepsilon_{t-1} + \mu_{2t} \quad (6)$$

$$\Delta \ln CCOIL = \beta_{30} + \sum_{i=1}^{p} \beta_{31i} \Delta \ln CCOIL_{t-i} + \sum_{j=1}^{q} \beta_{32j} \Delta \ln GDP_{t-j} + \sum_{k=1}^{r} \beta_{33k} \Delta \ln CO2_{t-k} + \sum_{m=1}^{t} \beta_{34m} \Delta \ln CNG_{t-m} + \sum_{n=1}^{u} \beta_{35n} \Delta \ln CELEC_{t-n} + \beta_{36} \varepsilon_{t-1} + \mu_{3t} \quad (7)$$

$$\Delta \ln CNG = \beta_{40} + \sum_{i=1}^{p} \beta_{41i} \Delta \ln CNG_{t-i} + \sum_{j=1}^{q} \beta_{42j} \Delta \ln GDP_{t-j} + \sum_{k=1}^{r} \beta_{43k} \Delta \ln CO2_{t-k} + \sum_{l=1}^{s} \beta_{44l} \Delta \ln CCOIL_{t-l} + \sum_{n=1}^{u} \beta_{45n} \Delta \ln CELEC_{t-n} + \beta_{46} \varepsilon_{t-1} + \mu_{4t} \quad (8)$$

$$\Delta \ln CELEC = \beta_{50} + \sum_{i=1}^{p} \beta_{51i} \Delta \ln CELEC_{t-i} + \sum_{j=1}^{q} \beta_{52j} \Delta \ln GDP_{t-j} + \sum_{k=1}^{r} \beta_{53k} \Delta \ln CO2_{t-k} + \sum_{l=1}^{s} \beta_{54l} \Delta \ln CCOIL_{t-l} + \sum_{n=1}^{u} \beta_{55n} \Delta \ln CNG_{t-n} + \beta_{56} \varepsilon_{t-1} + \mu_{5t} \quad (9)$$

where β is the parameter to be estimated; u_t is the serially uncorrelated error term; p, q, r, s, t, and u are the number of lags; ε_{t-1} is the vector error correction term (ECT), which is derived from the long-run cointegration relationship; $_t$ is the period; Δ is the first difference; *ln* represents the logarithm operator, respectively.

From the equations above, the long-run equilibrium equation among the variables can be expressed individually as the next model:

$$\varepsilon_{t-1} = \sum_{i=1}^{n} \beta_0 \ln GDP_{t-1} + \sum_{i=1}^{n} \beta_1 \ln CO2_{t-1} + \sum_{i=1}^{n} \beta_2 \ln CCOIL_{t-1} + \sum_{i=1}^{n} \beta_3 \ln CNG_{t-1} + \sum_{i=1}^{n} \beta_4 \ln CELEC_{t-1} + c$$

$$\sum_{i=1}^{n} \beta_0 \ln GDP_{t-1} = -\sum_{i=1}^{n} \beta_1 \ln CO2_{t-1} - \sum_{i=1}^{n} \beta_2 \ln CCOIL_{t-1} - \sum_{i=1}^{n} \beta_3 \ln CNG_{t-1} - \sum_{i=1}^{n} \beta_4 \ln CELEC_{t-1} - c + \varepsilon_{t-1} \quad (10)$$

5 Results

5.1 ADF test of unit root

ADF and PP unit root test was applied for all economic, environmental and energy use variables. The automatic selections of lag length are based on Schwarz Information Criterion (SIC). The results of the two unit root tests indicate that all level variable but lnCO_2 and lnCCOIL fail to reject the null hypothesis of a unit root at the 5 and 10 percent levels. However, after converting them to the first difference, all variables reject the null hypothesis. Therefore, all variables in this study do not have unit roots (i.e., stationarity) at the significance level of 1 percent and are cointegrated at order one. The results of ADF and PP tests are summarized in Table 3.

Table 3: Results of the ADF and PP unit root tests.

	ADF test statistics with intercept		With intercept and trend		PP test statistics with Intercept		With intercept and trend	
	t-statistic	p-values	t-statistic	p-values	Adj. t-statistic	p-values	Adj. t-statistic	p-values
lnGDP	-1.135	0.688	-3.286	0.188	-0.849	0.790	-3.214	0.101
lnCO_2	-1.145	0.684	-4.184	0.013**	-0.552	0.867	-3.378	0.074*
lnCCOIL	-1.000	0.740	-3.382	0.073*	-0.564	0.864	-3.372	0.074*
lnCNG	-1.625	0.458	-1.697	0.728	-1.589	0.476	-1.861	0.650
lnCELEC	-2.364	0.160	-2.645	0.265	-2.583	0.108	-2.526	0.314
ΔlnGDP	-7.625	0.000***	-7.602	0.000***	-8.133	0.000***	-8.842	0.000***
ΔlnCO_2	-4.402	0.002***	-4.416	0.008***	-10.449	0.000***	-10.548	0.000***
ΔlnCCOIL	-7.110	0.000***	-6.994	0.000***	-14.688	0.000***	-16.672	0.000***
ΔlnCNG	-7.056	0.000***	-7.226	0.000***	-6.943	0.000***	-8.818	0.000***
ΔlnCELEC	-5.983	0.000***	-6.056	0.000***	-5.983	0.000***	-6.059	0.000***

Null hypothesis: unit root (individual unit root process).
Notes: (1) P-values are reported in parentheses; (2) *, **, and *** denote rejections of the hypothesis at 1%, 5%, and 10% critical value respectively; (3) exogenous variables: individual effects; (4) critical values are from MacKinnon *et al*. [38].

5.2 Johansen's cointegration test

The following step would be to estimate the coefficients of the long-run associations using the J-J procedure as mentioned in the method section. To determine the number of cointegrating vectors, the trace method is utilized. Number of lags was nominated grounded on SIC criteria that for all equations uncovered to be one. Table 4 shows the results of the Johansen's trace test.

Table 4: Results of the J-J cointegration test (unrestricted cointegration rank test: trace).

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical value	Prob.
None *	0.734	81.053	69.819	0.005***
At most 1	0.619	42.650	47.856	0.141
At most 2	0.275	14.642	29.797	0.803
At most 3	0.167	5.316	15.495	0.774
At most 4	0.001	0.018	3.841	0.893

Null hypothesis: the variables are not cointegrated.
Notes: (1) Sample (adjusted): 1982 2010; (2) Intercept without trend; (3) * denotes rejection of the hypothesis at 5% level; (4) The p-values (prob.) are drawn from MacKinnon *et al*. [38].

The results of trace statistics are reported in Table 4 advocates that there is one cointegrating relationship among the variables at the 0.05 levels. These findings indicate that a vector exclusively describes the cointegration space and there exists a cointegrating relationship among the GDP, energy use, and the CO_2 emissions (as a proxy of environmental pollution). Accordingly, this study can estimate the vector error correction procedures.

5.3 Vector error correction model

The results reported in Table 5 exhibit that the corrections are around 4 percent for Eq. (5), 2 percent for Eq. (6), 0.3 percent for Eq. (7), 10 percent for Eq. (8), and 7 percent for (6) for cointegration Eq. (9). No coefficients of ECTs in all cointegration equations but Eq. (8) show significant at the 0.1 levels. Not only the coefficient of ECT in Eq. (8) is statistically significant, but also it has a negative sign implying that the series have significant relationship in the long run. The optimal lags on variables are identified by SIC and found to be one. The estimations of the vector error correction model and results for the Wald statistics is presented in Table 5 and Table 6.

Table 5: Estimations of the vector error correction model (cointegrating equations).

	GDP	CO_2	CCOIL	CNG	CELEC
	1.000	-2.194	3.848**	1.288***	-7.055***
		[-1.615]	[2.764]	[3.300]	[-5.688]
Error correction	-0.040	0.026	0.003	-0.100*	0.079

Null: There is no relationship between variables.
Notes: (1) Sample (adjusted): 1982 2010; (2) Included observations: 28 after adjustments; (3) *, **, and *** denote rejections of the null hypothesis at 1%, 5%, and 10% levels according to the p-values obtained from t-statistics in the square brackets.

Table 6: Results of Wald test statistics.

	GDP	CO_2	CCOIL	CNG	CELEC
GDP	-----	-0.219	-0.203	-0.377	-0.214
CO_2	0.389	-----	0.118	-0.380	0.585***
CCOIL	-0.317	-0.028	-----	0.293	-0.159
CNG	-0.112	0.033	0.070	-----	-0.079
CELEC	0.082	0.007	0.291**	-0.342	-----

Null: There is no relationship between variables.
Notes: (1) Sample (adjusted): 1982 2010; (2) Included observations: 28 after adjustments; (3) *, **, and *** denote rejections of the null hypothesis at 1%, 5%, and 10% levels; (4) Wald statistics follow an asymptotic Chi-square distribution with p degrees of freedom. Significance indicates that the column variable Granger causes the row variable.

First, the CO_2 emissions seems not to be a key element of Iraq's GDP. The coefficients of CO_2 emissions are neither significantly positive nor negative in the short- and long-run relationship informed in the table. However, long-run unidirectional relationships between the consumptions of diverse energy sources and GDP were discovered. The consumption of petroleum products and the direct combustion of crude oil and natural gas variables show significantly negative relationships with GDP. That is to say, in the long term, the contribution of more oil and natural gas use to economic growth is negative and statistically significant. This result is somewhat surprising as the research hypothesis expects that the consumption of natural gas have a positive relationship. A unidirectional relationship runs from consumption of electricity to the growth of economy as well. The coefficient of the consumption of electricity is statistically significant and its sign is positive in the long term.

5.4 Diagnostic tests for VEC residuals

Portmanteau test, white heteroskedasticity (no cross terms) test, and CUSUM test are considered respectively for testing serial correlation, heteroskedasticity and stability. As reported in Tables 8, 9, and 10, it is revealed that the residuals from the estimated VEC model have rational properties: there exists neither autocorrelation nor heteroskedasticity matters.

Table 7: Results of the Portmanteau autocorrelations tests.

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	10.646	NA*	11.027	NA*	NA*
2	29.022	0.969	30.763	0.948	45
3	55.437	0.898	60.226	0.791	70
4	79.294	0.877	87.900	0.684	95
5	99.276	0.916	112.046	0.685	120
6	122.635	0.911	141.497	0.567	145
7	139.000	0.961	163.070	0.635	170
8	150.080	0.993	178.370	0.798	195
9	170.974	0.994	208.667	0.698	220
10	182.934	0.999	226.922	0.790	245

Note: df is degrees of freedom for (approximate) chi-square distribution.

Table 8: Results of the white heteroskedasticity tests.

Dependent	F(12,16)	Prob.	Chi-sq(12)	Prob.	Dependent	F(12,16)	Prob.	Chi-sq(12)	Prob.
res1*res1	1.149	0.390	13.422	0.339	res4*res1	0.149	0.999	2.916	0.996
res2*res2	0.742	0.695	10.372	0.583	res4*res2	1.068	0.442	12.898	0.377
res3*res3	2.627	0.037	19.236	0.083	res4*res3	0.170	0.998	3.286	0.993
res4*res4	0.374	0.955	6.352	0.897	res5*res1	0.275	0.986	4.955	0.960
res5*res5	3.441	0.012	20.902	0.052	res5*res2	0.658	0.766	9.582	0.653
res2*res1	1.742	0.149	16.427	0.173	res5*res3	0.399	0.943	6.681	0.878
res3*res1	1.791	0.137	16.624	0.164	res5*res4	0.990	0.497	12.358	0.417
res3*res2	1.196	0.362	13.710	0.320					

6 Conclusion

This study has examined the factors (i.e., consumption of different kinds of energy and CO_2 emissions) of economic growth (i.e., GDP) of the case of Iraq over the period 1980–2010. This paper investigates the factors of Iraq's economic growth (i.e. GDP) by operating VECM and cointegration techniques. It has been confirmed from the diagnostic tests for VEC residuals that the estimated models have neither heteroskedasticity nor autocorrelation. Consequently this study can draw inferences from the results based on the consistent models.

It is discovered that CO_2 emissions is not a leading component in Iraq's economic growth. However it is revealed that the consumption of electricity is a key contributor to the growth of Iraq's economy. Increasing electricity use in Iraq would further boost Iraq's economic growth. The test outcomes propose that the influence of oil and natural gas use on economic growth is unexpectedly negative with a statistical significance. According to the outcomes of this paper, Iraq's constant ingestion of petroleum products and the direct combustion of crude oil and natural gas might result in unceasing declines in the growth of Iraq's economy in the coming decades. This has associations for the international energy trading together with the Iraq's economy.

The results have some critical suggestions for policymakers and researchers. In the short-run, policies on energy consumption have no adverse or beneficial effects on economic growth. Replacing other kinds of energy sources (e.g., oil or natural gas) to electricity is preferred to achieve a sustainable economic growth since electricity consumption would increase economic growth of Iraq according to this study. Furthermore, the evidence denotes that energy saving policies are partly appreciated in the country. Thus, it is necessary to invest in R&D for innovative energy-efficient technologies, particularly in natural gas and oil for a long-run sustainable economic development.

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