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Testing the Environmental Kuznets Curve Hypothesis: Evidence from Egypt, Kenya and Turkey

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ABSTRACT

In this study, the Environmental Kuznets Curve (EKC) hypothesis is examined for 3 developing countries which are Egypt, Kenya and Turkey for the period between 1971 and 2014. The EKC hypothesis is examined under two nexus which are GDP, CO_2 and energy consumption, and GDP, CO_2, energy consumption and the square of GDP. The EKC hypothesis is not confirmed for Egypt, Kenya and Turkey, and the growth hypothesis is confirmed for Egypt and Kenya. The neutrality hypothesis is confirmed for Turkey. Unidirectional causality running from CO_2 to energy consumption is found for Turkey and no causal relationship is found between CO_2 and GDP for Egypt, Kenya and Turkey. Authorities in Turkey, Egypt and Kenya should continue to invest in emission reduction policies since these policies are likely not to have a detrimental effect on economic growth. These countries are likely to achieve further economic growth without causing environmental degradation since no causal relationship is found between CO_2 and GDP. Limits of our study are that results are obtained for 3 developing countries and the period between 1971 and 2014 are examined for these countries.

Keywords: Environmental Kuznets Curve Hypothesis, International Economics, GDP, Energy Consumption
JEL Classifications: Q50, F10, Q4

1. INTRODUCTION

Kuznets (1955) studied the relationship between economic growth and income inequality, and found an inverse U relationship between them. In the 1990s, the Kuznets curve was examined as the Environmental Kuznets Curve (EKC) which stated an inverse U relationship between emissions and income. Studies by Grossman and Krueger (1991), Shafik and Bandyopadhyay (1992), and Panayotou (1993) are among the important studies in the 1990s for EKC literature.

Many studies have examined the dynamic relationships between energy and income, income and emissions, and energy, income and emissions by taking the EKC as base in the academic literature. Researchers implemented many kinds of econometrical methods such as multivariate regressions, the Johansen cointegration test, ADF unit root test, vector autoregressive model (VAR), impulse response analysis, variance decomposition analysis, the Granger causality test and panel data analysis in the methodology part of their articles to examine these dynamic relationships. Researchers obtain different results for the validity of EKC relationships depending on different samples, methodologies and time periods.

For emissions, income and energy variables, there are four research focuses in the literature (Table 1).

After the introduction section, the literature review is discussed in Section 2. Section 3 and section 4 present the data and methodology of this study respectively. The empirical results and conclusion take place in Section 5 and Section 6 respectively in this study.

The main purpose of this study is to reveal the stable long-run relationships and causal relationships between emissions, income and energy consumption, test the EKC curve for developing

Table 1: Research focuses for emissions, income and energy variables

Research focus	Studies in research focus
Income-emissions nexus	There are studies that test EKC relationships alone and there are other studies that investigate for causality, long-run and short-run relationships between income and emissions by adding explanatory variables
Income-energy nexus	Studies in this context investigate to verify the neutrality hypothesis, conservation hypothesis, growth hypothesis and feedback hypothesis. The neutrality hypothesis states that there is no causality between energy consumption and income. The conservation hypothesis states that there is unidirectional causality running from income to energy consumption. The growth hypothesis states that there is unidirectional causality running from energy consumption to income. The feedback hypothesis states that there is bidirectional causality between income and energy consumption
Emissions-energy nexus	Studies in this context investigate causal, long-run and short-run relationships between emissions and energy
Emissions-energy-income nexus	Studies in this context examine causal, long-run and short-run relationships between emissions, energy and income

Source: Authors' work

countries and expand literature for individual country studies of developing countries. Long-run relationships between variables are examined through Johansen (1991) co-integration test and causal relationships are revealed through VAR granger causality test.

2. LITERATURE REVIEW

Impulse response and variance decomposition tests are implemented to determine the impact of independent variables on dependent variable for developing countries.

Income-emissions nexus and income-emissions-energy nexus are examined by single-country, multi-country and panel studies in the literature. Single-country, multi-country and panel studies test the neutrality hypothesis, conservation hypothesis, growth hypothesis and feedback hypothesis besides the EKC hypothesis.

For panel studies, Gao and Zhang (2014) verified EKC relationship for 14 sub-Saharan African countries. Kasman and Duman (2015) verified EKC relationships for 15 countries which were Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Iceland, Latvia, Lithuania, FYR of Macedonia, Malta, Poland, Romania, Slovak Republic, Slovenia, and Turkey. Pao and Tsai (2011) verified EKC relationships for panel countries of Brazil, Russia, India and China.

Osabuohien et al. (2014), Kim (2019) and Apergis and Payne (2009) verified EKC relationships for 50 African countries, newly industrialized Asian countries and six Central American countries respectively. Anastacio (2017) verified EKC relationships for panel study of Canada, United States and Mexico.

Alom (2014) confirmed the growth hypothesis for Bangladesh, India, Pakistan, Sri Lanka and Nepal in the short run. Magazzino (2014) tested and verified the growth hypothesis for six ASEAN countries. Chen et al. (2016), Wang et al. (2011) and Apergis and Payne (2009) verified the feedback hypothesis for developing countries out of 188 countries, China, and six Central American countries respectively in the short run. Dritsaki and Dritsaki (2014) verified the feedback hypothesis for Greece, Spain and Portugal in the short run and in the long run. Wang et al. (2016) and Wang et al. (2016) confirmed the feedback hypothesis for China. Gao and Zhang (2014) and Kais and Mbarek (2017) verified the feedback hypothesis for 14 sub-Sahara African countries and three North African countries respectively in the long run.

Mallick and Tandi (2015) tested EKC relationships for Bangladesh, India, Nepal, Pakistan, and Sri Lanka. An EKC relationship was not verified for the panel countries in the long run, but EKC relationships were verified for Bangladesh and Sri Lanka in individual analysis. Zoundi (2017), Wang (2012) and Saleh and Abedi (2014) tested for and found no evidence for EKC relationships for 25 countries, 98 countries and Iran respectively.

For single-country studies, Ghosh et al. (2014) and Amin et al. (2012) tested for EKC relationships and found no evidence for an EKC relationship in Bangladesh.

Balibey (2015) and Ozturk and Oz (2016) examined EKC relationships in Turkey. Balibey (2015) verified a quadratic relationship between CO_2 and GDP. Ozturk and Oz (2016) verified an EKC relationship in Turkey both in the long-run and short-run. Friedl and Getzner (2002) tested for an EKC relationship in Austria and found no evidence for it. Saboori and Soleymani (2011), Boopen and Vinesh (2011) and Alkhathlan et al. (2012) tested for EKC relationships and found no evidence in Iran, Mauritus and Saudi Arabia respectively.

Amri (2017), Latifa et al. (2014) examined EKC relationships in Algeria. Amri (2017) verified an EKC relationship in Algeria but the GDP turning point was not within the sample's period. Latifa et al. (2014) verified EKC relationships both in the long run and short run. Ahmed and Long (2013), Munir and Khan (2014) and Shahbaz et al. (2012) examined EKC relationships in Pakistan. While Munir and Khan (2014) and Shahbaz et al. (2012) verified an EKC relationship in Pakistan, Ahmed and Long (2013) did not verify an EKC relationship in the short run in Pakistan. Ahmed and Long (2013) verified an EKC relationship in the long run between CO_2 and GDP, energy consumption, trade openness and population density in Pakistan.

Tang and Tan (2016) and Yazdi and Mastorakis (2016) verified EKC relationships in Cambodia and Iran respectively.

Jalil and Mahmud (2009) and Saboori et al. (2016) verified EKC relationships in China and Malaysia respectively. Can and Gozgor

(2016), Saboori et al. (2012), Ahmed (2014) and Shahbaz et al. (2015) verified EKC relationships both in the long run and short run in France, Malaysia, Mongolia and Portugal respectively.

Liu et al. (2016) and Wang et al. (2011) tested for EKC relationships in China. While Wang et al. (2011) found no evidence for an EKC relationship, Liu et al. (2016) found an inverted N-shaped relationship between CO_2 and GDP. Saboori et al. (2012) tested for an EKC relationship and found no evidence for it in Indonesia. They also found that GDP impacted negatively in the short-run and positively in the long-run. Alege and Ogundipe (2015) examined an EKC relationship in Nigeria and found a positive linear relationship between CO_2 and GDP.

Dogan and Turkekul (2016) examined an EKC relationship and found no evidence for it in the USA. Farhani and Ozturk (2015), Fodha and Zaghdoud (2010) and Mrabet et al. (2014) examined EKC relationships in Tunisia. While Farhani and Ozturk (2015) and Mrabet et al. (2014) found positive monotonic relationship between CO_2 and GDP, Fodha and Zaghdoud (2010) found positive monotonic relationship between CO_2 and GDP and an inverted U relationship between SO2 emissions and GDP.

Bozkurt and Akan (2014) studied the relationships between CO_2, GDP and energy consumption (EN) in Turkey for the period between 1960 and 2010 with Johansen-Juselius cointegration test, the vector error correction model and impulse response analysis. Bozkurt and Akan (2014) found that variables were cointegrated, CO_2 had a negative impact on GDP and energy consumption had a positive impact on GDP. Yavuz (2014) investigated the long-run relationship between CO_2, GDP and energy consumption in Turkey for the period between 1960 and 2007 with Johansen cointegration test and the Gregory and Hansen cointegration test. Yavuz (2014) found that CO_2, energy consumption and GDP were cointegrated. Ang (2007) and Nain et al. (2017) confirmed the growth hypothesis in the short run in France and for aggregated level sector, industrial sector, domestic sector and commercial sectors in India in the short run respectively. Nain et al. (2017) confirmed the growth hypothesis in India in the long run for the domestic sector and the commercial sector.

Kuo et al. (2014) verified the feedback hypothesis in Hong Kong. For multi-country studies, Magazzino (2016) examined the relationships between CO_2, GDP and energy consumption in Armenia, Azerbaijan, Georgia and Turkey for the period between 1992 and 2013 with the ARDL bounds test, the Gregory and Hansen cointegration test with breaks, the Toda and Yamamoto granger non-causality test and the standard granger test methodologies. Magazzino (2016) verified the conservation hypothesis for Armenia and verified the feedback hypothesis and the growth hypothesis for Azerbaijan and Georgia, respectively, and the neutrality hypothesis for Turkey.

Magazzino (2016) examined the relationships between CO_2, GDP and energy consumption in six gulf cooperation council countries for the period between 1960 and 2013 with the Johansen cointegration test, the Gregory and Hansen cointegration test and the Toda and Yamamoto granger non-causality test. Magazzino (2016) confirmed the long-run relationship between the variables only for Oman and the growth hypothesis for Kuwait, Oman and Qatar.

Magazzino (2017) verified the conservation hypothesis for Bahrain, the feedback hypothesis for Saudi Arabia and the neutrality hypothesis for the United Arab Emirates.

Shahbaz et al. (2016b) investigated the direction of causality between CO_2, GDP and energy consumption in Next 11 countries for the period between 1972 and 2013 with time-varying granger causality methodology. Shahbaz et al. (2016b) found unidirectional causality running from GDP to energy consumption for Bangladesh and Vietnam, unidirectional causality running from to GDP for Egypt and Pakistan, unidirectional causality running from energy consumption to GDP for South Korea and the Philippines, unidirectional causality running from GDP to CO_2 for Indonesia and unidirectional causality running from GDP to energy consumption and CO_2 for Turkey.

3. DATA AND METHODOLOGY

The data is obtained from World Bank's official web site for CO_2 emissions (metric tons per capita), energy consumption (kg of oil equivalent per capita) and GDP per capita (constant 2010 US$). The period for the data in this study is determined according to the availability of data sets in data sources. The Period for data in this study is from 1971 to 2014 for Egypt, Kenya and Turkey (Table 2).

Augmented Dickey and Fuller (1981) unit root test is applied to find stationary levels of each variable. Johansen (1991) cointegration test is applied to examine the cointegration relationship between variables since variables are at stationary levels with I(1).

The VAR model is applied for variables which are integrated at I(1) with no cointegration. The AR root graph, the VAR Residual Serial Correlation LM test and the VAR Residual Heteroskedasticity test are applied to determine the stability of the VAR model.

Impulse response analysis and variance decomposition analysis are applied to find how each variable impacts and influences the other variables. The VAR Granger causality/block exogeneity wald test is used to find the causal relationships between variables which are integrated at I(1) with no co-integration.

Two models in this study are used to examine EKC relationships for Egypt, Kenya and Turkey. Causal relationships are examined between CO_2, GDP and energy consumption. EKC relationships

Table 2: Data

Data	Source	Code
CO_2 emissions (metric tons per capita)	World Bank	CO_2
Energy consumption (kg of oil equivalent per capita)	World Bank	EN
GDP per capita (constant 2010 US$)	World Bank	GDP

Source: Authors' calculations

are examined between CO_2, GDP and energy consumption, and CO_2, GDP, the square of GDP and energy consumption.

$$\text{In}(CO_2)_t = \beta_0 + \beta_2 (GDP)_t + \beta_2 \text{In}(EN) + e_t \tag{1}$$

$\beta_0, \beta_1, \beta_2$, are estimated parameters. t is time index. e is error term. CO_2 is carbon dioxide emissions per capita. GDP is gross domestic product per capita. EN is energy consumption per capita.

$$\text{In}(CO_2)_t = \beta_0 + \beta_1 \text{In}(GDP)_t + \beta_2 \text{In}(GDP)_t^2 + \beta_3 \text{In}(EN) + e_t \tag{2}$$

$\beta_0, \beta_1, \beta_2$, and β_3, are estimated parameters. t is time index. e is error term. CO_2 is carbon dioxide emissions per capita. GDP is gross domestic product per capita. EN is energy consumption per capita.

3.1. CO_2, GDP and EN NEXUS (Egypt)

For Egypt, LNCO$_2$, LNEN and LNGDP are at I(1), I(1) and I(1) levels (Table 3). Since variables are stationary at I(1), the Johansen co-integration test is applied. According to the Johansen co-integration test results, no co-integration is found between CO_2, GDP and energy consumption (Table 4). There is no long-run relationship between CO_2, GDP and energy consumption. The VAR model is established, and the VAR granger causality/block exogeneity wald tests are applied for causality between CO_2, GDP and energy consumption. The VAR Residual Serial Correlation LM test and the VAR Residual Heteroskedasticity test results show the model is stable (Tables 5 and 6).

Table 3: ADF unit root tests for Egypt, Kenya and Turkey

Variable	At level	At first difference
	Intercept	Intercept
LNCO_2 Egypt	−2.017766 (0)	−7.416083 (0)*
LNEN Egypt	−2.486051 (0)	−5.587300 (0)*
LNGDP Egypt	−2.553432 (4)	−3.624684 (0)*
LNGDP2 Egypt	−2.246949 (4)	−3.695775 (0)*
LNCO_2 Kenya	−2.190654 (0)	−6.641608 (0)*
LNEN Kenya	0.258768 (0)	−3.588524 (0)**
LNGDP Kenya	−0.056672 (1)	−5.677609 (0)*
LNGDP2 Kenya	−0.029963 (1)	−5.584770 (0)*
LNCO_2 Turkey	−1.370848 (0)	−6.416403 (0)*
LNEN Turkey	−1.241822 (0)	−6.482424 (0)*
LNGDP Turkey	0.497154 (0)	−6.217744 (0)*
LNGDP2 Turkey	0.663548 (0)	−6.166588 (0)*

* and ** show the statistical significance at 1% and 5% levels, respectively. The lag length is shown by the values in parentheses. Source: Authors' calculations

Table 4: Results for Johansen co-integration test of - GDP-EN for Egypt

Unrestricted cointegration rank test (trace)				
Hypothesized No. of CE (s)	Eigenvalue	Trace statistic	0.05 critical value	Prob.
None	0.299873	21.13330	29.79707	0.3494
At most 1	0.110183	6.160593	15.49471	0.6765
At most 2	0.029498	1.257556	3.841466	0.2621
Unrestricted cointegration rank test (maximum eigenvalue)				
Hypothesized No. of CE (s)	**Eigenvalue**	**Trace statistic**	**0.05 critical value**	**Prob.**
None	0.299873	14.97271	21.13162	0.2908
At most 1	0.110183	4.903037	14.26460	0.7540
At most 2	0.029498	1.257556	3.841466	0.2621

Source: Authors' calculations

The VAR satisfies the stability condition (Figure 1). According to the VAR granger causality/block exogeneity wald tests results, there is no causality from LNEN and LNGDP to LNCO_2 and no causality from LNCO_2 and LNGDP to LNEN. Unidirectional causality running from LNEN to LNGDP is found and no causality is found from LNCO_2 to LNGDP (Table 7).

Impulse response analysis is applied to find how each variable influences the other variables. Energy consumption has a positive impact on CO_2 in the short run and GDP affects CO_2 positively in the short run (Figure 2).

CO_2 affects energy consumption positively in the short run. GDP has a positive impact on energy consumption in the short run.

CO_2 has a positive impact on GDP in the short run and in the long run. Energy consumption has a positive impact on GDP in the short run and in the long run. Variance decomposition analysis is applied to find how each variable impacts and influences the other variables. Energy consumption can cause an 8.66% fluctuation in CO_2 in the short run and an 8.69% fluctuation in CO_2 in the long run. GDP can cause a 2.19% fluctuation in CO_2 in the short run and a 2.26% fluctuation in CO_2 in the long run (Table 8).

CO_2 can cause a 16.92% fluctuation in energy consumption in the short run and a 17.01% fluctuation in energy consumption

Table 5: VAR residual serial correlation LM test results of - GDP-EN for Egypt

Lags	LM-stat.	Prob.
1	12.82999	0.1705

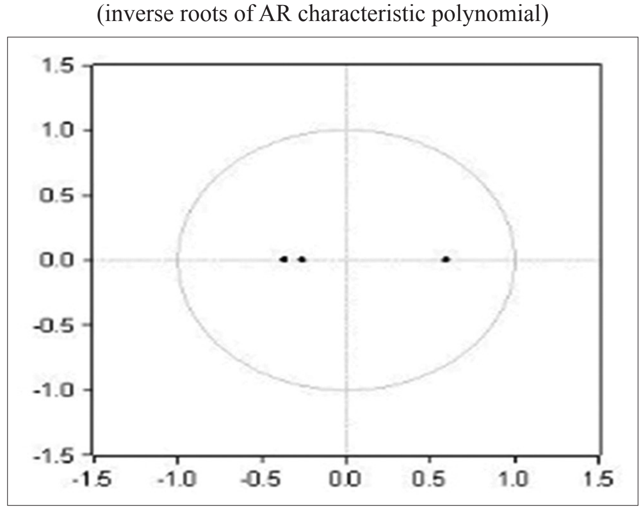
Source: Authors' calculations

Table 6: VAR residual heteroskedasticity tests: No cross terms (only levels and squares) of - GDP-EN for Egypt

Joint test		
Chi-square	**Df**	**Prob.**
33.67141	36	0.5798

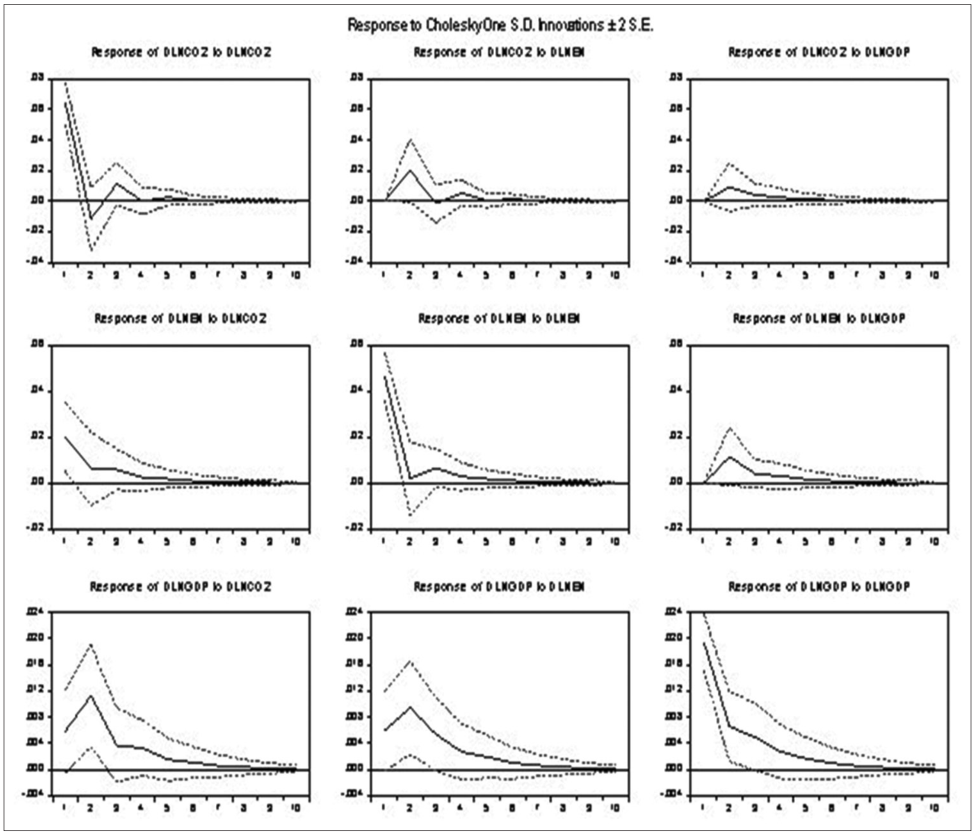
Source: Authors' calculations

Figure 1: VAR model stability results of CO_2-GDP-EN for Egypt (inverse roots of AR characteristic polynomial)



Source: Authors' calculations

Figure 2: Impulse response analysis of CO_2-GDP-EN for Egypt



Source: Authors' calculations

Table 7: VAR granger causality/block exogeneity Wald tests results of -GDP-EN for Egypt

Excluded	Chi-square	df
Dependent variable: DLNCO_2		
Excluded	**Chi-square**	**df**
DLNEN	2.687448	1
DLNGDP	1.378543	1
All	6.019976	2
Dependent variable: DLNEN		
Excluded	**Chi-square**	**df**
DLNCO_2	0.165193	1
DLNGDP	3.573330	1
All	3.973119	2
Dependent Variable: DLNGDP		
Excluded	**Chi-square**	**df**
DLNCO_2	3.019892	1
DLNEN	4.665610	1
All	11.14177	2

Source: Authors' calculations

in the long run. GDP can cause a 5.64% fluctuation in energy consumption in the short run and a 5.77% fluctuation in energy consumption in the long run. CO_2 can cause a 23.33% fluctuation in GDP in the short run and a 23.44% fluctuation in GDP in the long run. Energy consumption can cause a 20.06% fluctuation in GDP in the short run and a 20.38% fluctuation in GDP in the long run.

3.2. CO_2, GDP, Square of GDP and EN NEXUS (Egypt)

For Egypt, LNCO_2, LNEN, LNGDP and LNGDP2 are at I(1), I(1), I(1) and I(1) levels (Table 3). Since variables are stationary at I(1), the Johansen co-integration test is applied. According to the Johansen co-integration test results, no co-integration is found between CO_2, GDP, square of GDP and energy consumption (Table 9). Since no long-run relationship is found between CO_2, GDP, the square of GDP and energy consumption, EKC hypothesis is not confirmed for Egypt.

3.3. CO_2, GDP and EN NEXUS (Kenya)

For Kenya, LNCO_2, LNEN and LNGDP are at I(1), I(1) and I(1) levels (Table 3). Since variables are stationary at I(1), the Johansen co-integration test is applied. According to the Johansen co-integration test results, no co-integration is found between CO_2, GDP and energy consumption (Table 10).

There is no long-run relationship between CO_2, GDP and energy consumption. The VAR model is established, and the VAR granger causality/block exogeneity wald tests are applied for causality between CO_2, GDP and energy consumption. The VAR Residual Serial Correlation LM test and the VAR residual heteroskedasticity test results show the model is stable (Tables 11 and 12). The VAR satisfies the stability condition (Figure 3).

According to the VAR granger causality/block exogeneity wald tests results, there is no causality from LNEN and LNGDP to LN and no causality from LNCO_2 and LNGDP to LNEN. Unidirectional causality running from LNEN to LNGDP is found and no causality is found from LNCO_2 to LNGDP (Table 13).

3.4. GDP and EN NEXUS (Kenya)

For Kenya, LNCO_2, LNEN and LNGDP are at I(1), I(1) and I(1) levels (Table 3). Since variables are stationary at I(1), the Johansen co-integration test is applied. According to the Johansen co-integration test results, no co-integration is found between CO_2, GDP and energy consumption (Table 10).

There is no long-run relationship between CO_2, GDP and energy consumption. The VAR model is established, and the VAR Granger Causality/Block Exogeneity Wald tests are applied for causality between CO_2, GDP and energy consumption. The VAR residual serial correlation LM test and the VAR residual heteroskedasticity test results show the model is stable (Tables 11 and 12). The VAR satisfies the stability condition (Figure 3).

According to the VAR granger causality/block exogeneity wald tests results, there is no causality from LNEN and LNGDP to LNCO_2 and no causality from LNCO_2 and LNGDP to LNEN. Unidirectional causality running from LNEN to LNGDP is found and no causality is found from LNCO_2 to LNGDP (Table 13).

Impulse response analysis is applied to find how each variable impacts and influences the other variables. Energy consumption has a positive impact on CO_2 in the short run. GDP affects CO_2 in the first two periods positively and then affects negatively in the short run after two periods (Figure 4). CO_2 affects energy consumption first positively and then affects negatively it in the short run. GDP has a negative impact on energy consumption in the short run.

Table 8: Variance decomposition analysis of - GDP-EN for Egypt

Period	S.E.	DLNCO_2	DLNEN	DLNGDP
1	0.064029	100.0000	0.000000	0.000000
2	0.068624	89.89007	8.328539	1.781394
3	0.069732	89.78736	8.113165	2.099474
4	0.069988	89.13279	8.667939	2.199275
5	0.070053	89.09533	8.657050	2.247621
6	0.070075	89.04758	8.691887	2.260531
7	0.070081	89.04029	8.693538	2.266171
8	0.070084	89.03590	8.696226	2.267872
9	0.070084	89.03481	8.696659	2.268531
10	0.070085	89.03434	8.696916	2.268747
Period	**S.E.**	**DLNCO_2**	**DLNEN**	**DLNGDP**
1	0.050652	15.71205	84.28795	0.000000
2	0.052398	16.12514	78.91828	4.956580
3	0.053305	16.82639	77.80521	5.368404
4	0.053540	16.92463	77.42541	5.649960
5	0.053631	16.99238	77.28053	5.727091
6	0.053662	17.00767	77.23602	5.756310
7	0.053673	17.01488	77.21884	5.766281
8	0.053676	17.01697	77.21326	5.769769
9	0.053678	17.01780	77.21121	5.770994
10	0.053678	17.01806	77.21052	5.771420
Period	**S.E.**	**DLNCO_2**	**DLNEN**	**DLNGDP**
1	0.021178	7.792379	7.887662	84.31996
2	0.026608	22.91753	17.54135	59.54112
3	0.027850	22.70956	19.77050	57.51994
4	0.028311	23.33833	20.06988	56.59179
5	0.028466	23.38067	20.30721	56.31213
6	0.028519	23.43196	20.35158	56.21645
7	0.028538	23.44148	20.37618	56.18233
8	0.028545	23.44663	20.38259	56.17079
9	0.028547	23.44802	20.38532	56.16666
10	0.028548	23.44860	20.38616	56.16524

Source: Authors' calculations

Table 9: Results for Johansen co-integration test of -GDP-EN-square of GDP for Egypt

Unrestricted cointegration rank test (trace)				
Hypothesized No. of CE (s)	**Eigenvalue**	**Trace statistic**	**0.05 critical value**	**Prob.**
None	0.373494	40.05675	7.85613	0.2205
At most 1	0.231440	20.41767	29.79707	0.3950
At most 2	0.186842	9.361741	15.49471	0.3330
At most 3	0.015940	0.674878	3.841466	0.4114
Unrestricted cointegration rank test (maximum eigenvalue)				
Hypothesized No. of CE (s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob.**
None	0.373494	19.63908	27.58434	0.3666
At most 1	0.231440	11.05593	21.13162	0.6417
At most 2	0.186842	8.686862	14.26460	0.3131
At most 3	0.015940	0.674878	3.841466	0.4114

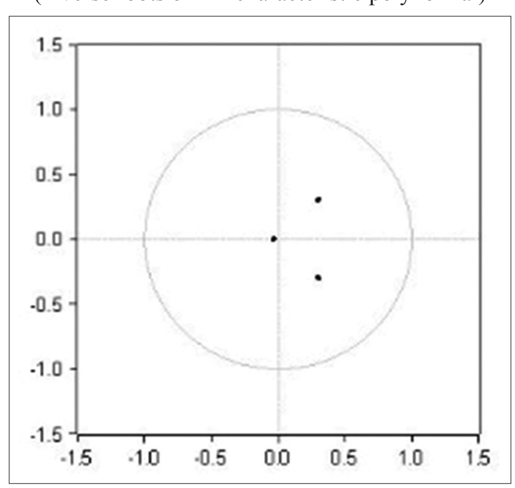
Source: Authors' calculations

Table 10: Results for Johansen co-integration test of -GDP-EN for Kenya

Unrestricted cointegration rank test (trace)				
Hypothesized No. of CE (s)	**Eigenvalue**	**Trace statistic**	**0.05 critical value**	**Prob.**
None	0.180158	12.82782	29.79707	0.8993
At most 1	0.093274	4.484799	15.49471	0.8608
At most 2	0.008826	0.372358	3.841466	0.5417
Unrestricted cointegration rank test (maximum eigenvalue)				
Hypothesized No. of CE (s)	**Eigenvalue**	**Trace statistic**	**0.05 critical value**	**Prob.**
None	0.180158	8.343024	21.13162	0.8815
At most 1	0.093274	4.112441	14.26460	0.8473
At most 2	0.008826	0.372358	3.841466	0.5417

Source: Authors' calculations

Figure 3: VAR model stability results of CO_2-GDP-EN for Kenya (inverse roots of AR characteristic polynomial)



Source: Authors' calculations

Table 11: VAR residual serial correlation LM test results of -GDP-EN for Kenya

Lags	LM-stat.	Prob.
1	3.680465	0.9312

Source: Authors' calculations

Table 12: VAR residual heteroskedasticity tests: No cross terms (only levels and squares) of - GDP-EN for Kenya

Joint test		
Chi-square	Df	Prob.
34.99052	36	0.5164

Source: Authors' calculations

Table 13: VAR granger causality/block exogeneity wald tests results of -GDP-EN for Kenya

Dependent variable: DLNCO_2			
Excluded	Chi-square	Df	Prob.
DLNEN	2.765956	1	0.0963
DLNGDP	0.141803	1	0.7065
All	3.574902	2	0.1674
Dependent variable: DLNEN			
DLNCO_2	3.749794	1	0.0528
DLNGDP	0.431947	1	0.5110
All	4.521057	2	0.1043
Dependent variable: DLNGDP			
DLNCO_2	1.887841	1	0.1694
DLNEN	12.26824	1	0.0005
All	12.27213	2	0.0022

Source: Authors' calculations

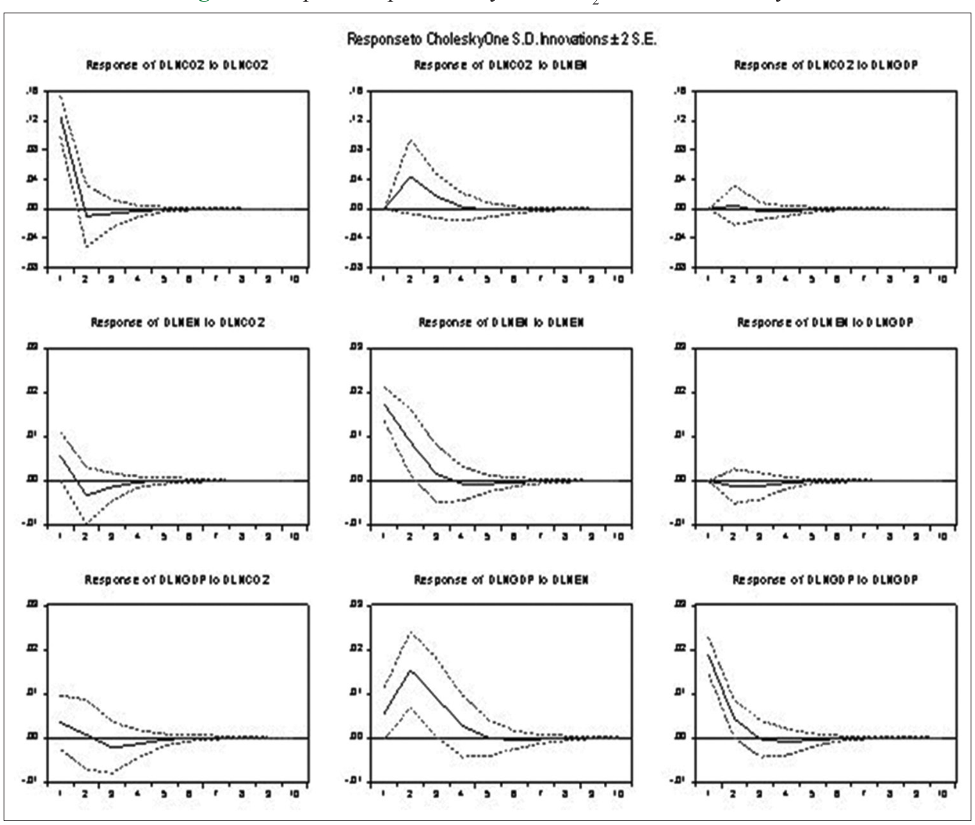
CO_2 has a positive impact on GDP first and then has a negative impact in the short run. Energy consumption has a positive impact on GDP in the short run. Variance decomposition analysis is applied to find how each variable impacts and influences the other variables. Energy consumption can cause a 12.42% fluctuation in CO_2 in the short run and a 12.44% fluctuation in CO_2 in the long run. GDP can cause a 0.21% fluctuation in CO_2 in the short-run and a 0.22% fluctuation in CO_2 in the long run (Table 14).

CO_2 can cause a 10.41% fluctuation in energy consumption in the short run and a 10.40% fluctuation in energy consumption in the long run. GDP can cause a 0.76% fluctuation in energy consumption in the short run and a 0.76% fluctuation in energy consumption in the long run. CO_2 can cause a 2.59% fluctuation in GDP in the short run and a 2.61% fluctuation in GDP in the long run. Energy consumption can cause a 48.17% fluctuation in GDP in the short run and a 48.16% fluctuation in GDP in the long run.

3.5. CO_2, GDP, Square of GDP and EN NEXUS (Kenya)

For Kenya, LNCO_2, LNEN, LNGDP and LNGDP2 are at I(1), I(1), I(1) and I(1) levels (Table 3). Since variables are stationary at I(1), the Johansen co-integration test is applied. According to the Johansen co-integration test results, no co-integration is found between CO_2, GDP, the square of GDP and energy consumption (Table 15). Since no long run relationship is found between CO_2, GDP, the square of GDP and EN, EKC hypothesis is not confirmed for Kenya.

Figure 4: Impulse response analysis of CO_2-GDP-EN for Kenya



Source: Authors' calculations

3.6. GDP and EN NEXUS (Turkey)

For Turkey, LNCO_2, LNEN and LNGDP are at I(1), I(1) and I(1) levels (Table 3). Since variables are stationary at I(1), the Johansen co-integration test is applied. According to the Johansen co-integration test results, no co-integration is found between CO_2, GDP and energy consumption (Table 16). There is no long-run relationship between CO_2, GDP and energy consumption. The VAR model is established, and the VAR granger causality/block exogeneity wald tests are applied for causality between CO_2, GDP and energy consumption. The VAR residual serial correlation LM test and the VAR residual heteroskedasticity test results show that the model is stable (Tables 17 and 18). The VAR satisfies the stability condition (Figure 5). According to the VAR granger causality/block exogeneity wald tests results, there is no causality from LNEN and LNGDP to LNCO_2 and no causality from LNCO_2 and LNEN to LNGDP. Unidirectional causality running from LNCO_2 to LNEN is found and no causality is found from LNGDP to LNEN (Table 19).

Impulse response analysis is applied to find how each variable impacts and influences the other variables. Energy consumption

Table 14: Variance decomposition analysis of -GDP-EN for Kenya

Period	S.E.	DLNCO_2	DLNEN	DLNGDP
1	0.125616	100.0000	0.000000	0.000000
2	0.133605	88.91104	10.94984	0.139119
3	0.134902	87.41940	12.39684	0.183757
4	0.134981	87.35757	12.42570	0.216732
5	0.134993	87.34350	12.43477	0.221736
6	0.135000	87.33449	12.44370	0.221812
7	0.135002	87.33295	12.44519	0.221853
8	0.135002	87.33289	12.44523	0.221887
9	0.135002	87.33287	12.44524	0.221892
10	0.135002	87.33286	12.44525	0.221892
Period	**S.E.**	**DLNCO_2**	**DLNEN**	**DLNGDP**
1	0.018203	9.538608	90.46139	0.000000
2	0.020547	10.11840	89.50537	0.376239
3	0.020682	10.41707	88.87411	0.708823
4	0.020700	10.41681	88.82151	0.761685
5	0.020711	10.40734	88.83049	0.762167
6	0.020713	10.40735	88.83024	0.762411
7	0.020713	10.40766	88.82959	0.762744
8	0.020713	10.40766	88.82954	0.762799
9	0.020713	10.40765	88.82955	0.762800
10	0.020713	10.40765	88.82954	0.762800
Period	**S.E.**	**DLNCO_2**	**DLNEN**	**DLNGDP**
1	0.019768	3.087737	7.860172	89.05209
2	0.025451	1.938825	41.51228	56.54890
3	0.027127	2.369346	47.84485	49.78580
4	0.027310	2.595238	48.17079	49.23397
5	0.027319	2.619516	48.14126	49.23922
6	0.027324	2.618618	48.15690	49.22448
7	0.027325	2.618947	48.16256	49.21849
8	0.027325	2.619176	48.16291	49.21791
9	0.027325	2.619202	48.16288	49.21792
10	0.027325	2.619201	48.16290	49.21790

Source: Authors' calculations

Table 15: Results for Johansen co-integration test of -GDP-EN-square of GDP for Kenya

Unrestricted cointegration rank test (trace)				
Hypothesized No. of CE (s)	**Eigenvalue**	**Trace Statistic**	**0.05 critical value**	**Prob.**
None	0.473761	45.63571	47.85613	0.0796
At most 1	0.254053	18.67168	29.79707	0.5167
At most 2	0.093675	6.361468	15.49471	0.6528
At most 3	0.051721	2.230470	3.841466	0.1353
Unrestricted cointegration rank test (maximum eigenvalue)				
Hypothesized No. of CE (s)	**Eigenvalue**	**Trace statistic**	**0.05 critical value**	**Prob.**
None	0.473761	26.96403	27.58434	0.0599
At most 1	0.254053	12.31021	21.13162	0.5173
At most 2	0.093675	4.130998	14.26460	0.8453
At most 3	0.051721	2.230470	3.841466	0.1353

Source: Authors' calculations

Table 16: Results for Johansen co-integration test of -GDP-EN for Turkey

Unrestricted cointegration rank test (trace)				
Hypothesized No. of CE (s)	**Eigenvalue**	**Trace Statistic**	**0.05 critical value**	**Prob.**
None	0.347224	24.60853	29.79707	0.1759
At most 1	0.143902	6.694637	15.49471	0.6134
At most 2	0.004018	0.169077	3.841466	0.6809
Unrestricted cointegration rank test (maximum eigenvalue)				
None	0.347224	17.91389	21.13162	0.1331
At most 1	0.143902	6.525560	14.26460	0.5467
At most 2	0.004018	0.169077	3.841466	0.6809

Table 17: VAR residual serial correlation LM test results of -GDP-EN for Turkey

Lags	LM-stat.	Prob.
1	8.696153	0.4658

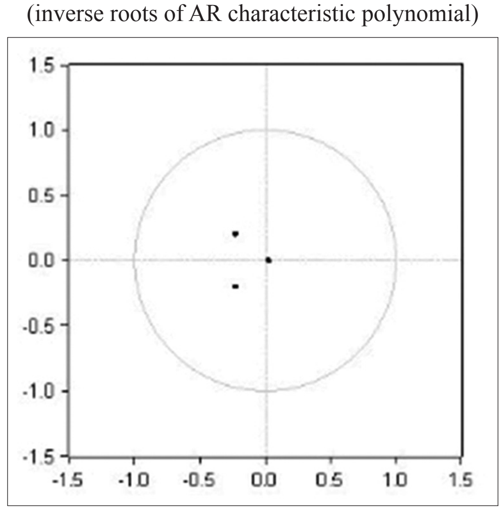
Source: Authors' calculations

Table 18: VAR residual heteroskedasticity tests: No cross terms (only levels and squares) of -GDP-EN for Turkey

Joint test		
Chi-square	**Df**	**Prob.**
34.50176	36	0.5399

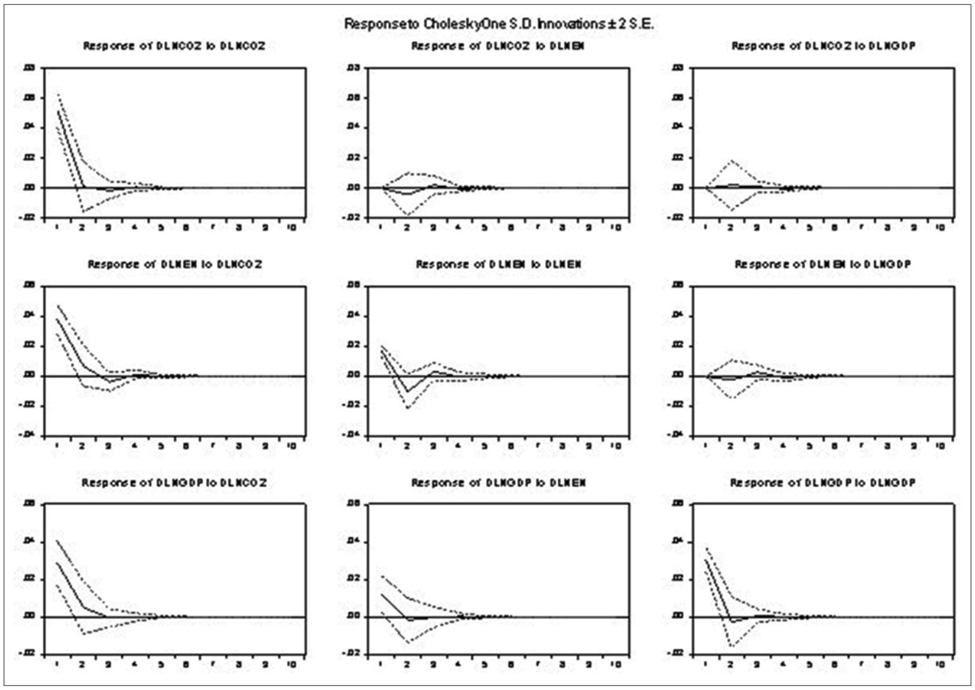
Source: Authors' calculations

Figure 5: VAR model stability results of CO_2-GDP-EN for Turkey (inverse roots of AR characteristic polynomial)



Source: Authors' calculations

Figure 6: Impulse Response Analysis of CO_2-GDP-EN for Turkey



Source: Authors' calculations

Table 19: VAR granger causality/block exogeneity wald tests results of -GDP-EN for Turkey

Dependent variable: DLNCO_2			
Excluded	**Chi-square**	**Df**	**Prob.**
DLNEN	0.460307	1	0.4975
DLNGDP	0.054208	1	0.8159
All	0.460310	2	0.7944
Dependent variable: DLNEN			
DLNCO_2	4.027007	1	0.0448
DLNGDP	0.140018	1	0.7083
All	4.080556	2	0.1300
Dependent variable: DLNGDP			
DLNCO_2	0.343564	1	0.5578
DLNEN	0.010798	1	0.9172
All	0.762243	2	0.6831

Source: Authors' calculations

has a negative impact on CO_2 in the short run in the first two periods and then has a positive impact in the other two periods in the short run. GDP has a positive impact on CO_2 in the short run (Figure 6).

CO_2 affects energy consumption first positively and then affects it negatively in the short run. GDP has a negative impact for the first two periods on energy consumption and then GDP haves a positive impact on energy consumption after two periods in the short run. CO_2 has a positive impact on GDP in the short run. Energy consumption has a positive impact on GDP in the short run.

Variance decomposition analysis is applied to find how each variable impacts and influences the other variables. Energy consumption can cause a 0.85% fluctuation in CO_2 in the short run and a 0.85% fluctuation in CO_2 in the long run. GDP can cause a

Table 20: Variance decomposition analysis of -GDP-EN for Turkey

Period	S.E.	DLNCO_2	DLNEN	DLNGDP
1	0.051684	100.0000	0.000000	0.000000
2	0.051907	99.17399	0.693540	0.132471
3	0.051982	98.98571	0.848213	0.166080
4	0.051993	98.96388	0.858365	0.177759
5	0.051994	98.96275	0.858444	0.178810
6	0.051994	98.96270	0.858468	0.178832
7	0.051994	98.96269	0.858478	0.178833
8	0.051994	98.96269	0.858478	0.178833
9	0.051994	98.96269	0.858479	0.178833
10	0.051994	98.96269	0.858479	0.178833
Period	**S.E.**	**DLNCO_2**	**DLNEN**	**DLNGDP**
1	0.041484	83.80635	16.19365	0.000000
2	0.043321	79.45040	20.23312	0.316471
3	0.043669	78.90574	20.41693	0.677331
4	0.043696	78.87375	20.40387	0.722381
5	0.043696	78.87247	20.40344	0.724094
6	0.043696	78.87224	20.40367	0.724092
7	0.043697	78.87220	20.40369	0.724110
8	0.043697	78.87220	20.40369	0.724113
9	0.043697	78.87220	20.40369	0.724113
10	0.043697	78.87220	20.40369	0.724113
Period	**S.E.**	**DLNCO_2**	**DLNEN**	**DLNGDP**
1	0.043490	43.43596	7.800789	48.76325
2	0.043907	43.94599	7.814421	48.23959
3	0.043917	43.94410	7.813317	48.24258
4	0.043918	43.94277	7.816579	48.24065
5	0.043918	43.94274	7.816999	48.24027
6	0.043918	43.94274	7.817011	48.24024
7	0.043918	43.94274	7.817011	48.24024
8	0.043918	43.94274	7.817011	48.24024
9	0.043918	43.94274	7.817011	48.24024
10	0.043918	43.94274	7.817011	48.24024

Source: Authors' calculations

Table 21: Results for Johansen co-integration test of -GDP-EN-square of GDP for Turkey

Unrestricted cointegration rank test (trace)				
Hypothesized No. of CE (s)	Eigenvalue	Trace statistic	0.05 critical value	Prob.
None	0.432080	39.83431	47.85613	0.2285
At most 1	0.222579	16.07174	29.79707	0.7072
At most 2	0.114354	5.497248	15.49471	0.7540
At most 3	0.009404	0.396835	3.841466	0.5287
Unrestricted cointegration rank test (maximum eigenvalue)				
None	0.432080	23.76256	27.58434	0.1432
At most 1	0.222579	10.57449	21.13162	0.6895
At most 2	0.114354	5.100413	14.26460	0.7291
At most 3	0.009404	0.396835	3.841466	0.5287

Source: Authors' calculations

0.17% fluctuation in CO_2 in the short run and a 0.17% fluctuation in CO_2 in the long run (Table 20).

CO_2 can cause a 78.87% fluctuation in energy consumption in the short run and a 78.87% fluctuation in energy consumption in the long run. GDP can cause a 0.72% fluctuation in energy consumption in the short run and a 0.72% fluctuation in energy consumption in the long run.

CO_2 can cause a 43.94% fluctuation in GDP in the short run and a 43.94% fluctuation in GDP in the long run. Energy consumption can cause a 7.81% fluctuation in GDP in the short run and a 7.81% fluctuation in GDP in the long run.

3.7. CO_2, GDP, Square of GDP and EN NEXUS (Turkey)

For Turkey, LNCO_2, LNEN, LNGDP and LNGDP2 are at I(1), I(1), I(1) and I(1) levels (Table 3). Since variables are stationary at I(1), the Johansen cointegration test is applied.

According to the Johansen co-integration test results, no co-integration is found between CO_2, GDP, the square of GDP and energy consumption (Table 21). Since no long run relationship is found between CO_2, GDP, the square of GDP and EN, the EKC hypothesis is not confirmed for Turkey.

4. CONCLUSION

The EKC hypothesis is examined in our study by two models which are CO_2, GDP and energy consumption nexus, and CO_2, GDP, the square of GDP and energy consumption nexus between the period of 1971 and 2014 for 3 developing countries which are Egypt, Kenya and Turkey.

The EKC hypothesis is not confirmed for 3 developing countries which are Egypt, Kenya and Turkey by CO_2, GDP and energy consumption nexus, and CO_2, GDP, the square of GDP and energy consumption nexus. The EKC hypothesis states that economic growth will lead to reduction in emissions. The results of this study do not verify this statement.

Causal relationships are examined by the VAR Granger causality/block exogeneity wald test. For Egypt, no causality is found between CO_2 and GDP, and no causality is found between EN and CO_2. Unidirectional causality is found from EN to GDP which confirms the growth hypothesis for Egypt.

For Kenya, no causality is found between CO_2 and GDP and no causality is found between EN and CO_2. Unidirectional causality is found from EN to GDP which confirms the growth hypothesis for Kenya.

For Turkey, no causality is found between EN and GDP which confirms the neutrality hypothesis. Unidirectional causality is found from CO_2 to EN.

One of the significant findings of our study is that the EKC hypothesis is rejected for Turkey, Egypt and Kenya, and no causal relationships are found between CO_2 and GDP. Balibey (2015), Ozturk and Oz (2016), Bozkurt and Akan (2014), Shahbaz et al. (2016a) and Yavuz (2014) confirmed the EKC hypothesis for Turkey but our findings show the opposite result for the EKC hypothesis. For Egypt, our findings for the EKC hypothesis are in line with Ibrahiem (2016), El-Aasar and Hanafy (2018) and Alaoui (2015). Al-Mulali et al. (2016) confirmed the EKC hypothesis for Kenya which is the opposite result of our findings for the EKC hypothesis. Ibrahiem (2016) found bilateral causality between CO_2 and GDP which differs from our findings for Egypt. Another significant finding of our study is that the neutrality hypothesis is confirmed for Turkey which states there is no causal relationship between EN and GDP. Ozturk and Oz (2016) found the growth hypothesis for Turkey which is different from our findings. Magazzino (2016) found the neutrality hypothesis for Turkey which is line with our findings. The other significant finding of our study is that the growth hypothesis is found for Egypt and Kenya which states that there is unidirectional causality running from EN to GDP. Ibrahiem (2016) confirmed the conservation hypothesis for Egypt which is the opposite result of our findings for Egypt. Unidirectional causality running from CO_2 to energy consumption is found for Turkey for emissions-energy nexus which is in line with Ozturk and Oz (2016).

Turkey's CO_2 emissions from fuel consumption increased by 141.6% between 1990 and 2014. Total final consumption increased by 35.8% between 2004 and 2014 in Turkey. Oil consumption was 35.6% of the total final consumption in 2014. Natural gas was 22.4% of the total final consumption, electricity was 20.6% of the total final consumption and coal was 12.3% of the total final consumption in 2014. Oil was consumed mainly in the transport (60.9%) and industry (18.3%) sectors in 2014. The transport sector's share in oil consumption increased from 41% in 2004 to 60.9% in 2014. From 2009 to 2014, only the transport sector's demand for oil increased. Turkey should implement efficient energy technology investments and energy efficiency policies. Turkey should implement a transportation policy to shift passenger and freight transport from road transportation to public transportation. Fuel taxation for diesel is less than gasoline. Turkey should implement fuel taxation to decrease diesel fuel usage since 70% of truck and transport vans run on diesel in road transportation. Under special consumption tax, vehicles are taxed according to vehicle type and engine capacity but not according to fuel usage. Fuel usage of a vehicle should be included in special consumption tax. Turkey should implement policies to increase rail and maritime transport and increase the number of electric cars. Old cars and vans should be scrapped, and incentives should be given to increase the number of vehicles with smaller engines and lower emissions. Renewable energy usage and natural gas usage should be increased in the transportation sector. Households accounted for 2.9% of oil consumption in 2014 and households' oil demand decreased by 66.5% between 2004 and 2014.

Turkey should invest in infrastructure to supply more households with natural gas to replace oil usage. This policy will decrease households' oil usage and CO_2 emissions. Increase in natural gas and renewable energy usage in the industry sector can replace most of oil usage. The industry sector accounted for 18.3% of oil consumption in 2014. Energy efficiency, natural gas usage and renewable energy usage should be increased in the industry sector.

Egypt should implement policies for sustainable growth. Fossil fuels accounted for 94% of Egypt's energy consumption in 2013. Natural gas and oil accounted for 51% and 43% of Egypt's energy consumption respectively in 2013. Emissions from electricity and heating production, the transportation sector and the industry sector accounted for 30.34%, 25.9% and 12.58% of Egypt's emissions in 2013 respectively. Egypt should continue to invest in solar and wind energy generation to increase the renewable energy share in electricity generation. Heavy subsidy on electricity should be addressed to prevent overconsumption of electricity. Policies should be implemented to increase energy efficiency in the industrial sector. Renewable energy accounted for 1% of Egypt's energy consumption in 2013. The renewable energy share should be increased in the industrial sector to decrease oil demand. The transportation sector mainly depends on road transportation and was the fastest growing sector for emissions by 2013. Policies should be implemented to finish the electrification of existing diesel railway lines and increase the number of electric vehicles in the transport sector. Egypt should implement a transportation policy to shift passenger and freight transport from road transportation to public transportation and current public transportation should be expanded.

The transport sector, electricity and heating production, and the industrial sector accounted for 23.18%, 8.11% and 4.6% of Kenya's emissions in 2013 respectively. The transport sector, electricity and heating production, and the industrial sector are the rapidly growing sectors for emissions and are expected to increase their shares in Kenya's emissions. The number of vehicles had increased from 600.000 to 2.2 million between 2000 and 2013 in Kenya. The industrial sector consumed 46% of electricity consumption in 2013. Oil was mainly used in the transport sector and 31% of electricity was generated by oil in 2013. Kenya should continue to invest in renewable energy such as geothermal, wind and solar energy. The renewable energy share in electricity generation should be increased. Policies should be implemented to shift passenger and freight transport from road transportation to public transportation and replace oil consumption in the transport sector with alternative fuels. Kenya should increase energy usage efficiency in the industrial sector. Policies should be implemented to increase the number of vehicles with smaller engines and lower emissions in the transport sector.

Economic growth is not likely to help Turkey, Egypt and Kenya to fight climate change by itself. Increasing the usage of renewable energy and improving energy efficiency in the transport and industry sectors will help Turkey, Egypt and Kenya significantly to fight climate change and meet emission targets.

Authorities in Turkey, Egypt and Kenya should continue to invest in emission reduction policies since these policies are likely not to have a detrimental effect on economic growth. These countries are likely to achieve further economic growth without causing environmental degradation since no causal relationship is found between CO_2 and GDP.

Limits of our study are that results are obtained for 3 developing countries and the period between 1971 and 2014 are examined for these countries.

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