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, CO₂ and energy consumption, and GDP, CO₂, 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 CO₂ to energy consumption is found for Turkey and no causal relationship is found between CO₂ 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 CO₂ 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
Studies in this context investigate causal, long-run and short-run relationships between income and energy consumption. The neutrality hypothesis states that there is no causality between income and energy consumption. 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. The conservation hypothesis, growth hypothesis, neutrality hypothesis, and feedback hypothesis besides the EKC hypothesis. 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.

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 Alkhatthlan et al. (2012) tested for EKC relationships and found no evidence in Iran, Mauritius 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

### 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
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 walld 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 CO₂, GDP and energy consumption, and CO₂, GDP, the square of GDP and energy consumption.

\[
\ln(\text{CO}_2) = \beta_0 + \beta_1 (\text{GDP}) + \beta_2 \ln(\text{EN}) + e_t \tag{1}
\]

\[
\beta_0, \beta_1, \beta_2, \text{ and } e_t \text{ are estimated parameters. } t \text{ is time index. } e \text{ is error term. CO}_2 \text{ is carbon dioxide emissions per capita. GDP is gross domestic product per capita. EN is energy consumption per capita.}
\]

\[
\ln(\text{CO}_2) = \beta_0 + \beta_1 \ln(\text{GDP}) + \beta_2 (\ln(\text{GDP}))^2 + \beta_3 \ln(\text{EN}) + e_t \tag{2}
\]

\[
\beta_0, \beta_1, \beta_2, \text{ and } e_t \text{ are estimated parameters. } t \text{ is time index. } e \text{ is error term. CO}_2 \text{ is carbon dioxide emissions per capita. GDP is gross domestic product per capita. EN is energy consumption per capita.}
\]

3.1. CO₂, GDP and EN NEXUS (Egypt)

For Egypt, LNCO₂, 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 CO₂, GDP and energy consumption (Table 4). There is no long-run relationship between CO₂, GDP and energy consumption. The VAR model is established, and the VAR granger causality/block exogeneity Wald tests results, there is no causality from LNEN and LNGDP to LNCO₂ and no causality from LNCO₂ and LNGDP to LNEN. Unidirectional causality running from LNEN to LNGDP is found and no causality is found from LNCO₂ 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 CO₂ in the short run and GDP affects CO₂ positively in the short run (Figure 2).

CO₂ affects energy consumption positively in the short run. GDP has a positive impact on energy consumption in the short run.

CO₂ 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 CO₂ in the short run and an 8.69% fluctuation in CO₂ in the long run. GDP can cause a 2.19% fluctuation in CO₂ in the short run and a 2.26% fluctuation in CO₂ in the long run (Table 8).

CO₂ can cause a 16.92% fluctuation in energy consumption in the short run and a 17.01% fluctuation in energy consumption.

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

| Variable        | At level | At first difference |
|-----------------|----------|---------------------|
|                 | Intercept| Intercept           |
| LNCO₂ Egypt     | −2.017766(0) | −7.416083(0)*      |
| LNEN Egypt      | −2.486051(0) | −5.873000(0)*      |
| LNGDP Egypt     | −2.553432(4) | −3.624684(0)*      |
| LNGDP2 Egypt    | −2.246094(4) | −3.695775(0)*      |
| LNCO₂ 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) | −5.854770(0)*      |
| LNCO₂ Turkey    | −1.370848(0) | −6.482424(0)*      |
| LNEN Turkey     | −1.241822(1) | −6.217744(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

| 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       | 14.97271            | 0.2908|
| At most 2                 | 0.029498   | 1.257556       | 3.841466            | 0.2621|

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| At most 1                 | 0.110183   | 6.160593       | 14.97271            | 0.2908|
| At most 2                 | 0.029498   | 1.257556       | 3.841466            | 0.2621|

Source: Authors’ calculations

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. |
|-----------------------------|------------|----|-------|
| Source: Authors’ calculations |

Figure 1: VAR model stability results of CO₂-GDP-EN for Egypt (inverse roots of AR characteristic polynomial)
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. \( \text{CO}_2 \) 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. \( \text{CO}_2 \), GDP, Square of GDP and EN NEXUS (Egypt)

For Egypt, \( \text{LNCO}_2 \), \( \text{LNEN} \), \( \text{LNGDP} \) and \( \text{LNGDP}^2 \) 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 \( \text{CO}_2 \), GDP, square of GDP and energy consumption (Table 9). Since no long-run relationship is found between \( \text{CO}_2 \), GDP, the square of GDP and energy consumption, EKC hypothesis is not confirmed for Egypt.

### 3.3. \( \text{CO}_2 \), GDP and EN NEXUS (Kenya)

For Kenya, \( \text{LNCO}_2 \), \( \text{LNEN} \) and \( \text{LNGDP} \) 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 \( \text{CO}_2 \), GDP and energy consumption (Table 10). There is no long-run relationship between \( \text{CO}_2 \), GDP and energy consumption. The VAR model is established, and the VAR granger causality/block exogeneity Wald tests are applied for causality between \( \text{CO}_2 \), 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 LNCO2 and LNGDP to LNEN. Unidirectional causality running from LNEN to LNGDP is found and no causality is found from LNCO2 to LNGDP (Table 13).
3.4. GDP and EN NEXUS (Kenya)

For Kenya, LNCO2, 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 CO2, GDP and energy consumption (Table 10).

There is no long-run relationship between CO2, GDP and energy consumption. The VAR model is established, and the VAR Granger Causality/Block Exogeneity Wald tests are applied for causality between CO2, 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 LNCO2 and no causality from LNCO2 and LNGDP to LNEN. Unidirectional causality running from LNEN to LNGDP is found and no causality is found from LNCO2 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 CO2 in the short run. GDP affects CO2 in the first two periods positively and then affects negatively in the short run after two periods (Figure 4). CO2 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. | DLNCO2 | 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 | 2.26531 |
| 7      | 0.070081 | 89.04029 | 8.693538 | 2.266171 |
| 8      | 0.070084 | 89.02599 | 8.596226 | 2.267787 |
| 9      | 0.070084 | 89.03401 | 8.696959 | 2.268747 |
| 10     | 0.070085 | 89.03434 | 8.696916 | 2.268747 |

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

| 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|

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

| 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                 | 0.088266   | 0.372358        | 3.841466            | 0.5417|

Figure 3: VAR model stability results of CO2-GDP-EN for Kenya (inverse roots of AR characteristic polynomial)
CO\textsubscript{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\textsubscript{2} in the short run and a 12.44% fluctuation in CO\textsubscript{2} in the long run. GDP can cause a 0.21% fluctuation in CO\textsubscript{2} in the short-run and a 0.22% fluctuation in CO\textsubscript{2} in the long run (Table 14).

CO\textsubscript{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\textsubscript{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\textsubscript{2}, GDP, Square of GDP and EN NEXUS (Kenya)

For Kenya, LNCO\textsubscript{2}, LNEN, LNGDP and LNGDP\textsuperscript{2} 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\textsubscript{2}, GDP, the square of GDP and energy consumption (Table 15). Since no long run relationship is found between CO\textsubscript{2}, GDP, the square of GDP and EN, EKC hypothesis is not confirmed for Kenya.

![Impulse response analysis of CO\textsubscript{2}-GDP-EN for Kenya](image)
3.6. GDP and EN NEXUS (Turkey)
For Turkey, LNCO₂, 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 CO₂, GDP and energy consumption (Table 16). There is no long-run relationship between CO₂, GDP and energy consumption. The

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

| Period | S.E. | DLNCO₂ | 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 |

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

VAR model is established, and the VAR granger causality/block exogeneity Wald tests are applied for causality between CO₂, 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 LNCO₂ and no causality from LNCO₂ and LNEN to LNGDP. Unidirectional causality running from LNCO₂ to LNEN is found and no causality is found from LNGDP to LNEN (Table 19).

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

| Hypothesized No. of CE (s) | Eigenvalue | Trace Statistic | 0.05 critical value | Prob. |
|---------------------------|------------|-----------------|---------------------|-------|
| None                      | 0.347224   | 17.91389        | 12.13162            | 0.1331 |
| At most 1                 | 0.143902   | 6.525560        | 5.341466            | 0.5467 |
| At most 2                 | 0.040418   | 0.169077        | 0.134981            | 0.6809 |

Table 17: VAR residual correla tion 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 CO₂-GDP-EN for Turkey (inverse roots of AR characteristic polynomial)
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 positive impact for the first two periods on energy consumption and then GDP has 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...
Beşe and Kalayci: Testing the Environmental Kuznets Curve Hypothesis: Evidence from Egypt, Kenya and 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 Akın (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

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

| 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|

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, LN\( CO_2 \), L\( LNEN \), LN\( GDP \) and LN\( GDP2 \) 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.
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 CO₂ 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 CO₂ 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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