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The Impact of Economic Growth on CO2 Emissions in Azerbaijan

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Abstract

This paper examines the relationship between the economic growth and CO2 emissions in Azerbaijan. A cointegration analysis is conducted over the period 1992-2013. For getting more robust results, Johansen, ARDLBT, DOLS, FMOLS and CCR methods to explore cointegration and estimate long-run coefficients are employed. We use cubic, quadratic and linear specifications and conclude that the last one is an adequate representation for the impact of the economic growth on CO2 emissions in Azerbaijan. The results from the different cointegration methods are consistent with each other and show that the economic growth has positive and significant impact on the emissions in the long-run implying that the EKC hypothesis does not hold for Azerbaijan. Moreover, we find that any short-run disequilibrium can be corrected towards the long-run equilibrium path within less than one year. The paper concludes that increasing the energy efficiency can be considered as a relevant environmental policy in order to reduce the carbon emissions.

Keywords: CO2 emissions, cointegration, economic growth, EKC hypothesis; Azerbaijan

JEL classifications: C32; Q01; Q43; Q52; Q53; Q56

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Introduction

It is well known that greenhouse gases (GHGs) are required to keep the Earth's temperature at levels so as to sustain life. However, increasing amounts of GHG emissions due to man-made activities, such as burning fossil fuels, absorb heat and cause global warming, giving rise to changes in the climate system. Arguably, this is one of the greatest problems humanity is facing today. Global climate change is therefore one of the main policy concerns of the century for all governments since it threatens societies' well-being, challenges the process of economic development and alters the natural environment. As it was noted in the "Transforming our world: the 2030 Agenda for Sustainable Development", according to the 13th Sustainable Development Goal, countries should "take urgent action to combat climate change and its impacts, strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries and integrate climate change measures into national policies, strategies and planning".[1]

According to the World Bank (2007), CO2 emissions stemming from the burning of fossil fuels and the manufacture of cement are responsible for almost 60% of GHGs.[2] Moreover, according to the Intergovernmental Panel on Climate Change (IPCC) (2014), CO2 emissions from fossil fuel combustion and industrial processes contributed about 78% of the increase in total GHG emission from 1970 to 2010, with a similar percentage contribution for the period 2000-2010. In order to attain environmental sustainability around the world in terms of GHGs, in 1997 the Kyoto protocol was signed by many governments of developed countries as well as developing and least developed countries. According to the IPCC (2007), these countries accounted for about 76.7% of total anthropogenic GHG emissions in 2004. The Protocol included mandatory emission reduction targets for developed countries.

Although the reduction commitments of CO2 emissions referred to developed countries, based on the fact that they are the largest contributors to global CO2 emissions, there have been calls on

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[1] Transforming our world: the 2030 Agenda for Sustainable Development, page 23.

[2] hiip://data.worldbank.org/indicator/EN.ATM.CO2E.KT/countries/AZ?display=graph, accessed on 10.10.2015. The World Bank defines carbon dioxide emissions as "are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring".

developing countries to play an active role in global emissions reduction (Winkler et al., 2002). The level of CO2 emissions from developing countries has been rapidly exceeding that of developed countries, which accounted for almost 50% of the world's CO2 emissions in 2003 (Martínez-Zarzoso and Maruotti, 2011). If the current level of energy consumption continues, today's CO2 trend is expected to grow. It is thus a common interest for all policymakers of any level to adopt those policy measures that will be most effective in mitigating CO2 emissions. However, because of the differences between developed and developing countries and even dissimilarities between different countries within the same group, those policy measures will generally not be identical and should be investigated for individual countries (Stern et al., 1996; de Bruyn et al., 1998; Dijkgraaf and Vollebergh, 1998; Stern and Common, 2001; Dinda, 2004, *inter alia*).

Many number of studies have been conducted on the relationship between CO2 emissions and their main drivers for different individual countries. Just to mention a few, these include Canada (Hamit-Haggar, 2012), China (Du et al., 2012), France (Iwata et al., 2010), India (Tiwari et al., 2013), Malaysia (Shahbaz et al., 2013), Russia (Pao et al., 2011), Spain (Esteve and Tamarit, 2012), Turkey (Yavuz, 2014), and for Brazil, China, Egypt, Japan, Mexico, Nigeria, South Korea, and South Africa (Onafowora and Owoye, 2014). To the best of our knowledge, no time series study has been conducted in the case of Azerbaijan.[3] In this paper, we investigate the relationship between CO2 emissions and economic growth for Azerbaijan. Four main reasons led us to select this country. First, as a resource-rich (mainly with oil and gas) country, Azerbaijan has been characterized by a considerable achievement in economic growth and it has been passed through different development stages (Hasanov and Hasanli, 2011, Hasanov et al., 2016). As pointed out by Winkler et al. (2002) among others, it is important to investigate the effect of economic growth on environmental degradation if a developing country experiences significant economic growth. The Azerbaijani economy has shown considerable economic growth since 2006. This new trend can be explained by the coming into force of oil contracts signed since the middle of 1990s. After the "Contract of the Century", which was signed in 1994 with 13 recognized world oil companies, 41 oil companies from

[3] Mikayilov et al. (2017) studied the impact of economic growth on CO2 emissions from transport sector, but they did not deal with the impact on total emissions.

19 countries have signed 27 additional contracts. Moreover, the Baku-Tbilisi-Ceyhan oil export pipeline construction process was completed in 2005 and Azerbaijani oil began to be exported through this pipeline to reach the world oil markets.

Second, energy consumption and economic growth, however, can determine negative impacts on environment by increasing CO2 emissions. In turn, a damaged environment and environmental resources have negative impacts on people, society and nature. In order to keep the balance among the elements of development, that is, to achieve a sustainable development, resources have to be used environmentally friendly. To reach this goal, some considerable activities, measures and programs have been implemented by the Azerbaijani government agencies since the second half of the 1990s. The country signed the Kyoto Protocol in 2000. Development concept called "Azerbaijan – 2020: Look into the Future" has released on December 29, 2012. In this concept, one of the main directions is to provide appropriate programs and activities to reach sustainable development. It is noteworthy that the concept planned to bring the amount of carbon dioxide in line with the appropriate level of member countries of the Organization for Economic Cooperation and Development by 2020. Therefore, it is important to investigate how CO2 and economic growth relationship evolves over time in light of the implemented policy measures.

Third, the relationship between economic growth and CO2 emissions has been studied for different countries in the literature. However, only a few panel studies have included Azerbaijan in their CO2 analysis and, to the best of our knowledge, there is no time series study investigating this issue for Azerbaijan.

Fourth, investigating the relationship in the case of Azerbaijan, a resource-rich developing country, would be an example for other similar countries and thus may provide some understandings which are common across such kind of economies.

All the above discussed considerations motivate the fact that building a well-designed econometric model relating CO2 emissions to economic and social factors is very important for Azerbaijan. In this study, we investigate the relationship between economic growth and CO2 emissions in the case of Azerbaijan employing different time series cointegration methods. Our study may contribute to the existing literature in a number of ways. First, considering that all previous CO2 studies for Azerbaijan have employed panel data methods, which might suffer from ignoring country specific features, this is the first time series study specifically for the country. Second, we test the Environmental Kuznets Curve (EKC) hypothesis for Azerbaijan using time series data. Furthermore, we test different possible representations of the relationship between CO2 emissions and income based on the EKC framework. Third, we employ five different cointegration methods as well as account for small sample bias correction as a robustness check. Fourth, we make extensive and constructive literature review of CO2-income studies for Azerbaijan and other oil exporting small open developing economies. Finally, the findings of this study might be a roadmap for the similar countries.

The rest of the paper is organized as follows: Section 2 provides a selected review of the related literature. Section 3 presents the conceptual framework of the study and the data employed. Section 4 discusses the methodology including model specification and estimation strategy. The empirical results are reported in Section 5. Section 6 discusses the empirical results and Section 7 concludes the study and provides policy implications.

2. Literature Review

In the early 1990s, three empirical studies independently analyzed the relationship between environmental degradation and per capita income (Grossman and Krueger, 1993; Shafik and Bandyopadhyay, 1992; Panayotou, 1993). All three studies concluded that the relationship between pollution variables and per capita income exhibited an inverted U-shaped curve, called the Environmental Kuznets Curve (EKC) by Panayotou (1993) to emphasize its similarity to the well-known Kuznets Curve between income distribution and per capita income levels (Kuznets and Simon, 1955).

Since then there have been a plethora of studies investigating the EKC, but the relationship between environmental degradation or quality and income remains hotly debated. There is a group of studies that discuss the theoretical underpinnings of the EKC, analyzing the potential explanations of a bellshaped relationship and the reasons for the 'turning back' of environmental impacts after some threshold level of income. Following Kijima et al. (2010), the theoretical models of the EKC can be divided into two groups: static and dynamic.[4] An example of static EKC approach is the paper by Lopez (1994) that discussed the theory of the EKC utilizing a production function approach. McConnell (1997), Andreoni and Levinson (2001), Lieb (2002), and Di Vita (2008) employ instead utility functions to explain the rationale for the EKC. Examples of the dynamic approach to the EKC include John and Pecchenino (1994), Selden and Song (1995), Dinda (2005), Chimeli and Braden (2009), and Prieur (2009) that consider resource allocation between consumption and abatement expenditures. Stokey (1998) and Tahvonen and Salo (2001) consider the effect of production technologies on the environment, whereas Jones and Manuelli (2001) and Egli and Steger (2007) propose models that take into account the effect of tax policy on pollution regulation. Finally, Wirl (2006) and Kijima et al. (2010) are examples of dynamic models dealing with the case of uncertainty in the economy.

In addition to the above mentioned theoretical studies, the empirical literature abounds with studies that investigate the environmental effects of energy use and economic growth for both developed and developing countries using different datasets, model specifications, methodologies, and functional forms.

The theoretical underpinnings suggest a non-linear relationship between environmental degradation and income. The empirical studies have therefore generally focused on quadratic and cubic EKC functional specifications, as originally proposed by Shafik and Bandyopadhyay (1992).[5] Table A1in Appendix summarizes the empirical contributions to the EKC limiting the attention to those for small open oil-exporting developing economies (SOOEDE) since 2010. These are countries that are similar to Azerbaijan which is the focus of this paper. While there are no time series estimates of the EKC for Azerbaijan, only a limited number of panel studies include this country: as such they might not be

[4] See the review of some of the theoretical EKC studies by Lieb (2003), Dinda (2004, 2005), and Kijima et al. (2010), among others.

[5] Additional detailed information on the empirical studies devoted to the EKC and its different aspects can be found in Lieb (2003), Stern (2004), Dinda (2004), and Uchiyama (2016).

able to capture the country-specific features of the relationship among the variables of interest. For example, three studies (Tamazian and Rao, 2010; Apergis and Payne, 2010; Al-Mulali et al., 2016), which include Azerbaijan, find an inverted U-shaped curve, two papers obtain a U-shaped curve (Brizga et al., 2013; Narayan et al., 2016), one ends up with no specific patterns (Perez-Suarez and Lopez-Menendez, 2015), and two studies obtain a monotonically increasing relationship (Ito, 2017; Mitic et al., 2017) between income and CO2 emissions.

One notable aspect is that many of the studies in the table (13 out of 24) employed the linear functional form, which can cause misspecification problem and misleading results. For example, using a linear specification, different studies found significantly different income elasticities for KSA (Alkhathlan and Javid, 2013: 0.45; Alshehry and Belloumi, 2016: 0.0025; Bekhet et al., 2017: -0.024; Narayan and Narayan, 2010: 0.40; Shahbaz et al., 2016: 0.26).

As said, there is not time series study devoted to Azerbaijan. In this regard, there is a need to conduct a time series study by taking into account all the above mentioned limitations including those noted in Table A1 of the existing studies in order to well understand the CO2-income relationship in Azerbaijan. To the best of our knowledge, the present one is the first study for Azerbaijan, investigating drivers of CO2 emissions and employing different time-series cointegration methods.

3. Model and Data

3.1 Employed Functional Form

The following is the traditional and widely used functional form for analyzing the relationship between CO2 emissions and GDP (Shafik and Bandyopadhyay, 1992; Grossman and Krueger, 1995; Lieb, 2003; Dinda, 2004, inter alia):

$$co_{2t} = b_0 + b_1 y_t + b_2 y_t^2 + b_3 y_t^3 + b_4 \boldsymbol{x}_t + u_t \qquad (1)$$

Where co_2 is CO2 emissions measured per capita, y is GDP per capita, $\boldsymbol{x}$ is a vector of additional explanatory variables and u is the error term**.** Often (1) is estimated with a time trend in order to capture the effects on CO2 emissions caused by technological progress or enhanced environmental awareness (Shafik and Bandyopadhyay, 1992; Lieb, 2003). Denoting a time trend with t, the model used for the present analysis is:

$$co_{2t} = b_0 + b_1 y_t + b_2 y_t^2 + b_3 y_t^3 + b_4 t + u_t \quad (2)$$

Equation (2) can be run in levels or in log form of the variables. In some cases, for example for the quadratic formulation, it may be preferable to estimate the model in log form (Cole et al. 1997), although the best formulation should be chosen in principle on the basis of the estimation results. We will use variables in the logarithmic form. Equation (2) enables us to test several forms of the CO2 emissions-economic development relationship (Dinda, 2004):

1. $b_1 = b_2 = b_3 = 0$: a flat pattern or no relationship between co_2 and y;

2. $b_1 > 0$ and $b_2 = b_3 = 0$: a monotonic increasing relationship or a linear relationship;

3. $b_1 < 0$ and $b_2 = b_3 = 0$: a monotonic decreasing relationship or a linear relationship;

4. $b_1 > 0, b_2 < 0$ and $b_3 = 0$: an inverted-U-shaped relationship, i.e., an Environmental Kuznets Curve (EKC);[6]

5. $b_1 < 0, b_2 > 0$ and $b_3 = 0$: a U-shaped relationship; [7]

6. $b_1 > 0, b_2 < 0$ and $b_3 > 0$: a cubic polynomial or N-shaped figure;

7. $b_1 < 0, b_2 > 0$ and $b_3 < 0$: the opposite to the N-shaped curve.

Note that all abovementioned equalities and inequalities are considered to hold with statistical significance. In the case of EKC, the turning point, where the emission level starts to fall, should be within a reasonable range (Uchiyama, 2016). From the abovementioned cases, it is clear that the EKC is only one of the possible shapes implied by model (2).

Following Shafik and Bandyopadhyay (1992), we will adopt the following testing procedure: if the cubic term is not statistically significant, it can be dropped. Likewise, if the squared term is also

[6] Strictly speaking the relationship is concave, implying decoupling of emissions from income.

[7] In principle, we could also have the case of a convex relationship, implying $b_1 > 0, b_2 > 0$ and $b_3 = 0$.

insignificant, we conclude the linear relationship between emissions and income. As it can be found in Table 1 of Shafik and Bandyopadhyay (1992), one can get all b_1, b_2 and b_3 to be insignificant in the cubic form, but b_1 and b_2 are significant in the case of the quadratic specification. In the case of an insignificant cubed term, we exclude it. Moreover, following Kaufmann et al. (1998), Scruggs (1998), Dinda et al. (2000), Harbaugh et al. (2000), Millimet and Stengos (2000) and Lieb (2003) we interpret a U-shaped emission-income relationship as evidence of a N-shaped curve. Additionally, following Cole et al. (1997) and Stern and Common (2001), we interpret an EKC with an estimated turning point outside the sample range as evidence for a monotonically increasing emission-income relationship.

3.2 Data

Our study uses annual data on carbon dioxide emissions and GDP over the period 1992-2013 for Azerbaijan[8]. CO2 emissions (CO_2) are measured in kilotons (kt) of carbon dioxide and are those stemming from the burning of fossil fuels and the manufacture of cement. This is our dependent variable, which we converted into per capita terms using population data measured in persons. The data on CO_2 and population are retrieved from the World Bank Development Indicators Database (WB, 2016) over the period indicated above. Only the values of CO2 for 2012 and 2013 are taken from the official webpage of EnerData (hiip://www.enerdata.net/) since they are not available from the World Bank Development Indicators Database. GDP per capita in 2005 constant USD is retrieved from the World Bank Development Indicators Database (WB, 2015) over the period indicated above. Figure 1 below shows the time profile of the above variables, both levels and growth rates, over the period 1992-2013.

[8] Note that selection of the period is based on data availability.

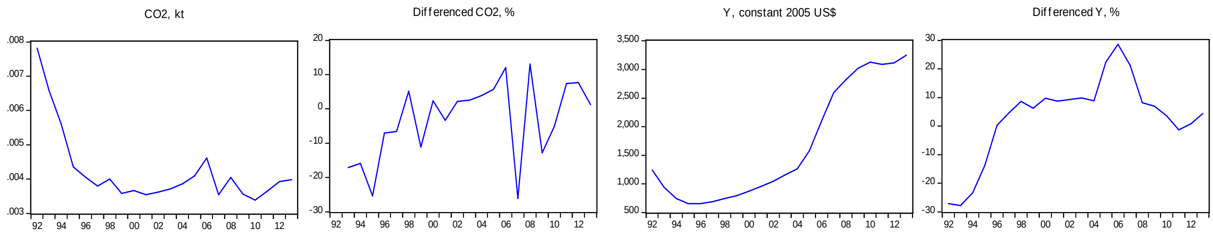

Figure 1. Levels and growth rates of the variables

As a general tendency for the chosen period co_2 and y increased, though the first variable has demonstrated volatility in the time profile since 2004. Before 1996 the level of CO2 emissions was decreasing due to the collapse of the previous economic system and only after that time the economy started to recover. Azerbaijani *CO2* emissions increased from 31510 kilotons in 1996 to 37513 kilotons in 2013 with an annual growth rate of 1.12% over the period. *GDP* instead increased by 11% annually. The jump in 2006 was most likely due to the effect of oil revenues following the completion of the Baku-Tbilisi-Ceyhan main export oil pipeline.

In the empirical analysis that follows we use the natural logarithm of the variables, which are denoted by small letters, i.e., co_2, y, y^2 and y^3.

4. Methodology

We use the Johansen cointegration approach as a main method. To get more robust results, we also employ the ARDLBT, DOLS, FMOLS and CCR methods. Moreover, we account for small sample bias in order to rule out misleading results.

Since most socio-economic and environmental variables are non-stationary, first we check this property of our variables before proceeding to the cointegration analysis. We employ three different unit root tests, namely the ADF, PP and KPSS to get more robust conclusion about integration order of the variables. Since these tests are widely used ones, we do not describe them here. Interested readers can refer to Enders (2010), Dickey and Fuller (1981), Philips and Perron (1988), Kwiatkowski, Phillips, Schmidt and Shin (1992).

4.1 The Johansen Cointegration Method

Johansen (1988) and Johansen and Juselius (1990) full information maximum likelihood method is based on the following Vector Error Correction Model (VECM):

$$\Delta z_t = \Pi z_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta z_{t-i} + \mu + \emptyset D + \psi_t \quad (3)$$

where, z_t is a (*n x 1*) vector of the *n* endogenous/modeled variables of interest, Π is a (*n x n*) adjustment coefficient matrix, Γ represents a (*n x (k*-1)) matrix of short-run coefficients, μ is a (*n x* 1) vector of constants, $\emptyset$ is vector of coefficients associated with D which is vector of deterministic regressors, such as deterministic trend, dummy variables, ψ_t denotes a (*n x 1*) vector of white noise residuals. If matrix Π has reduced rank ($0 < r < n$), then it can be split into a (n x r) matrix of loading coefficients α, and a (*n x r*) matrix of cointegrating vectors β. The former indicates the importance of the cointegration relationship in the individual equations of the system and of the speed of adjustment to equilibrium, while the latter represents the long-term equilibrium relationship, so that $\Pi = \alpha\beta'$.

Testing for cointegration, using Johansen's reduced rank regression approach, centers on estimating the matrix Π in an unrestricted form, and then testing whether the restriction implied by the reduced rank of Π can be rejected. In particular, the number of the independent cointegrating vectors depends on the rank of Π which in turn is determined by the number of its characteristic roots that are different from zero. Maximum eigenvalue and Trace tests statistics are used to test for nonzero characteristic roots.

The significance of a given variable implies that the null hypothesis of the corresponding coefficient β is zero can be rejected. Detailed discussion and empirical application of this and other tests in VECM framework can be found in Johansen and Juselius (1990), Johansen (1992a, 1992b).

4.2 Small Sample Bias Correction in the Johansen Method

Johansen (2002) notes that the Max-eigenvalue or Trace test statistics are biased toward rejecting the null hypothesis of no cointegration, in the case of a small number of observations. Given this, Reinsel and Ahn (1992) and Reimers (1992) propose a $\frac{\mathrm{T-kn}}{T}$ correction to the Max-eigenvalue or Trace test statistics in the case of small samples, where k is the lag length of the underlying Vector Autoregression (VAR) model in levels, while n and T are the number of endogenous variables and observations, respectively. Given the sample size for Azerbaijan, this correction is used in the empirical analysis undertaken here.

Due to space limitations, we do not describe ARDLBT, FMOLS, CCR and DOLS cointegration techniques in this section, but the detailed discussions can be found in Pesaran and Shin (1999), Pesaran et al. (2001), Hansen (1992a, 1992b), Phillips and Hansen (1990), Hamilton (1994), Park (1992), Saikkonen (1992), and Stock and Watson (1993), inter alia.

5. Empirical Results

This section first discusses the results of testing for unit roots and cointegration, and presents long-run estimation results of the Johansen, Bounds Testing approach to Auto Regressive Distributed Lag models (ARDLBT) (Pesaran and Shin, 1999; Pesaran et al., 2001), Fully Modifies Ordinary Least Squares (FMOLS) (Saikkonen, 1992; and Stock and Watson, 1993), Dynamic OLS (DOLS) (Hansen, 1992a, 1992b; Phillips and Hansen, 1990), and Canonical Cointegration Regression (CCR) (Park, 1992) methods.

5.1. Unit Root Tests

The results of the unit root test results are reported in Table 1.

Table 1: Results of unit root tests

	Variable	The ADF test				The PP test		The KPSS test	
		Level	k	First difference	k	Level	First difference	Level	First difference
Intercept	co_2	-4.212***	0	-4.445***	0	-4.783***	-4.443***	0.374**	0.416**
	y	-0.713	2	-3.456**	1	-0.435	-1.528	0.557	0.352**
	y^2	-0.655	2	-3.439**	1	-0.368	-1.537	0.559	0.361**
	y^3	-0.589	2	-3.405**	1	-0.300	-1.547	0.560	0.368**
Intercept and trend	co_2	-3.043	0	-5.348***	0	-3.352*	-5.288***	0.161*	0.127**
	y	-6.569***	1	-2.575	1	-3.995**	-1.922	0.139**	0.160*
	y^2	-6.220***	1	-2.572	1	-3.950**	-1.848	0.142**	0.160*
	y^3	-5.866***	1	-2.571	1	-3.874**	-1.881	0.145**	0.157*

Notes: ADF, PP and KPSS denote the Augmented Dickey-Fuller, Phillips-Perron and Kwiatkowski-Phillips-Schmidt-Shin tests respectively. Maximum lag order is set to two and optimal lag order (k) is selected based on Schwarz criterion in the ADF test; ***, ** and * indicate rejection of the null hypotheses at the 1%, 5% and 10% significance levels respectively; The critical values are taken from MacKinnon (1996) and Kwiatkowski-Phillips-Schmidt-Shin (1992) for the ADF, PP and KPSS tests respectively.

We can see that for co_2 emissions in the more general specification with intercept and trend, all tests indicate that the variable is stationary in first differences, i.e. it is I(1). The situation for y and its powers instead is not straightforward. When only the intercept is included, the Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests say that the income variables are I(1), while the Phillips-Perron (PP) test rejects the stationarity of the first differences. In the case of the intercept and trend model all tests reject the unit root hypothesis in the level of the variables. We note that in this case the coefficient of the lagged dependent variable of the ADF specification is found to be equal to -0.2. This in turn means that *p* in the original ADF specification is 0.8 (=1-0.2), which is closer to unity, indicating a unit root process. Moreover, it is known that in small samples these tests tend to reject the null. Considering the above mentioned facts, the graphical inspection and common theoretical sense we conclude that *y* and its powers are stationary in first differences. We thus conclude that our variables are non-stationary in levels but stationary in their first differences. In other words, they follow integrated of order one, I(1), processes.

5.2. Cointegration Analysis

Before testing the significance of the cubed and squared terms, we performed cointegration tests for the cubic and squared specifications. The tests concluded co-movement of the variables for either specifications in the long-run. To save the space we do not report the results here but they are available from the authors upon the request. Detailed discussion of the cointegration test results for the final specification are presented below.

As discussed in Section 3.1, if the cubic term is insignificant then it should be dropped from the model. Table A2 in Appendix shows that for all employed methods, except DOLS, the cubic term is insignificant. For DOLS it is significant only at 5% significance level. Moreover, the magnitude of the coefficient is completely different in comparison with other methods. Therefore, based on the fact that we have only one single weak evidence out of five cases, we drop the cubic GDP term from the model. Interestingly, the same holds for the quadratic income variable as well, that is the quadratic GDP term is statistically insignificant in all econometric methods employed, except for VECM. In the VECM results with squared income term, the sign of the trend is opposite to the conventional one. Moreover, based on the estimation results the turning point (3.533/2*0.200=8.833) occurs outside of the U-shaped relationship, which can be interpreted as monotonically decreasing relationship. But these two facts are opposite to the conventional known facts. Therefore, based on the estimation results from the five different methods we conclude that the squared term should also be dropped from the model. The coefficient b_1 is statistically significant in the case of the linear model. Therefore, we will proceed in our empirical analysis on the basis of a linear specification. The following discussion is based on this specification.

We first test for the existence of a long-run relationship among the variables involved and then turn to the estimated parameters of such relationship. We first apply the Johansen cointegration approach to equation (3) to see if there is one cointegration vector, because it is known that in the case of *n* variables there can be at most *n-1* cointegrating relationships. To apply the Johansen procedure, the optimal lag number should first be chosen. A Vector Auto Regressive (VAR) model was initially specified with the endogenous variables of co_2 and *y*, and exogenous variables intercept, trend and a pulse dummy.[9] The trend is included in order to see whether or not it has any power in explaining the behavior of the variables, especially y, as they are trending over time: if we excluded it, then our VAR would have instability problems.[10] A maximum of two lags was initially considered and both lag selection criteria and lag exclusion tests statistics suggested that indeed a lag of order two was optimal, which is intuitively appropriate given the small number of observations in the sample. It is worth nothing that the VAR with two lags successfully passes all the residual diagnostics tests, as indicated in Panels A through C of Table 2, as well as the stability test. The Johansen cointegration test results from the transposed version of the VAR, which is the VECM with one lag, are presented in Panels D and E of Table 2.

Table 2: VAR residual diagnostics, stability and cointegration tests results

Panel A: Serial Correlation LM Test [a]

Lags	LM-Statistic	P-value
1	2.088	0.720
2	2.970	0.563
3	4.121	0.390

Panel B: Normality Test [b]

Statistic	χ^2	d.f.	P-value
Jarque-Bera	2.926	9	0.967

Panel C: Heteroscedasticity Test [c]

	χ^2	d.f.	P-value
White Statistic	38.030	36	0.377

Panel D: Johansen Cointegration Test Summary

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type:	(a) No ***C*** and ***t***	(b) Only **C**	(c) Only **C**	(d) **C** and **t**	(e) **C** and **t**
Trace:	2	1	1	1	0
Max-Eig:	2	1	1	1	0

Panel E: Johansen Cointegration Test Results for type d

Null hypothesis:	$r = 0$	$r \leq 1$
λ_{trace}	30.417^{**}	6.593
λ^{a}_{trace}	24.881^{*}	5.327
λ_{max}	23.824^{**}	6.593
λ^{a}_{max}	19.488^{**}	5.327

[9] The pulse dummy, equal to one in 2007 and zero otherwise, is included in order to capture the jump of co_2 in 2007.

[10] Juselius (2006) discusses that one should take care of other variables along with a variable of interest since VAR is a system of variables. All the intermediate results are not reported here to conserve on space, but are available from the authors under request.

Notes: [a] The null hypothesis in the Serial Correlation LM Test is that there is no serial correlation at lag of order h of the residuals; [b] The Normality Test is the Urzua (1997) system normality test with the null hypothesis of the residuals are multivariate normal; [c] The White Heteroscedasticity Test takes the null hypothesis of no cross terms heteroscedasticity in the residuals; χ^2 is the Chi-square distribution; d.f. stands for degree of freedom; ***C*** and ***t*** indicate intercept and trend. ***r*** is the rank of the Π matrix, i.e., the number of cointegrated equations; λ_{trace} and λ_{max} are the Trace and Max-Eigenvalue statistics, while λ^a_{trace} and λ^a_{max} are adjusted version of them; *,** and *** denote rejection of null hypothesis at the 10, 5 and 1% significance levels respectively; Critical values for the cointegration test are taken from MacKinnon et al. (1999).

Although Table A2 has shown that the cointegrating equation is mainly linear, as in columns (c) or (d) of Panel D of Table 2, we check for the existence of cointegration in all possible five test types. We can see that type (e) reports no cointegration equation. It is difficult to believe that the variables are cointegrated with a quadratic trend because, first, the unit root tests do not show any non-stationarity with a quadratic trend and, second, it is a very rare case for socio-economic variables and, finally, it is hard to interpret economically. For cases (b), (c) and (d) both the trace and the max-eigenvalue test statistics indicate one cointegration relationship among the variables. The results of the small sample corrected version of the trace and max-eigenvalue tests are given in the Panel E. Here, again both tests point in favor of the existence of one cointegration relationship trace at 10% and max-eigenvalue at 5% significance levels. Therefore, we conclude that there is a cointegrating relationship among the variables.

The Johansen approach outperforms all its alternative methods in the case of more than two variables in terms of correctly determining the number of cointegrated relations. This is why we adopted it. However, we also employed the ARDLBT and Engle-Granger type DOLS, FMOLS and CCR methods to test whether the variables are cointegrated. The results from the ARDLBT, even after correcting for small sample bias using Narayan (2005) critical values, and other the three methods also indicate that there is a cointegrating relation among the variables. This indicates that the cointegration results from the Johansen approach are robust.[11] The ARDLBT, FMOLS, DOLS and CCR methods were also employed as a robustness check alongside the VECM in estimating the long-run coefficients. The results are presented in Table 3.[12]

[11] The results are not reported here but are available from the authors under request.

[12] Note that we set a maximum lag order equal to two in running the ARDLBT estimation as we did for the VAR. Then optimum lag order for dependent variable and regressors is selected with the Schwarz criterion, which is the more relevant information criterion in the case of small samples. In the DOLS estimation, we set maximum number of lag and lead order to one and the optimal order is selected by the Schwarz criterion because of the same reason. Since there is no dynamic part in FMOLS and CCR methods, we used a pulse dummy taking on unity in 2007 and zero otherwise, to capture the sharp decrease in CO2 emission in 2007. Also, note that we included a time trend in the ARDLBT, FMOLS, DOLS and CCR to capture technological and other changes and it appeared to be significant in all estimators.

Table 3: Estimation and testing results from the different cointegration methods

Method	VECM	ARDLBT	DOLS	CCR	FMOLS
		Panel A: Long-run equations			
Regressor	Coef. (Std. Er.)	Coef. (Std. Er.)	Coef. (Std. Er.)	Coef. (Std. Er.)	Coef. (Std. Er.)
y	0.823 (0.100) ***	0.786 (0.117) ***	0.724 (0.046) ***	0.706 (0.030) ***	0.697 (0.042) ***
$trend$	-0.078 (0.010) ***	-0.072 (0.013) ***	-0.071 (0.005) ***	-0.067 (0.002) ***	-0.067 (0.003) ***
		Panel B: Residuals diagnostics tests results and Speed of Adjustment Coefficient			
SoA	-0.763 [0.000]	-1.037 [0.000]			
$Q_{AR(2)}$	5.562 [0.592]	1.990 [0.370]			
LM_{SC}	1.177 [0.882]	1.921 [0.166]			
χ^2_{HETR}	30.363 [0.173]	4.278 [0.639]			
JB_N	2.583 [0.630]	0.554 [0.758]			

Panel C: The results of testing hypotheses 1-7

	Hypothesis	Result	Decision
1.	$H_0: b_1 = b_2 = 0$	b_1 is positive and statistically significant while b_2 is dropped because it is statistically insignificant in all the estimations in Panel A.	H_0 is rejected.
2.	$H_0: b_1 > 0\ and\ b_2 = 0$	b_1 is positive and statistically significant while b_2 is statistically insignificant in all the estimations in Panel A.	H_0 is accepted.
3.	$H_0: b_1 < 0\ and\ b_2 = 0$	b_1 is positive and statistically significant while b_2 is dropped because it statistically insignificant in all the estimations in Panel A.	H_0 is rejected.
4.	$H_0: b_1 > 0\ and\ b_2 < 0$	b_1 is positive and statistically significant while b_2 is dropped because it is statistically insignificant in all the estimations in Panel A.	H_0 is rejected.
5.	$H_0: b_1 < 0\ and\ b_2 > 0$	b_1 is positive and statistically significant while b_2 is dropped because it is statistically insignificant in all the estimations in Panel A.	H_0 is rejected.
6.	$H_0: b_1 > 0\ and\ b_2 < 0\ and\ b_3 > 0$	b_1 is positive and statistically significant while b_2 and b_3 are dropped because they are statistically insignificant in all the estimations in Panel A.	H_0 is rejected.
7.	$H_0: b_1 < 0\ and\ b_2 > 0\ and\ b_3 < 0$	b_1 is positive and statistically significant while b_2 and b_3 are dropped because they are statistically insignificant in all the estimations in Panel A.	H_0 is rejected.

Notes: Dependent variable is co_{2t}; Coef. and Std. Er. denote coefficient and standard error; *, ** and *** indicate significance levels at 10%, 5% and 1%; Probabilities are in brackets; SoA = Speed of adjustment; $Q_{AR(2)}$ = Q-statistic from testing AR(2) process; LM_{SC} = Lagrange multiplier statistic of serial correlation test; χ^2_{HETR} = Chi-squared statistic for heteroscedasticity test; JB_N = Jarque-Bera statistic for testing normality; In VECM, Jarque-Bera statistic was taken from the option of Orthogonalization: Residual Correlation (Doornik-Hansen). Intercepts of the long-run equations are not reported for simplicity.

As it can be seen from the Table 3 the long-run coefficients from the five different techniques are very close to each other in terms of sign and magnitude and they all are statistically significant. Additionally, the residuals of the estimated specifications successfully pass the residuals diagnostics tests which is another indication of the robustness of the estimation results. The long-run elasticity of carbon emission with respect to income is around 0.7, as the magnitude of the estimated income coefficients ranges from 0.697 to 0.823. In the models with trend the estimated coefficient of this variable lies between -0.067 and -0.078.

6. Discussion of the Empirical Results

The results from the unit root tests, given in Table 1, indicate that the levels of the variables follow a unit root process. This implies that any shock to these variables will have a permanent effect and therefore they will deviate from their underlying development path. As a piece of evidence of this fact, for example, the global financial crisis in 2008 has changed significantly the development path of GDP as can be seen in Figure 1. The figure also shows that there has not been a permanent change in the development path of carbon emission. This does not necessarily mean that this variable is not non-stationary, but rather indicates that the crisis has not had a permanent effect on it. Different variables simply can react to shocks differently. The concept is also true when the variables are positively shocked. Moreover, having a unit root process implies that the variables contain a stochastic trend, so that it is difficult to predict futures values of them. The implication for policy makers and forecasters is that they should consider growth rates rather than levels of the variables in their policy analysis and projections.

The finding of a cointegrating relationship among the variables, as reported in Table 2, implies that there is a stochastic trend which is the same for all of them. In other words, there is a long-run relationship among carbon emission and GDP. Since such a relationship exists, it is useful for policy analysis and forecasting purposes to estimate numerical values, i.e., parameters (especially elasticities) of this long-run relationship. To this end, we estimated the dependence of the carbon emission from GDP employing the five different cointegration methods as a robustness check. The desirable outcome from these estimations, reported in Table 2, is that they produce consistent results numerically, statistically and conceptually: as the magnitude of the corresponding coefficients are close to each other, they all are statistically significant and have the same expected signs.

For all methods, the estimated coefficient of the income variable has a positive sign, which implies a linear relationship (monotonically increasing) among income and emissions. This says that the EKC does not hold for Azerbaijan over the period analyzed. It is noteworthy that some previous panel studies also found the similar results. For example, recent studies such as Ito (2017) and Mitic et al.

(2017) find a monotonically increasing relationship for the panel with Azerbaijan. Thus, we conclude that there is a linear relationship between GDP and CO2 emissions. This implies that an increase in GDP results in an increase in environmental pollution in Azerbaijan. Such a conclusion is quite reasonable in the sense that the EKC usually holds for developed countries and Azerbaijan is a developing economy.

As can be seen from the Table 5, based on the VECM approach, the income elasticity of CO2 emissions is 0.823. Hence, all other things being equal, a 1% increase in GDP leads to 0.823% increase in carbon emissions. The estimated income elasticity obtained by Brizga et al. (2013) for the panel of former Soviet countries including Azerbaijan was equal to 0.86%. The difference between our finding and previous results in terms of magnitudes might be due to the use of individual countries data in our case, while all previous studies employed panel of countries.

As a further robustness check, we applied a Threshold Regression (TR) model to our data and the results showed that there is not a threshold value, i.e. a turning point in the relationship, which also can be seen as an evidence against non-linear relationship between income and CO2 emissions.

The finding of a monotonically increasing relationship between emissions and income can be explained as follows. Since, after the “Contract of the Century” the Azerbaijan economy has been benefiting from sizeable oil revenues. This in turn caused an increase in environmental degradation as result of the revitalization of the economy after the collapse of the Soviet Union. Moreover, CO2 emissions started to increase again after the beginning of the reinvigoration process of the industrial sector in 2009. The construction and launching of a number of new factories and techno-city, as well as recovering of the old ones, might be the main reason of this increase.[13]

Finally, long-run estimates show that carbon emission declines on average 7% per annum over the period 1992-2013, which can be considered as a result of technological improvement with other implicit factors. The negative sign of the trend variable is in line with the emission-income relationship. In other words, the effect of development in employed technologies on the environmental degradation is expected to be positive, which implies the expected sign of the trend

[13] hiip://www.azerbaijan.az/_Economy/_Industry/_industry_e.html

variable is negative.

Among others, one of the solutions to reduce carbon emission is to decrease energy intensity. To shed further light on this point, Azerbaijan was able to reduce energy intensity - which is calculated as energy for every dollar of GDP output at market exchange rates from 0.42 in 1990 to 0.24 in 2013, while CO_2 emissions has decreased by 56.8% over the period (Vazim et al., 2016). These numbers show that Azerbaijan gained considerable achievement in the reduction of the CO_2 emissions and energy intensity during the period of investigation. It has to be noted that the reduction in energy intensity in Azerbaijan can be the result of two different issues. On the one hand, as the country develops, modern technologies are used in sectors of the economy, which leads to decrease in the carbon emission. On the other hand, over the period a lot of plants and factories, which were mainly the large carbon emitters remained from the former Soviet Union period were shut down. Instead, other less carbon emitting sectors, like services, tourism etc., developed and grew (Hasanov, 2013; Oomes and Kalcheva, 2007). Nevertheless, compared with the world average, the CO_2 intensity in Azerbaijan was 1.1 mt in 2011, while the world average figure was 0.6 mt, which is 1.8 times smaller. Energy intensity was 19376 Btu in Azerbaijan in 2011 and this figure is almost 3 times higher than the world average of 9905 Btu.[14] To put it differently, Azerbaijan spends three times more energy than the world average to generate each dollar value added. Menyah and Wolde-Rufael (2010) among others point out that some countries endowed with abundant energy resources experience inefficiency in their energy use.

The above discussion highlights that energy inefficiency is one of the main challenges for the country. The energy intensity can be reduced by two channels: (a) using less energy intensive equipment and technologies in cement production and power generation to save energy and decrease a loss during distribution and transmission; (b) implementing different tariff mechanisms and cutting subsidies.

[14] hiip://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=92&pid=46&aid=2&cid=AJ,&syid=1996&eyid=2011&unit=BTUPUSDM, 14.12.15

7. Conclusion and Policy Implications

This study investigated carbon dioxide emission effects of economic growth in Azerbaijan using annual data for the period 1992-2013. The Johansen, ARDLBT, FMOLS, DOLS and CCR cointegration methods were employed to analyze the long-run relationships between the variables. The methods produced consistent results, which can be considered a sign of robustness of our findings. The results endorse the validity of a cointegrating relationship among the variables. The estimation results point to the invalidity of the EKC hypothesis in Azerbaijan. The relationship between CO_2 emissions and income is found to be monotonically increasing. The other finding of our study is that economic growth has a positive and statistically significant impact on carbon emissions in the long-run. In comparison with the World's average figures, in terms of CO_2 emissions, each dollar costs 1.8 times more than the World's average. The country has a potential to materialize economic development implementing energy conservative measures without causing an increase in CO_2 emissions (Opitz et al., 2015 inter alia). Moreover, the Azerbaijani government planned to bring down the amount of carbon dioxide in line with the appropriate figures of the OECD countries by the end of 2020. Therefore, a suitable environmental policy to reduce total CO_2 emissions without harming economic growth is to improve energy efficiency, which can be obtained by increasing optimal infrastructure investment and employing energy conservative policies to avoid unnecessary use of energy. Put differently, using less energy intensive technologies, minimizing the loss of power during distribution and transmission processes, and employing different tariff mechanisms to control energy use are some applicable policies that are capable to increase energy efficiency.

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Appendix

Table A1: Review of the CO2 studies for small open oil-exporting developing economies

Study	Sample Period	Country or Region	Explanatory variables	Functional Form	Econometric methodology	Income elasticity	Shape of EIR
Narayan and Narayan (2010)	1980-2004	43 developing countries (including Bahrain, Iran, Kuwait, Oman, Qatar, KSA and UAE)	COT, GDPT	LLF	FMOLS. Panel data.	Bahrain 0.74 Iran 1.22 Iraq -0.10 Kuwait 1.13 Oman 1.88 Qatar 0.15 KSA 0.40 Syria 0.71 UAE -0.04 Yemen -2.20	MI MI MD MI MI MI MI MI MD MD
Tamazian and Rao (2010)	1993-2004	24 transition economies (including Azerbaijan, Kazakhstan and Russia)	COPC, GDPPC, Inf, FDI, PL, FTL, TO, FL, IQ, EC, EI	QLF	GMM. Panel data.	0.04-1.22 lnGDP[1]	IUS
Apergis and Payne (2010)	1992-2004	11 CIS countries (including Azerbaijan, Kazakhstan and Russia)	COPC, ECPC, GDPPC and $GDPPC^2$	QLF	FMOLS. Panel data.	For panel with Russia: 1.55–2.96lnGDP; For panel without Russia: 1.37–2.54lnGDP[2]	IUS
Pao et al. (2011)	1990-2007	Russia	COT, GDPT, $GDPT^2$, ECT	LLF[3]	VECM. Time series data.	-0.23	MD
Arouri et al. (2012)	1981-2005	MENA	COPC, ECPC, GDPPC and $GDPPC^2$	QLF	Cross Correlated Effects estimation method. Panel data.	Bahrain 1.507–2.20lnGDP Kuwait 3.823–3.854lnGDP UAE 2.337+2.142lnG Oman 0.278–0.456lnGDP Qatar 3.039–2.376lnGDP KSA 0.385–2.488lnGDP[4]	IUS IUS US IUS IUS IUS
Stolyarova (2013)	1960-2008	93 countries including Azerbaijan, Bahrain, Iran, Kazakhstan, Kuwait, Oman, Qatar, Russia, KSA, UAE	COPC, GDPPC and energy mix (alternative and nuclear energy use)	LLF	GMM. Panel data.	Short-run elasticity[5]: 0.3-0.79	Not reported
Alkhathlan and Javid (2013)	1980-2011	KSA	COPC, ECPC, OCPC, GCPC,	LLF[6]	ARDL. Time series.	0.45(total) 0.56(oil)	MI MI

			ELCPC, GDPPC			-0.41(gas) 0.24(electricity)	MD MI
Al-Mulali and Tang (2013)	1980-2009	GCC	COPC, GDPPC, ECPC, FDI	LLF	FMOLS. Panel data.	Bahrain -0.344 Kuwait -0.434 Oman 0.904 Qatar 0.089 KSA 0.069 UAE -0.917	MD MD MI MD MD MD
Omri (2013)	1990-2011	MENA	COPC, GDPPC, ECPC, TO, U	LLF	GMM. Panel data.	Bahrain 0.498 Iran 0.253 Kuwait 0.359 Oman 0.508 Qatar 0.871 KSA 0.670 UAE -0.223	MI MI MI MI MI MI MD
Ozcan (2013)	1990-2008	12 Middle East countries	COPC, ECPC, GDPPC, $GDPPC^2$	QLF[7]	FMOLS. Panel data.	Bahrain -17.5+1.44lnGDP UAE 21.21-2.02lnGDP Iran 1.71-0.16lnGDP KSA -13.23+1.64lnGDP Oman -20.11+2.38lnGDP[8]	US IUS IUS[9] US US
Brizga et al. (2013)	1990-2010	15 former Soviet countries(including Azerbaijan)	COPC, GDPPC, In, EI, POP	LLF	Index decomposition analysis and OLS. Time series data.	0.86	Azerbaijan US, Kazakhstan IUS, Russia LS
Shahbaz et al. (2014)	1975Q1-2011Q4, quarterly data transformed from annual data	UAE	COPC, ELCPC, GDPPC, $GDPPC^2$, ExPC	QLF	ARDL. Time series data.	19.82-1.58lnGDP[10]	IUS
Farhani and Shahbaz(2014)	1980-2009	MENA	COPC, ELCPC, GDPPC, $GDPPC^2$	QLF	FMOLS and DOLS. Panel data.	FMOLS: Renewable: 0.132–0.023 ln GDP and Nonrenewable 0.250–0.071ln GDP. DOLS: Renewable: 0.135–0.023 ln GDP and Nonrenewable 0.254–0.070ln GDP[11].	IUS
Farhani et al.	1990-	MENA		QLF	FMOLS and DOLS. Panel	Iran: 0.0384- −3.2468lnGDP	IUS

(2014a)	2009		COPC, ECPC, GDPPC, $GDPPC^2$, TO		data.	(FMOLS) and 6.4250-3.1504lnGDP. KSA: 0.8356- −1.6008lnGDP (FMOLS) and 5.1554-−1.533lnGDP. For the panel of countries: 0.057-1.97lnGDP[12].	
Farhani et al. (2014b)	1990-2010	10 MENA countries	COPC, GDPPC, $GDPPC^2$, TO, HDI, MAN	QLF	FMOLS and DOLS. Panel data.	FMOLS: 2.095 – 0.202.lnGDP; DOLS: 2.081 – 0.200.lnGDP;	IUS
Zakarya et al. (2015)	1990-2012	BRIC countries	COPC, ECPC, GDPPC, FDI	LLF	FMOLS and DOLS. Panel data.	6.08	MI
Apergis and Ozturk (2015)	1990-2011	14 Asian countries(including Iran, Oman, KSA, UAE)	COPC, GDPPC, PD, L, ISH, and 4 variables for quality of institutions	CLF	GMM, FMOLS, DOLS, PMGE, MG. Panel data.	$3.6-0.56\ln GDP+0.18\ln^2 GDP$[13]	NS[14]
Shahbaz et al. (2015)	1975-2014	99 countries including Kuwait, KSA, Bahrain, Oman, UAE, Qatar, Iran	COPC, ECPC, GDPPC, FDI	LLF (with respect to income)	FMOLS. Panel data.	High income countries: 0.05; Middle income countries: 0.04; low income countries: 0.39	MI
Perez-Suarez and Lopez-Menendez (2015)	1860-2012	175 countries (including Azerbaijan)	COPC, GDPPC, $GDPPC^2$, $GDPPC^3$	CLF	NLS	Not reported	No specific pattern
Alshehry and Belloumi (2016)	1971-2011	KSA	TCOPC, TECPC, GDPPC	LLF[15]	ARDL. Time series data.	0.0025	MI
Shahbaz et al. (2016)	1980-2014	Panel of 105 countries	COPC, GDPPC, TO	LLF (with respect to income)	FMOLS. Panel data.	Kuwait 1.72 Oman 0.43 KSA 0.26 UAE 0.40 Iran 2.11 Syria 1.57	MI
Narayan et al. (2016)	1960-2008	181 countries (including Azerbaijan)	COPC, GDPPC,	Correlation coefficients are used	Cross-correlation estimate. Time series data.	Not reported	Bahrain IUS Kuwait MI KSA MD UAE MI Azerbaijan US Iran IUS

							Kazakhstan US Russia US
Al-Mulali et al. (2016)	1980-2010	107 countries (including Azerbaijan, Kazakhstan, Russia, Iran)	COT, GDPT, $GDPT^2$, TO, RE, U, FD	QLF	DOLS. Panel data.	4.75-0.18lnGDP[16] for the group with Azerbaijan	IUS for the group with Azerbaijan
Bekhet et al.(2017)	1980-2011	GCC	COPC, ECPC, GDPPC, FD	LLF	ARDL. Time series data.	KSA -0.024 UAE 0.098 Oman -0.106 Kuwait 0.926 Qatar -0.444 Bahrain -0.207	MD MI MD MI MD MD
Ito (2017)	2002-2011	42 developing countries (including Azerbaijan, Iran, Kazakhstan, Russia)	COPC, GDPPC, FEC, REC	LLF	GMM and PMG. Panel data.	GMM: 0.13 PMG: 0.34	MI
Mitic et al. (2017)	1997-2014	17 transitional economies (including Azerbaijan, Kazakhstan, Russia)	COT, GDPT	LLF	DOLS and FMOLS. Panel data.	0.35	MI

Legend:
ARDL= Autoregressive Distributed Lagged model, FMOLS= Fully Modified Ordinary Least Squares, DOLS=Dynamic Ordinary Least Squares, GMM=Generalized Method of Moments, OLS=Ordinary Least Squares, PMGE=Pooled Mean Group Estimator, MG=Mean Group estimator, VECM=Vector Error Correction Method and NLS=non-linear least squares method.
KSA=Kingdom of Saudi Arabia, GCC=Gulf Council Countries, UAE=United Arab Emirates, BRIC=Brazil-Russia-India and China, MENA=Meddle East and North African countries and CIS=Commonwealth of Independent States, respectively.
MI = Monotonically Increasing, MD = Monotonically Decreasing, US= U-shaped, IUS= Inverted U-shaped, LS=L-shaped, NS=N-shaped, EIR = Emission-Income Relationship.
LLF= Log-linear function, QLF= Quadratic functional form in logarithms, CLF=cubic functional form
COPC= CO2 emissions per capita, COT=total CO2 emissions, GDPPC= GDP per capita, GDPT=total GDP, Inf= inflation, FDI= foreign direct investment, PL= price liberalization, FTL= forex and trade liberalization, TO= trade openness, FL= financial liberalization, IQ= institutional quality, ECPC=per capita energy consumption, ECT= total energy consumption, EI= energy imports, U=urbanization, OCPC=per capita oil consumption, GCPC=per capita gas consumption, ELCPC=per capita electricity consumption, In=industrialization, EI=energy intensity, POP=population, ExPC= per capita real exports, PD= population density, L=land, ISH=industry shares, TCOPC= per capita transport CO2 emissions, TECPC= road transport energy consumption, FD=financial development, FEC=fossil fuel energy consumption, REC=renewable energy consumption, RE=electricity consumption from renewable energy sources, HDI= human development index, MAN=manufacture added value.

Notes:
1. For different specifications the coefficient are slightly different, hence we took the average of obtained coefficients (results from table 4 were used) and calculated the elasticity. The mean of lnGDP not provided, hence only elasticity formula is calculated.
2. The mean of lnGDP not provided, hence only elasticity formula is calculated.
3. QLF is used but then the squared term excluded due to the multicollinearity.
4. Study reported elasticities as formulas and the mean of lnGDP not provided.
5. Only the model with growth rates is used.
6. There are 4 models: one with total energy consumption and other three models with sectorial energy consumptions.
7. The cubic term found to be insignificant
8. Author reported elasticities as formulas and mean of lnGDP not provided.
9. But the coefficients are insignificant
10. The elasticity formula was not reported and calculated based on the results of that study. Income elasticity is found to be 0.35% using the estimation results of that study, by authors of the present study.
11. Based on the provided mean of lnGDP we calculated the appropriate elasticities, they are -0.10, -0.49, -0.11 and -0.48 respectively.
12. The mean of lnGDP for individual countries are not provided.
13. It has not been reported. Calculated by authors based on the estimation results of that study.

14. Although the authors concluded an inverted U-shaped curve, the signs of coefficients indicate an N-shaped relationship.
15. Quadratic term is found to be insignificant
16. Authors' calculation it based on the results of that study.

Table A2: Long-run coefficients from different specifications

Method	**VECM**			**ARDLBT**			**DOLS**			**CCR**			**FMOLS**		
Regressor	Coef. (p-values)			Coef. (p-values)			Coef. (p-values)			Coef. (p-values)			Coef. (p-values)		
y	0.823*** (0.002)	-3.533*** (0.000)	-51.262 (0.160)	0.786*** (0.000)	2.422 (0.141)	-137.158 (0.075)	0.724*** (0.000)	-0.836 (0.300)	-96.635** (0.030)	0.706*** (0.000)	0.740 (0.223)	-10.495 (0.574)	0.697*** (0.000)	0.505 (0.356)	-15.108 (0.272)
y^2	-	0.200*** (0.000)	6.992 (0.170)	-	-0.113 (0.308)	19.322 (0.074)	-	0.076 (0.172)	13.274** (0.032)	-	-0.004 (0.918)	1.520 (0.559)	-	0.012 (0.748)	2.162 (0.256)
y^3	-		-0.317 (0.182)	-	-	-0.903 (0.074)	-	-	-0.605** (0.034)	-	-	-0.069 (0.568)	-	-	-0.098 (0.262)
$trend$	-0.078*** (0.006)	0.033 (0.127)	-0.016 (0.210)	-0.072*** (0.000)	-0.067*** (0.001)	-0.004 (0.813)	-0.071*** (0.000)	-0.036*** (0.000)	-0.019** (0.036)	-0.067*** (0.000)	-0.036*** (0.000)	-0.068*** (0.000)	-0.067*** (0.000)	-0.068*** (0.000)	-0.068*** (0.000)

Notes: Dependent variable is co_2. ** and *** mean significance at the 5% and 1% levels, respectively.