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The Relationship among Real Gross Domestic Product, CO_2 Emissions, and Energy use in South Caucasus and Turkey

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ABSTRACT

The paper analyses the relationship among real gross domestic product (GDP), CO_2 emissions and energy use in South Caucasus countries and Turkey over the 1992-2013 years. Results of unit root tests show that all variables are integrated of order one. In general, cointegration tests with breaks suggest the presence of a long-run relationship between these variables. Causality results suggest that "conservation hypothesis" holds for Armenia; while, for Azerbaijan and Georgia, we reached mixed results, since both "feedback hypothesis" and "growth hypothesis" received support by empirical findings. Finally, no evidence of causality emerges for Turkey, in favour of "neutrality hypothesis." Therefore, the relevant policy implication of the study is that a common energy policy strategy would not be pursued by these countries, given the different causality links emerged in the area.

Keywords: Gross Domestic Product, CO_2 Emissions, Energy Use, South-Caucasus, Turkey, Time-series
JEL Classifications: B22, C32, N55, Q43

1. INTRODUCTION

The South Caucasus is often depicted as the main doorway to the energy-rich Caspian region in the energy security narratives of the European Union and of other Western actors in the region. The EU has a long-term interest in improving the energy security of the South Caucasus, since it can contribute to stability in the EU's neighborhood. Since the 1990s, the EU has provided technical and financial assistance to promote regulatory reform, energy efficiency and renewable energy, nuclear safety and the development of infrastructure and interconnections.

As a result of the disruption of the Soviet energy and economic space and infrastructure during the 1990s, energy and economic potential of Azerbaijan, Georgia and Armenia were virtually nullified. Thus, the 1990s represented the period when the countries of the region had to rebuild their energy infrastructure that was damaged by political instability. At the same time, they had to determine which economic and energy spaces they saw themselves as being part of. Such an imbalance between the countries of South Caucasus with regards to energy dependence and political development poses the question as to how it would be possible to ensure the safety of energy transit and stable political relations between these differing spheres of European and Russian influence. Thus, taking the existing regional context into account, the transit potential of South Caucasus can play an important role in bringing the Caspian energy resources to the global market. It will be necessary to resolve issues that are vital for its stability and future development, which implies serious reforms.

Azerbaijan and Georgia started close cooperation, and the two countries, together with Turkey, have successfully built strategic partnerships and developed mutually beneficial energy projects such as the South Caucasus Gas pipeline, Baku-Tbilisi-Ceyhan and Baku-Tbilisi-Supsa oil pipelines. The realization of these projects illustrates that energy has become an important precondition for South Caucasus states for reducing poverty and promoting regional economic growth and prosperity.

If we compare the energy consumption of the leading developed countries, the result is alarming for Georgia: Georgia's energy consumption per capita is 10 times less than the same figure for the United States and 4-5 times less than the EU average (Aslanishvili, 2016).

The relationship between economic growth and energy use, as well as economic growth and environmental pollution, has been the subject of several research projects in the last years. Notwithstanding, the empirical results remains mixed and debatable. In addition, many studies concern the relation among energy consumption, CO_2 emissions and economic growth, but very few studies have been devoted to the South Caucasus case.

In this study, the nexus among economic growth, CO_2 emissions and energy use in three South Caucasus countries (Armenia, Azerbaijan and Georgia) and Turkey has been investigated for the period 1992-2013, using time-series methodologies. The results might help to define and implement the appropriate energy and environmental policies in this area. To our knowledge, this is the first study that investigates the relationship among economic growth, energy use, and CO_2 emissions in the area.

Besides the Introduction, the rest of the paper proceeds as follows. Section 2 gives a brief survey of the literature. Section 3 contains an overview of the econometric methodology and a brief discussion of the data used. Section 4 discusses the applied findings. Section 5 presents some concluding remarks and, finally, Section 6 gives suggestions for future researches.

2. LITERATURE REVIEW

The relationship between carbon dioxide emissions, energy consumption, and real output is a synthesis of the Environmental Kuznets Curve (EKC) and the energy consumption growth literatures (Kuznets, 1955; Babu and Datta, 2013). The literature on the economic growth-energy consumption has been summarized in Magazzino (2014d) and Ozturk (2010), while Magazzino (2014b) and Payne (2010) contain an overview of the electricity demand - gross domestic product (GDP) nexus. Ben Jebli et al. (2016), Ozturk and Al-Mulali (2015), Bo (2011) and Dinda (2004) present surveys on the EKC literature.

With regard to the South-Caucasus countries, very few researches have been conducted. Sentürk and Sataf (2015) investigated the relationship between energy consumption and economic growth in seven countries (Turkey, Azerbaijan, Kazakhstan, Turkmenistan, Tajikistan, Uzbekistan, and Kyrgyzstan) during the period of 1992-2012. Adopting a vector error correction model, the empirical results indicate that the feedback hypothesis is acceptable. Kalyoncu et al. (2013) investigated the relationship between energy consumption and economic growth in Georgia, Azerbaijan and Armenia during the period of 1995-2009. For Georgia and Azerbaijan, it is found that these two variables are not cointegrated, while cointegration emerged in the case of Armenia. The research outcomes reveal that there is unidirectional causality from per capita GDP to per capita energy consumption for Armenia. While Yesevi and Tiftikcigil (2015) analyzed the economic and political nature of Turkey-Azerbaijan relations.

On the contrary, several studies have been devoted to the Turkish case.

Saatci and Dumrul (2013) investigated the role of energy consumption in economic growth for the Turkish economy from 1960 to 2008, concluding that energy consumption and economic growth have a positive relationship when structural breaks are taken into account.

Tükenmez and Demireli (2012) reviewed renewable energy policy in Turkey, showing that renewable energy supply in Turkey is dominated by hydropower and biomass, but fast growing urbanization and scarcity of supply have led to a decline in biomass.

Azgun (2011) examined the relationship between the aggregate electricity consumption, the sub-components of electricity consumption (industrial electricity consumption, residential and commercial, government offices and street illuminations), and real gross domestic product by means of a structural VAR model for the Turkish economy. Both the structural factorization results and Impulse-Response Functions show that aggregate electricity consumption shocks and the sub-components shocks of electricity consumption has not fluctuate real gross domestic product, while real gross domestic product innovations affect the total electrical energy consumption and the sub-components of electricity consumption.

Kaplan et al. (2011) examined the causal relationship between energy consumption and economic growth for Turkey during 1971-2006. The results indicate that energy consumption and economic growth are cointegrated and there is bidirectional causality running from energy consumption to economic growth and vice versa.

Ozturk and Acaravci (2010) examined the long-run and causal relationship issues among economic growth, carbon emissions, energy consumption and employment ratio in Turkey by using Auto-regressive distributed lag (ARDL) bounds testing approach of cointegration. Empirical results for Turkey over the period 1968-2005 suggest an evidence of a long-run relationship.

Akbostanci et al. (2009) investigated the relationship between income and environmental quality for Turkey, with a time series model for the years 1968-2003, and a panel data model and a panel data model that covers 1992-2001 including observations from 58 provinces. A monotonically increasing relationship between CO_2 and income is found in the long-run according to time series analysis. On the other hand, panel data analysis indicates an N-shape relationship for SO_2 and PM_{10} emissions. Therefore, the results do not support the EKC hypothesis.

Halicioglu (2009) attempted to empirically examine the dynamic causal relationships between carbon emissions, energy consumption, income, and foreign trade in the case of Turkey using the time-series data for the period 1960-2005, using the bounds testing to cointegration procedure. The results indicate that there exist two forms of long-run relationships between the variables. In the case of first form of long-run relationship, carbon emissions are determined by energy consumption, income and foreign trade. In the case of second long-run relationship, income is determined by carbon emissions, energy consumption and foreign trade.

The empirical results suggest that income is the most significant variable in explaining the carbon emissions in Turkey, which is followed by energy consumption and foreign trade. Moreover, there exists a stable carbon emissions function.

Soytas and Sari (2009) investigated the long-run granger causality relationship between economic growth, carbon dioxide emissions and energy consumption in Turkey, controlling for gross fixed capital formation and labor. The most interesting result is that carbon emissions seem to Granger cause energy consumption.

Balat (2008) gave an overview of the increasing of Turkish energy demand with the growth of the economy and utilization of domestic energy sources and the case of investments and imports in Turkey during the period 1980-2005. Moreover, Balat (2006) presented energy policies of Turkey.

Erdal et al. (2008) applied causality test to examine the causal relationship between primary energy consumption and real Gross National Product for Turkey during 1970-2006. The empirical results indicate that the two series are found to be non-stationary at their levels. However, first differences of these series lead to stationarity. Further, the results indicate that the series are cointegrated, and there is bidirectional causality. This means that an increase in energy consumption directly affects economic growth, and that economic growth also stimulates further energy consumption.

Telli et al. (2008) utilized a computable general equilibrium model for Turkey to study the economic impacts of the intended policy scenarios of compliance with the Kyoto Protocol over the period 2006-2020. The results suggest that the burden of imposing emission control targets and the implied abatement costs could be quite high, and that there is a need to finance the expanded abatement investments from scarce domestic resources.

Jobert and Karanfil (2007) provided a detailed analysis of the energy consumption in Turkey since 1960s and studying the causal relationships between income and energy consumption at the aggregate level and focusing on the industrial sector. Empirical findings suggest that in the long-run, income and energy consumption appear to be neutral with respect to each other both at the aggregate and at the industrial level.

Lise and Van Montfort (2007) analyzed the linkage between energy consumption and GDP by undertaking a cointegration analysis for Turkey with annual data over the period 1970-2003. The analysis shows that energy consumption and GDP are cointegrated.

Ozturk et al. (2007) discussed the electricity sector in Turkey.

Kaya (2006) investigated the renewable energy policies and the political organizations that shape these policies for Turkey, showing that energy development has been dominated by public investment and management.

Kiliç (2006) investigate Turkey's main energy sources and importance of its usage in the energy sector, showing that the country's energy policy is mainly concentrated on assurance of energy supply in a reliable manner and sufficiently in time, under economic and clean terms and in a way to support and orientate the target growth and social developments.

Lise (2006) studied the factors that explain CO_2 emissions by undertaking a complete decomposition analysis for Turkey over the period 1980-2003. The analysis shows, as is common to relatively fast growing economies, that the biggest contributor to the rise in CO_2 emissions is the expansion of the economy (scale effect). The carbon intensity and the change in composition of the economy also contribute to the rise in CO_2 emissions, albeit at a slower rate.

Say and Yücel (2006) overviewed Turkey's energy sector during the period 1970-2002, analysing the relationship between energy consumption and CO_2 emissions.

Ulutaş (2005) applied the Analytic Network Process model to evaluate the alternative energy sources for Turkey. Biomass is found to be the most attractive source to use.

Altinay and Karagol (2004) used unit root and causality tests to detect causality between the GDP and energy consumption in Turkey employing Hsiao's version of Granger causality method for the 1950-2000 period. No evidence of causality is found between energy consumption and GDP in Turkey based on the detrended data.

Ocak et al. (2004) and Kaygusuz (2003) discussed energy utilization and its major environmental impacts from the standpoint of sustainable development, including anticipated patterns of future energy use and subsequent environmental issues in Turkey.

Kaygusuz and Kaygusuz (2002) presented a review of the energy situation and sustainability, technical and economic potential of renewable energy sources and future policies for the energy sector in Turkey.

Demirbaş (2001) reviewed Turkish energy sector, providing information on the government's pricing and taxation policy as well as a directory of the key entities in the energy sector of the country.

Güllü et al. (2001) investigated the energy studies on alternative energy resources in Turkey and Turkey's energy policies to maximize investigation profit.

3. METHODOLOGY AND DATA

The first step of our empirical strategy concerns stationarity and unit root tests. According to Engle and Granger (1987), a linear combination of two non-stationary series can be stationary, and if such a stationarity exists, the series are considered to be cointegrated. This requires, however, that the series have the same order of integration. Therefore, the Augmented Dickey and Fuller (1979), the Elliott et al. (1996), the Phillips and Perron (1988), and the Kwiatkowski et al. (1992) tests were performed to test whether the data are difference stationary or trend stationary, as well as to determine the number of unit roots at their levels. Moreover, we also checked if any of the variables have structural breaks. To this extent, the Zivot and Andrews (1992) and the Clemente et al. (1998) tests were performed.

Once we found that the variables are non-stationary at their levels and are in the same order of the integration, we can apply the cointegration test.

The ARDL bounds testing approach of cointegration is developed by Pesaran and Shin (1999) and Pesaran et al. (2001). This approach has several advantages over the traditional cointegration approaches of Engle and Granger (1987), and Johansen and Juselius (1990). This takes care of small sample properties and simultaneity biasness in relationship among variables. The main constraint in the application of the conventional cointegration techniques is that they require all the variables included in the model to be non-stationary at levels but should be integrated of the same order. The present ARDL approach to cointegration method surmounts this problem as it is applicable irrespective of order of integration of regressors whether I(0) or I(1) or mixture of both. Apart from that, the ARDL model also has advantages in selecting sufficient numbers of lags to capture the data generating process in a general-to-specific modeling framework. These meritorious features justify the use of ARDL model to obtain robust estimates.

To measure the causal relationship among income, emissions and CO_2 emissions, we use the notion of Granger causality and the notion of instantaneous (or contemporaneous) causality. These notions can be used when we are dealing with stationary series. Traditionally, to test the causal relationship between two variables, the standard Granger (1969) test has been employed in the relevant literature. This test states that, if the past values of a variable X_2 significantly contribute to forecast the values of another variable X_1, then X_2 is said to Granger cause X_1 and vice versa. The definition of Granger causality does not mention anything about possible instantaneous correlation between X_2 and X_1. With stationary series, the tests are based on the following regression as it was shown in Granger (1969):

$$X_{1t}=\delta_1+\sum_{i=1}^{p} a_i X_{1t-i}+\sum_{i=1}^{p} b_i X_{2t-i}+u_{1t} \qquad (1)$$

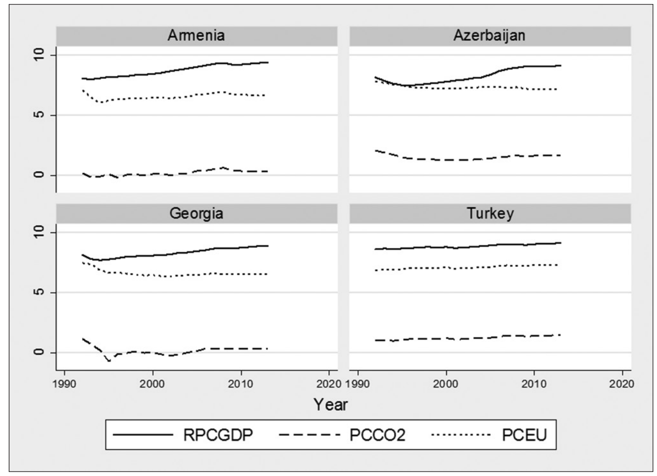
$$X_{2t}=\delta_2+\sum_{i=1}^{p} c_i X_{1t-i}+\sum_{i=1}^{p} d_i X_{2t-i}+u_{2t}$$

Where δ_1 and δ_2 are constant terms, u_{1t} and u_{2t} are white noise series and p represents the lag order. To test for the lack of Granger causality of the X_2 variable on the X_1 variable, a Fisher test is sufficient to see whether all the coefficients b_i are equal to zero. Similarly, the simple causal model given in (1) implies that X_1 is causing X_2 if some c_j is not zero.

Cointegration analysis considered also the Gregory and Hansen (1996) test for cointegration with regime shifts. The null hypothesis (H_0) is no cointegration, against the alternative (H_1) of cointegration with a single shift at an unknown point in time.

Developments in the time-series analysis have improved the standard Granger test. The first step is to check for the

Figure 1: Per capita real gross domestic product, CO_2 emissions and energy use for South-Caucasian countries and Turkey (1992-2013, log-scale)



Sources: WB and IEA data

stationarity of the variables and then test cointegration between them. According to Granger (1988), the test remains valid with non-stationary and not cointegrated variables if the variables are differentiated ΔX_t. Furthermore, Toda and Phillips (1994) and Toda and Yamamoto (1995) propose a procedure to perform Granger causality test with non-stationary and cointegrated variables.

Initially, we derived the log-transformation of our three variables. The empirical analysis uses yearly data of real per capita GDP, per capita CO_2 ($PCCO_2$) emissions, and per capita energy use, in the period 1992-2013 for Armenia, Azerbaijan, Georgia and Turkey. The data are obtained from the World Development Indicator and from the International Energy Agency[1]. In this paper, per capita GDP is expressed in constant 2005 US$ (RPCGDP), CO_2 emissions in metric tons $PCCO_2$, and per capita energy use in terms of kg oil PC equivalent (PCEU). In order to better understand and compare the emission trends in these four countries over time and in an international perspective, the measures of per capita emissions and GDP were used. The choice of the starting period was constrained by country's history and data availability.

Figure 1 shows the evolution of these variables in each selected country of the sample.

A visual inspection of the log-series shows an upward trend for real GDP in all countries.

Exploratory data analyses are shown in Table 1 as a preliminary analysis. Mean value of all variables is positive. Real aggregate income and energy use have negative value of skewness, indicating that the distribution is left-skewed, with more observations on the right. However, the mean and median values are similar for each variable, suggesting a Gaussian distribution.

1 See, for more details: http://www.econstats.com/wdi/wdic_ISR.htm and http://www.iea.org/.

Moreover, 10-Trim values are near to the mean, and standard deviation to the Pseudo Standard Deviation, which are in line with the fact that the Inter-Quartile Range shows the absence of outliers in the observed sample.

The series are strongly correlated, since all the correlation coefficients (r) exceed 0.80 in each country. Moreover, these results are broadly confirmed by cross correlations analyses.

4. EMPIRICAL RESULTS

In this section, we applied time-series techniques on stationarity and unit root processes to the data. Our series do not seem to exhibit the stationary properties in levels (by graphical inspections), contrarily to the relative first differences. Table 2 below contains the results of common unit root and stationarity tests to determine the order of integration.

Table 1: Exploratory data analyses

Variable	Mean	Median	SD	Variance	Skewness	Kurtosis	IQR
RPCGDP	8.5390	8.6671	0.5115	0.2617	−0.3217	2.0074	0.8612
$PCCO_2$	6.9074	6.9374	0.3872	0.1499	−0.0003	1.9867	0.7029
PCEU	0.7758	1.0053	0.6592	0.4345	−0.0935	1.6625	1.2007

Country	Variable	Mean	Median	SD	Variance	Skewness	Kurtosis	IQR
Armenia	RPCGDP	8.7335	8.7354	0.5016	0.2516	−0.0437	1.4195	0.9723
	$PCCO_2$	6.5690	6.5127	0.2416	0.0584	0.0340	2.8976	0.3188
	PCEU	0.1846	0.1537	0.2143	0.0459	0.1055	2.3851	0.3098
Azerbaijan	RPCGDP	8.2602	8.1091	0.6131	0.3759	0.2797	1.4772	1.2763
	$PCCO_2$	7.3281	7.2864	0.1726	0.0298	1.4394	4.4145	0.1302
	PCEU	1.5140	1.5006	0.2085	0.0435	0.8403	3.2754	0.2965
Georgia	RPCGDP	8.3061	8.2501	0.3818	0.1458	0.0423	1.6878	0.6489
	$PCCO_2$	6.6221	6.5532	0.2797	0.0782	2.1667	6.8225	0.1591
	PCEU	0.1658	0.1872	0.3692	0.1363	0.2611	4.5502	0.3683
Turkey	RPCGDP	8.8563	8.7976	0.1657	0.0274	0.1977	1.6996	0.2976
	$PCCO_2$	7.1106	7.0854	0.1441	0.0208	0.0111	1.8766	0.2177
	PCEU	1.2389	1.2068	0.1511	0.0228	0.0823	1.7831	0.2488

Sources: Our calculations on WB and IEA data. SD: Standard deviation; IQR: Inter-Quartile Range

Table 2: Results for unit roots and stationarity tests for Armenia

Variable	Unit root and stationarity tests				
	Deterministic component	ADF	DF-GLS	PP	KPSS
Armenia					
RPCGDP	Constant, trend	−1.581 (−3.600)	−1.920 (−3.485)	−1.579 (−3.600)	0.138* (0.146)
PCEU	Constant, trend	−3.837** (−3.600)	−1.816 (−3.485)	−5.313*** (−3.600)	0.102 (0.146)
$PCCO_2$	Constant, trend	−3.347* (−3.600)	−2.858* (−3.194)	−3.537** (−3.600)	0.0838 (0.146)
ΔRPCGDP	Constant	−3.336** (−3.000)	−2.018 (−2.575)	−3.336** −3.000)	0.141 (0.463)
ΔPCEU	Constant	−4.628*** (−3.000)	−1.209 (−2.575)	−4.628*** (−3.000)	0.220 (0.463)
$\Delta PCCO_2$	Constant	−1.725 (−3.000)	−0.932 (−2.496)	−6.917*** (−3.000)	0.143 (0.463)
Azerbaijan					
RPCGDP	Constant, trend	−2.902* (−3.000)	−1.120 (−2.575)	−2.902* (−3.000)	0.459* (0.463)
PCEU	Constant, trend	−3.756*** (−3.000)	−2.287* (−2.575)	−3.756*** (−3.000)	0.408 (0.463)
$PCCO_2$	Constant, trend	−1.968 (−3.000)	−1.315 (−2.575)	−2.741* (−3.000)	0.681** (0.463)
ΔRPCGDP	Constant	−3.336** (−3.000)	−2.018 (−2.575)	−3.336** −3.000)	0.141 (0.463)
ΔPCEU	Constant	−4.628*** (−3.000)	−1.209 (−2.575)	−4.628*** (−3.000)	0.220 (0.463)
$\Delta PCCO_2$	Constant	−1.725 (−3.000)	−0.932 (−2.496)	−6.917*** (−3.000)	0.143 (0.463)
Georgia					
RPCGDP	Constant, trend	−3.092** (−3.600)	−1.688 (−3.347)	−7.300*** (−3.600)	0.121* (0.146)
PCEU	Constant, trend	−2.021 (−3.600)	−0.608 (−3.485)	−5.215*** (−3.600)	0.239*** (0.146)
$PCCO_2$	Constant, trend	−4.651*** (−3.600)	−3.169* (−3.485)	−4.051** (−3.600)	0.155** (0.146)
ΔRPCGDP	Constant	−7.268** (−3.000)	−1.256 (−2.575)	−7.268** (−3.000)	0.262 (0.463)
ΔPCEU	Constant	−4.770*** (−3.000)	−1.187 (−2.575)	−2.813* (−3.000)	0.555** (0.463)
$\Delta PCCO_2$	Constant	−1.884 (−3.000)	−1.861 (−2.575)	−4.022*** (−3.000)	0.284 (0.463)
Turkey					
RPCGDP	Constant, trend	−2.779** (−3.600)	−2.527 (−3.485)	−2.636 (−3.600)	0.100 (0.146)
PCEU	Constant, trend	−2.369 (−3.600)	−2.442 (−3.485)	−2.676 (−3.600)	0.083 (0.146)
$PCCO_2$	Constant, trend	−2.327 (−3.600)	−2.323 (−3.485)	−2.619 (−3.600)	0.094 (0.146)
ΔRPCGDP	Constant	−4.959*** (−3.000)	−2.745*** (−2.575)	−4.959*** (−3.000)	0.060 (0.463)
ΔPCEU	Constant	−5.107*** (−3.000)	−3.524*** (−2.575)	−5.107*** (−3.000)	0.061 (0.463)
$\Delta PCCO_2$	Constant	−5.131*** (−3.000)	−3.642*** (−2.575)	−5.131*** (−3.000)	0.054 (0.463)

The tests are performed on the log-levels of the variables. ADF, DF-GLS, PP, and KPSS refers respectively to the Augmented Dickey-Fuller test, the Elliot, Rothenberg, and Stock GLS test, the Phillips-Perron test, and the Kwiatkowski, Phillips, Schmidt, and Shin test. When it is required, the lag length is chosen according to the SBIC. 5% Critical Values are given in parentheses. ***P<0.01, **P<0.05, *P<0.10

All series are non-stationary in their level form, but after taking the first difference we reject the null hypothesis of non-stationarity at 5% significance level. Thus, we can conclude that these three series are integrated of order one, or I(1).

In Table 3 are the results of Zivot and Andrews's unit root test. The null hypothesis of a unit root cannot be rejected in levels for our series. For Armenia a break in the energy use and carbon dioxide emissions series emerges in 2010. A break in the emissions is discovered for Azerbaijan and Georgia, while in the case of Turkey no break is detected at levels. We therefore can conclude that all our series are integrated of order one, or I(1). The lag-order se-lection has been chosen according to the Akaike's information criterion, the Schwarz's Bayesian information criterion, and the Hannan-Quinn information criterion.

The ARDL bounds *F*-tests for cointegration yield evidence of a long-run relationship among real income, CO_2 emissions and energy use for each equation in the case of Azerbaijan and Georgia, and in the energy use and CO_2 emissions equations for Armenia and Turkey (Table 4).

Diagnostic checks for the estimated ARDL model do not reveal any evidence of non-normality, serial correlation, heteroskedasticity, and autoregressive conditional heteroskedasticity.

Since structural breaks emerge in our series, we applied the Gregory and Hansen (1996) cointegration test with breaks (Table 5). The tests roughly confirm previous ARDL bounds tests finding. In fact, for Armenia and Turkey a long-run relationship is detected in the equation with energy use and emissions as dependent variable; for Azerbaijan, only in the equation of the energy use cointegration does not emerge; while, a cointegration relation is found in each specification in the case of Georgia.

Granger (1969) causality tests following the Toda and Yamamoto (1994) approach requires the estimation of an augmented VAR (k+d) model, where *k* is the optimal lag length and *d* is the order of integration of the series. Tests suggest for Turkey the inclusion of one lag in a VAR model and thus k=1; hence, the final model to be estimated is a VAR (2). For Azerbaijan and Georgia k=3, so that we estimate a VAR (4). While, for Armenia the optimal lag length is 2 and the estimated model a VAR (3). To ensure that the VAR models are well specified, additional tests are carried out. Though the results are not reported to save space, diagnostic tests indicate, in each case, the general absence of problems in all estimated VAR models, with regards to normality and autocorrelation in the residuals, stability condition, and lag-exclusion. Moreover, the stability of coefficient estimates is supported, since the plots of both CUSUM and CUSUMSQ fall inside the critical bounds of 5% significance, in each case. This indicates that the estimated parameters do not show a structural instability.

In Table 6 the results of causality tests are reported. For Armenia, the Toda and Yamamoto tests (panel above) and the standard Granger tests show that energy use and CO_2 emissions are both driven by real GDP, in line with the "conservation hypothesis." In essence, multivariate and bivariate systems present similar results. The unidirectional causality from economic growth to energy use suggests that the policy of conserving energy use may be implemented with little or no adverse effect on economic growth, such as in a less energy-dependent economy. The interdependency of CO_2 emissions and economic growth suggests that though economic growth induces further emissions, efforts to reduce emissions will have an adverse effect on economic growth as well.

For Azerbaijan, the results are somewhat controversial. In fact, both multivariate systems tests are in line with the "feedback hypothesis," since a bidirectional causality flow between GDP and energy use is found. However, Toda and Yamamoto bivariate tests indicate that the unidirectional causality runs from energy use to GDP ("growth hypothesis,") while Granger bivariate tests are marginally (5%) in favour of the opposite direction (RPCGDP→PCEU, "conservation hypothesis").

In the case of Georgia peculiar results emerge, as both multivariate and bivariate Toda and Yamamoto tests indicate the existence of a bidirectional causality flow ("feedback hypothesis"); while both multivariate and bivariate Granger tests show that only the energy use affects the aggregate income (PCEU→RPCGDP, "growth hypothesis"). Moreover, all tests reveal that real GDP and energy use influence carbon dioxide emissions.

Finally, for Turkey the majority of the tests indicate the prevalence of the "neutrality hypothesis," given the fact that no causality exists between GDP and energy. This implies that energy use is not correlated with aggregate income.

Our results, with regard the three South-Caucasus countries, are partially in line with those by Sentürk and Sataf (2015) and Kalyoncu et al. (2013). As concerns Turkey, our cointegration findings support those by Kaplan et al. (2011), Ozturk and Acaravci (2010), Halicioglu (2009), Erdal et al. (2008), and Lise and Van Montfort (2007); in addition, the evidence of no causality among our three variables is shown also in Ozturk and Acaravci (2010), Halicioglu (2009), Soytas and Sari (2009), Jobert and Karanfil (2007), and Altinay and Karagol (2004).

However, the empirical evidence remains controversial and ambiguous until now, and there is no consensus in the literature on the economic level at which environmental degradation starts declining (Dinda, 2004).

5. CONCLUSIONS AND POLICY IMPLICATIONS

This study analyzes the relationship among economic growth, CO_2 emissions and energy use, using annual data for Turkey and three South-Caucasus countries (Armenia, Azerbaijan and Georgia) over the period 1992-2013. The results for unit root tests reveal that all variables are integrated of order one, I(1). Cointegration tests with breaks suggest the presence of a long-run relationship between these variables. In fact, in each country, at least two

Table 3: Results for unit root tests with structural breaks (in intercept or in trend) and for additive outlier unit root tests (single structural break)

Armenia

ZA tests

Variable	(a) T_b	(a) k	(a) t_{min}	(b) T_b	(b) k	(b) t_{min}
RPCGDP	2009	1	−3.344 (−4.80)	2008	1	−2.577 (−4.42)
PCEU	2010	0	−7.475*** (−4.80)	2009	0	−8.080*** (−4.42)
$PCCO_2$	2010	0	−4.670* (−4.80)	2009	0	−4.971*** (−4.42)
ΔRPCGDP	2009	0	−5.359*** (−4.80)	2004	0	−3.587 (−4.42)
ΔPCEU	2008	0	−4.329 (−4.80)	1996	0	−8.373*** (−4.42)
$\Delta PCCO_2$	2009	2	−4.214 (−4.80)	2006	2	−2.359 (−4.42)

CMR tests

Variable	Optimal break point	k	t-statistic	5% critical value
RPCGDP	2009	1	−3.118	−3.560
PCEU	2008	1	−4.828***	−3.560
$PCCO_2$	2008	3	−3.298*	−3.560
ΔRPCGDP	2007	3	−0.876	−3.560
ΔPCEU	2008	0	−4.557***	−3.560
$\Delta PCCO_2$	2008	0	−6.944***	−3.560

Azerbaijan

ZA tests

Variable	(a) T_b	(a) k	(a) t_{min}	(b) T_b	(b) k	(b) t_{min}
RPCGDP	2005	1	−8.014*** (−4.80)	2000	1	−3.806 (−4.42)
PCEU	2003	0	−3.585 (−4.80)	1997	0	−3.082 (−4.42)
$PCCO_2$	2005	0	−4.645* (−4.80)	1996	0	−4.831** (−4.42)
ΔRPCGDP	2008	0	−3.502 (−4.80)	2006	0	−2.681 (−4.42)
ΔPCEU	2007	3	−6.136*** (−4.80)	2002	0	−5.528*** (−4.42)
$\Delta PCCO_2$	2009	1	−3.246 (−4.80)	1999	1	−3.320 (−4.42)

CMR tests

Variable	Optimal break point	k	t-statistic	5% critical value
RPCGDP	2008	1	−3.106	−3.560
PCEU	1997	0	−2.992	−3.560
$PCCO_2$	2006	0	−4.126***	−3.560
ΔRPCGDP	2007	1	−3.934***	−3.560
ΔPCEU	2008	0	−5.149***	−3.560
$\Delta PCCO_2$	2006	0	−4.126***	−3.560

Georgia

ZA tests

Variable	(a) T_b	(a) k	(a) t_{min}	(b) T_b	(b) k	(b) t_{min}
RPCGDP	2005	1	−4.782* (−4.80)	2008	1	−3.471 (−4.42)
PCEU	2004	2	−4.966** (−4.80)	2009	2	−3.567 (−4.42)
$PCCO_2$	2005	1	−5.054** (−4.80)	1996	1	−5.944*** (−4.42)
ΔRPCGDP	2008	1	−5.357*** (−4.80)	2006	1	−4.376* (−4.42)
ΔPCEU	1996	0	−8.670*** (−4.80)	1997	0	−8.652*** (−4.42)
$\Delta PCCO_2$	2003	2	−13.842*** (−4.80)	2007	2	−9.557*** (−4.42)

CMR tests

Variable	Optimal break point	k	t-statistic	5% critical value
RPCGDP	2004	0	−2.060	−3.560
PCEU	1996	1	−6.909***	−3.560
$PCCO_2$	2005	2	−5.197***	−3.560
ΔRPCGDP	2005	1	−5.607***	−3.560
ΔPCEU	2007	1	−6.934***	−3.560
$\Delta PCCO_2$	2005	4	−4.181***	−3.560

(Contd..)

Table 3: ***(Continued)***

Turkey						
ZA tests						
Variable	(a)			(b)		
	T_b	k	t_{min}	T_b	k	t_{min}
RPCGDP	2005	0	−3.455 (−4.80)	2002	0	−3.013 (−4.42)
PCEU	2001	0	−4.006 (−4.80)	2003	0	−2.812 (−4.42)
$PCCO_2$	2001	0	−4.137 (−4.80)	2003	0	−2.823 (−4.42)
ΔRPCGDP	2008	0	−5.285** (−4.80)	1997	0	−5.085*** (−4.42)
ΔPCEU	2003	0	−5.483*** (−4.80)	2000	0	−4.909** (−4.42)
$\Delta PCCO_2$	2003	0	−5.587*** (−4.80)	1996	0	−5.001 (−4.42)

CMR tests				
Variable	Optimal break point	k	t-statistic	5% critical value
RPCGDP	2004	0	−2.758	−3.560
PCEU	2003	0	−2.645	−3.560
$PCCO_2$	2004	0	−2.568	−3.560
ΔRPCGDP	1999	1	−4.285***	−3.560
ΔPCEU	1999	1	−5.000***	−3.560
$\Delta PCCO_2$	1991	1	−5.140***	−3.560

(a) refers to the model allowing for break in intercept and (b) the model allowing for break in trend. T_b is the break date endogenously selected. t_{min} is the minimum t-statistic. k denotes the lag length. 5% Critical Values are given in parentheses. ***P<0.01, **P<0.05, *P<0.1. PCEU: Per capita equivalent

Table 4: ARDL bounds test estimation results

Model for estimation	Lag length	*F*-statistics	Significance level	Critical bound *F*-statistics	
				I(0)	I(1)
Armenia					
$F_{RPCGDP}^{PCEU,PCCO_2}$	2	2.349	1	5.15	6.36
			2.5	4.41	5.52
$F_{PCEU}^{RPCGDP,PCCO_2}$	2	84.304***	5	3.79	4.85
			10	3.17	4.14
$F_{PCCO_2}^{PCEU\ RPCGDP}$	2	36.344***			
Azerbaijan					
$F_{RPCGDP}^{PCEU,PCCO_2}$	4	4.266*	1	5.15	6.36
			2.5	4.41	5.52
$F_{PCEU}^{RPCGDP,PCCO_2}$	4	4.553*	5	3.79	4.85
			10	3.17	4.14
$F_{PCCO_2}^{PCEU,RPCGDP}$	4	9.334***			
$F_{PCCO_2}^{PCEU,RPCGDP}$	4	9.334***			
Georgia					
$F_{RPCGDP}^{PCEU,PCCO_2}$	2	4.777*	1	5.15	6.36
			2.5	4.41	5.52
$F_{RPCGDP}^{PCEU,PCCO_2}$	2	20.579***	5	3.79	4.85
			10	3.17	4.14
$F_{PCCO_2}^{PCEU,RPCGDP}$	2	9.097***			
Turkey					
$F_{PCCO_2}^{PCEU,RPCGDP}$	1	1.773	1	5.15	6.36
			2.5	4.41	5.52

(Contd...)

Table 4: ***(Continued)***

Model for estimation	Lag length	*F*-statistics	Significance level	Critical bound *F*-statistics	
				I(0)	I(1)
$F_{PCEU}^{RPCGDP, PCCO_2}$	1	5.732**	5	3.79	4.85
			10	3.17	4.14
$F_{PCCO_2}^{PCEU\ RPCGDP}$	1	5.834**			

Asymptotic critical value bounds are obtained from table F-statistic in Pesaran et al. (2001). ***P<0.01, **P<0.05, *P<0.10. PCEU: Per capita equivalent

Table 5: Gregory and Hansen cointegration tests

Country	Constant	Constant and trend	Constant and slope	Constant, slope and trend
Dependent variable: RPCGDP				
Armenia	−4.90 (2009)	−4.89 (2001)	−4.84 (2009)	−4.89 (2001)
Azerbaijan	−3.87 (2001)	−5.76* (2010)	−6.19*** (1999)	−5.75* (2001)
Georgia	−3.66 (2004)	−7.30*** (1995)	−3.96 (1999)	−7.41*** (1997)
Turkey	−3.35 (2002)	−3.37 (2002)	−3.61 (2002)	−3.69 (2002)
Dependent variable: PCEU				
Armenia	−5.16** (1994)	−5.06* (1994)	−5.07 (1994)	−6.96*** (1996)
Azerbaijan	−3.96 (2007)	−3.92 (2001)	−4.23 (2003)	−5.16 (2003)
Georgia	−9.47*** (1996)	−9.65*** (1996)	−10.95*** (1996)	−9.68*** (1997)
Turkey	−5.11** (1994)	−5.68** (2006)	−5.11 (1997)	−5.81* (2006)
Dependent Variable: $PCCO_2$				
Armenia	−5.48** (2009)	−6.82*** (2001)	−7.16*** (1994)	−8.14*** (1996)
Azerbaijan	−3.63 (2007)	−5.22* (2010)	−7.11*** (1999)	−6.80*** (2001)
Georgia	−9.14*** (1996)	−8.99*** (1995)	−8.60*** (1999)	−8.48*** (1997)
Turkey	−5.23** (2005)	−5.88*** (2006)	−6.20*** (2006)	−8.44*** (2006)

5% Critical Values: −4.92, −5.29, −5.50, −5.96 respectively. ***P<0.01, **P<0.05, *P<0.1. Breakpoint date in parentheses. PCEU: Per capita equivalent

cointegration relations have been found. The results of causality tests show that, for Armenia, energy use and CO_2 emissions are both driven by real GDP, in line with the "conservation hypothesis" (a unidirectional causality running from economic growth to energy). For Azerbaijan and Georgia we reached mixed results, inasmuch as both "feedback hypothesis" and "growth hypothesis" received support by empirical findings. Finally, no causality link is found for Turkey, indicating that "neutrality hypothesis" holds.

The "conservation hypothesis" prevailing in Armenia is supported if an increase in GDP causes an increase in energy use (Ozturk, 2010). Therefore, in this situation energy conservation policies designed to reduce energy use and waste will have little or no effect on economic growth. For Azerbaijan and Georgia, bidirectional causality corresponds with the "feedback hypothesis," which argues that energy and real GDP affect each other simultaneously. In this case, policymakers should take into account the feedback effect of real GDP on energy consumption by implementing regulations to reduce energy use. Additionally, economic growth should be decoupled from energy consumption to avoid a negative impact on economic development resulting from a reduction of energy use. Whilst the "growth hypothesis" suggests that energy use is a crucial component in growth, directly or indirectly as a complement to capital and labour as input factors of production. Hence, a decrease in energy use causes a decrease in real GDP. In this case, the economy is called 'energy dependent', and energy conservation policies may be implemented with adverse effects on real GDP. Finally, the "neutrality hypothesis" prevailing in Turkey indicates that reducing energy use does not affect economic growth, or vice versa. Hence, energy conservation policies would not have any impact on real GDP.

To sum up, given the different causality links in the area, it would not be advisable for this group of countries to implement common energy policy strategies.

6. SUGGESTIONS FOR FUTURE RESEARCHES

Given the little amount of studies devoted to the analysis of the nexus between economic growth, energy consumption, and emissions for South-Caucasus, new studies may concern the estimation of the EKC for the area. Moreover, new studies on the relationship between disaggregated energy sources and economic growth would be useful for an adequate energy policies planning (Magazzino, 2012). Finally, panel data analyses using P-VAR approach could shed new light on energy policies of these countries (Magazzino, 2014a).

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Table 6: Results of causality tests

Armenia							
Toda and Yamamoto tests							
Multivariate				Bivariate			
Dependent variables	Independent variables			Dependent variables	Independent variables		
	RPCGDP	PCEU	CO_2		RPCGDP	PCEU	CO_2
RPCGDP	-	3.077 (0.380)	5.643 (0.130)	RPCGDP	-	0.765 (0.682)	4.434 (0.109)
PCEU	8.611** (0.035)	-	1.750 (0.626)	PCEU	25.473*** (0.000)	-	2.656 (0.448)
$PCCO_2$	7.886** (0.035)	11.872*** (0.008)	-	$PCCO_2$	9.942*** (0.007)	15.832*** (0.001)	-
Granger tests							
RPCGDP	-	0.694 (0.405)	0.152 (0.696)	RPCGDP	-	1.206 (0.272)	0.651 (0.420)
PCEU	2.304 (0.129)	-	0.084 (0.773)	PCEU	3.177* (0.075)	-	0.870 (0.768)
$PCCO_2$	4.443** (0.035)	0.586 (0.444)	-	$PCCO_2$	3.850** (0.050)	0.087 (0.768)	-
Azerbaijan							
Toda and Yamamoto tests							
RPCGDP	-	14.550*** (0.006)	6.024 (0.197)	RPCGDP	-	11.717*** (0.008)	8.435*(0.077)
PCEU	30.429*** (0.000)	-	45.750*** (0.000)	PCEU	2.862 (0.413)	-	22.241*** (0.000)
$PCCO_2$	121.26*** (0.000)	123.540*** (0.000)	-	$PCCO_2$	55.112*** (0.000)	56.308*** (0.000)	-
Granger tests							
RPCGDP	-	13.246*** (0.004)	2.597 (0.458)	RPCGDP	-	2.179 (0.140)	2.370 (0.499)
PCEU	12.803*** (0.005)	-	15.884*** (0.001)	PCEU	3.278* (0.070)	-	4.168 (0.244)
$PCCO_2$	39.027*** (0.000)	123.910*** (0.000)	-	$PCCO_2$	7.792* (0.051)	46.182*** (0.000)	-
Georgia							
Toda and Yamamoto tests							
RPCGDP	-	17.925*** (0.001)	22.669*** (0.000)	RPCGDP	-	12.783*** (0.005)	3.868 (0.145)
PCEU	9.299* (0.054)	-	2.502 (0.644)	PCEU	18.268*** (0.000)	-	1.757 (0.415)
$PCCO_2$	18.054*** (0.001)	27.599*** (0.000)	-	$PCCO_2$	16.229*** (0.000)	26.037*** (0.000)	-
Granger tests							
RPCGDP	-	13.313*** (0.004)	8.486** (0.037)	RPCGDP	-	10.747*** (0.005)	1.293 (0.256)
PCEU	4.064 (0.255)	-	3.539 (0.316)	PCEU	1.025 (0.599)	-	0.009 (0.926)
$PCCO_2$	11.899*** (0.008)	11.818*** (0.008)	-	$PCCO_2$	14.449*** (0.000)	13.779*** (0.000)	-
Turkey							
Toda and Yamamoto tests							
RPCGDP	-	8.212** (0.016)	7.924** (0.019)	RPCGDP	-	0.330 (0.848)	0.123 (0.940)
PCEU	6.281** (0.043)	-	5.073* (0.079)	PCEU	3.419 (0.181)	-	2.342 (0.310)
$PCCO_2$	8.447** (0.015)	6.565** (0.038)	-	$PCCO_2$	5.607* (0.061)	3.913 (0.141)	-
Granger tests							
RPCGDP	-	5.458* (0.065)	5.558* (0.062)	RPCGDP	-	0.235 (0.628)	0.059 (0.808)
PCEU	3.374 (0.185)	-	4.011 (0.135)	PCEU	1.282 (0.258)	-	0.604 (0.437)
$PCCO_2$	4.297 (0.117)	5.572* (0.062)	-	$PCCO_2$	0.614 (0.433)	0.556 (0.456)	-

Wald tests (P-values in parentheses), ***P<0.01, **P<0.05, *P<0.1. PCEU: Per capita equivalent

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