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Causality Relationship between GDP and Energy Consumption in Georgia, Azerbaijan and Armenia

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ABSTRACT: This research aims to investigate the relationship between energy consumption and economic growth in Georgia, Azerbaijan and Armenia during the period of 1995–2009. The Engle-Granger cointegration and Granger causality tests are used in order to analyse the causal relationship between energy consumption and economic growth. It is crucial to see the directions of causality between two variables for the policy makers. For Georgia and Azerbaijan it is found that these two variables are not cointegrated. In case of Armenia these two variables are cointegrated. Accordingly, causality analysis is conducted for Armenia. The research outcomes reveal that there is unidirectional causality from per capita GDP to per capita energy consumption for Armenia.

Keywords: Economic growth; Energy consumption; Granger causality
JEL Classifications: O43; C22

1. Introduction

The question of the possibility of energy consumption affection towards the economic growth has received a significant attention in the literature related to energy economics. Government, academics and researchers alike are concerned with the impact of energy consumption on the economy. Some researchers argue that energy is as important input as well as other factors of production, for instance, capital and labor. That makes energy crucially required for economic growth. In contrary to that idea, some argue that energy consumption is only a small part of GDP and does not have a significant impact on economic growth.

Knowing the causality relationship between energy consumption and economic growth, it will assist the policy makers to determine an appropriate policy on energy conservation. For instance, if the energy consumption causes economic growth, the decreasing energy consumption may result in low income, unemployment or budget deficit. However, if energy consumption does not cause GDP then it is possible to implement energy conservation policy. Therefore, it is very important for policymakers to know the causal relationship between the two variables. Some academics examined the relationship between energy consumption and GDP for different countries, still consensus has not been reached on the issue. These conflicting empirical results are due to different time periods, different variables used, countries studied and different econometric methodologies used.

The aim of this paper is to analyze the causal relationship between energy consumption and economic growth in Georgia, Azerbaijan and Armenia using annual data for the periods of 1995-2009. There is no published empirical study which explores the relationship between energy consumption

and economic growth for these countries.[1] The present study aims to fill this gap in the empirical literature. Such researches will provide insights with respect to the role of energy consumption in economic developments for these countries. The first part of the study deals with a review of existing literature related to the energy-GDP nexus, theories and empirical findings are presented in Table 1. However, the consensus has not been achieved in the direction of causality. Findings of the studies are ranging from bi-directional or uni-directional to no directional causality.

Table 1. Overview of selected studies on energy-GDP nexus

Study	Method	Countries	Result
Kraft and Kraft (1978)	Bivar. Sims Causality	USA	Growth → Energy
Yu and Choi (1985)	Granger Test	US, UK, Poland	Growth — Energy
		Korea, Philippines	Energy → Growth
Masih and Masih (1996)	Sims Causality, Granger Causality	Malaysia, Singapore	Growth — Energy
		Philippine	Growth — Energy
		Pakistan	Growth ↔ Energy
		India	Energy → Growth
		Indonesia	Growth → Energy
Yu and Jin (1992)	Bivar. Granger test	USA	Growth — Energy
Stern (1993)	Granger Causality	USA	Growth — Energy
Glasure and Lee (1998)	Bivar. VECM	S. Korea & Singapore	Growth ↔ Energy
Cheng (1999)	Granger Causality	India	Growth → Energy
Asafu-Adjaye (2000)	Trivar. VECM	India & Indonesia	Energy → Growth
		Thailand & Philippines	Growth ↔ Energy
Soytas and Sari (2003)	Bivar. VECM	Turkey, S. Korea	Growth → Energy
		Argentina	Growth ↔ Energy
		Canada, USA & UK	Growth ↔ Energy
Fatai et al. (2002)	Granger Causality	New Zealand	Growth — Energy
Altinay and Karagol (2004)	Hsiao`s version of Granger Causality	Turkey	Growth — Energy
Oh and Lee (2004)	Trivar. VECM	South Korea	Growth ↔ Energy
Narayan and Smyth (2008)	Multiv. Panel VECM	G7 Countries	Energy → Growth
Apergis and Payne (2009)	Multiv. Panel VECM	11 countries of the Commonwealth of Independent States	Growth ↔ Energy
Ozturk et al. (2010)	Panel Causality	51 countries	
		Low income	Growth → Energy
		Lower middle income	Growth ↔ Energy
		Upper middle income	Growth — Energy
Lee and Lee (2010)	Multiv. Panel VECM	25 OECD Countries	Growth ↔ Energy
Bekle et al. (2010)	Granger Causality Test	25 OECD Countries	Growth ↔ Energy
Binh (2011)	Tresh. Coint and VECM	Vietnam	Growth → Energy
Kaplan et al. (2011)	Granger Causality Test	Turkey	Growth ↔ Energy
Adom (2011)	Toda Yamamoto Granger Causality Test	Ghana	Growth → Energy
Souhila & Kourbali (2012)	Granger Causality Test	Algeria	Growth → Energy
Apergis and Danuletiu (2012)	Panel Cointegration and VECM	Romania	Energy → Growth

Note: Growth → Energy means that the causality runs from economic growth to energy consumption. Growth ↔ Energy means that bi-directional causality exists between economic growth and energy consumption. Growth ----- Energy means that no causality exists between economic growth and energy consumption.
Energy → Growth means that the causality runs from energy consumption to economic growth.

[1] See Ozturk (2010) for a literature survey on the causal relationship between energy consumption and economic growth. Renolds and Kolodzieji (2008) examine the former Soviet Union and focuses exclusively on the bivariate Granger-causality relationship between oil, coal and natural gas production and GDP.

Pioneering study of the subject by Kraft and Kraft (1978) reports that causality runs from GNP to energy consumption for the USA over the period of 1947-1974 by using the Sims Granger methodology. However, in their research Yu and Jin (1992) conclude that no causality exists between two afore-mentioned variables for the USA.

Oh and Lee (2004) used the vector ECM in order to analyze the energy consumption - GDP nexus for South Korea, during the period of 1970-1999. They provide the evidence to support the bi-directional causality between energy and GDP. Moreover, Soytas and Sari (2003) examined the causality of energy and GDP for Turkey by using VECM, and found that causality runs from energy to GDP.

Cheng (1999) examined the causality between energy consumption and economic growth for India. The study revealed that causality is found from economic growth to energy consumption. Another study by Fatai et al (2004) analyzed causality relationship between employment, energy consumption and economic growth in New Zealand. According to the foundings there is no unidirectional causality from electricity consumption to employment and from oil to employment.

Yu and Choi (1985) studied the relationship between GNP and various types of energy consumptions for some countries. They found causal relationship from GNP to total energy consumption for South Korea and from total energy consumption to GNP for Philippines but did not find any causal linkages for US, UK and Poland. Masih and Masih (1996) considered six Asian countries (Philippines, Pakistan, India, Indonesia, Malaysia and Singapore) in order to find the causality between energy consumption and income. The study shows that two variables to be co-integrated for India, Pakistan and Indonesia, energy consumption is causing income in India, income is causing energy consumption in Indonesia and bi-directional causality exist in Pakistan. There could not be found any causality for the rest of the countries Philippines, Malaysia and Singapore).

As mentioned above, conflicting results are due to different countries, different methodologies and different period covered in different studies.

The rest of the paper is organized as follows. Section 2 includes review of energy sector in Georgia, Azerbaijan and Armenia. Section 3 describes the methodology employed and the sources of data collected. Section 4 reports the estimated results. Last section is the conclusion.

2. Energy Sector in Georgia, Azerbaijan and Armenia

Table 2 below provides an overview of the energy consumption and production, and level of economic development of Georgia, Azerbaijan and Armenia. Azerbaijan is net exporter of oil whilst Georgia and Armenia are net importers of oil. Although Azerbaijan is producing sufficient amount of natural gas, still Azerbaijan, Georgia and Armenia rely on natural gas imports from Russia to meet their consumption needs. There is no significant coal production and consumption for afore-mentioned countries.

The source of electricity production varies from country to country. The percentage of electricity production from oil is 27.68 % for Azerbaijan, 0.91 % for Georgia and 0.00% for Armenia. Armenia does not have any natural gas or oil reserves, and imports all consumed energy (oil or oil products from Georgia, Iran, Russia and Europe; gas exclusively from Russia through Georgia; and nuclear fuel from Russia). The percentage of electricity production from Hydroelectric is 85.81 % for Georgia, 14.18 % for Azerbaijan and 28.07 % for Armenia. Georgia is very rich with the rivers; there are 26,000 rivers within the territory of the country and around 300 rivers are significant in terms of energy production[2]. The percentage of electricity production from natural gas ranges from 58.14 % in Azerbaijan to 13.28 % in Georgia, the percentage of electricity production from nuclear ranges from 43.00 % for Armenia to 0.00 % for Azerbaijan and Georgia.

Efficiency of energy usage as measured by GDP per unit of energy use is changing from 2.77 % for Azerbaijan to 4.91 % for Armenia and Georgia. As indicated in Energy Information Agency report, the variation in the efficiency of energy usage is not surprising knowing that mentioned countries have an aging and inefficient energy infrastructure that needs capital investment and modernization.

[2] For more information, see www.investingeorgia.ge

Table 2. Overview of energy production and consumption (Armenia, Azerbaijan and Georgia)

	Armenia	Azerbaijan	Georgia
Petroleum			
Production	0.00	440.98	1.98
Consumption	40.00	115.00	13.40
Natural gas			
Production	0.00	205.50	0.50
Consumption	60.00	366.60	52.10
Coal			
Production	0.00	0.00	0.00
Consumption	0.10	0.00	0.00
Electricity			
Production	6.32	21.22	7.27
% Oil	0.00	27.68	0.91
% Natural gas	28.94	58.14	13.28
% Coal	0.00	0.00	0.00
% Hydroelectric	28.07	14.18	85.81
% Nuclear	43.00	0.00	0.00
Consumption	4.20	19.20	7.40
Energy intensity	4.91	2.77	4.91
Carbon dioxide			
Emissions per capita	1.20	3.77	0.86
Real GDP			
Per capita	$4162	$4575	$3520

Notes: Petroleum production and consumption measured in thousands of barrels per day. Natural gas production and consumption measured in billion cubic feet. Coal production and consumption measured in million short tons. Electricity production and consumption measured in billion kilowatt hours. Data on petroleum, natural gas, coal, and electricity consumption were obtained from the *Energy Information Agency-International Energy Data and Analysis* (www.eia.doe.gov). Data on electricity production, energy intensity measured in GDP per unit of energy use (constant 2005 PPP international dollars per kilogram of oil equivalent). Carbon dioxide emissions measured in metric tons per capita in 2004. Real GDP per capita measured in constant 2005 PPP international dollars. Data on electricity production, energy intensity, carbon dioxide emissions, and real GDP per capita were obtained from *World Bank Economic Indicators* CD-ROM.

3. Methodology and Data

The conducted empirical researched uses the annual time series data of per capita GDP (PCGDP) and per capita energy consumption (PCEC) for the period of 1995–2009. Data are obtained from the World Development Indicators produced by the World Bank. In this paper, per capita energy consumption is expressed in terms of kg oil equivalent and per capita GDP is expressed in constant 2000 US$. The choice of the starting period was constrained by the availability of data on energy consumption. Figure 1 and Figure 2 below display the historical trends of per capita energy use and per capita GDP in Georgia, Azerbaijan and Armenia. All the variables considered in the model are expressed in natural logarithms.

Figure 1. Per Capita Energy Consumption

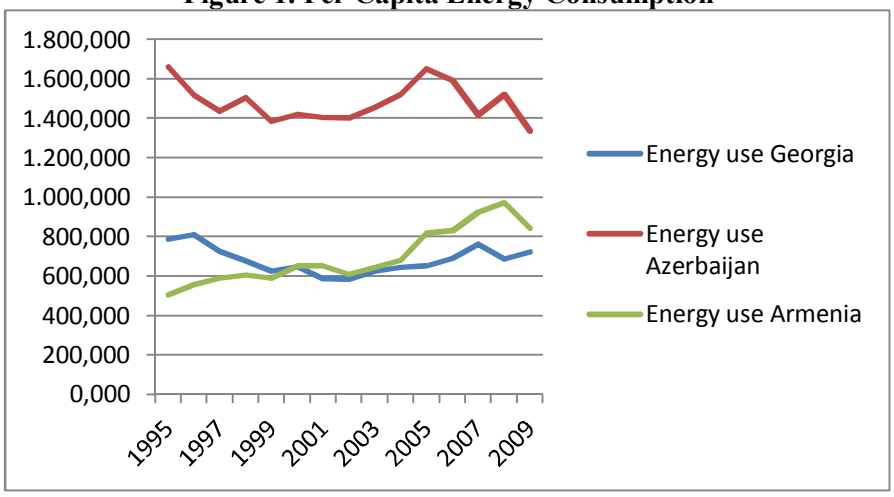
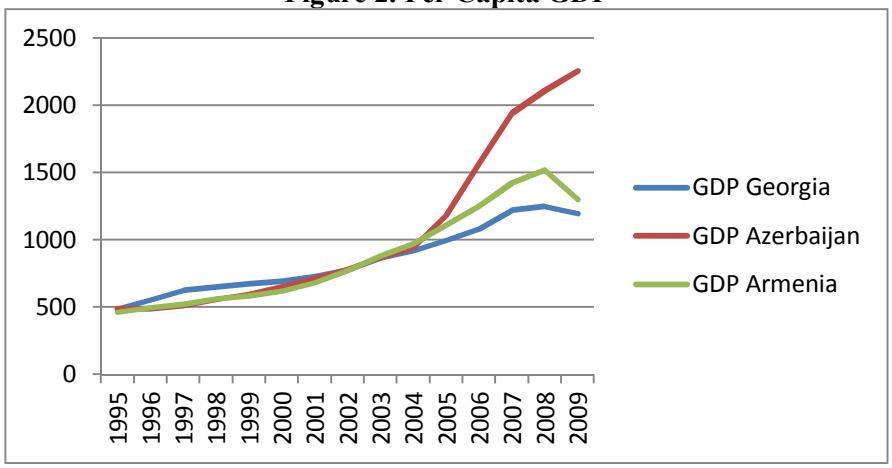


Figure 2. Per Capita GDP



4. Empirical Results

This section analyzes the time-series properties of the data obtained. The Augmented Dickey-Fuller (ADF) unit root test was conducted. The unit-root tests were performed on both levels and first differences of all variables.

As can be seen, Table 3 reports the results of non-stationary tests for PCEC and PCGDP series using Augmented Dickey-Fuller (ADF) test. A constant but no time trend result of ADF tests are reported. Test results indicate that the hypothesis of a unit root in PCEC and PCGDP cannot be rejected as a level. The hypothesis of a unit root in PCEC and PCGDP is rejected as a first difference. These results indicate that all the variables in question are integrated of order one I(1).

Table 3. ADF unit roots test results

Country		Level	AIC(lag)	First Difference	AIC(lag)
Georgia	PCEC	-1,780	-2.425 (0)	-3.556 *	-2.122 (0)
	PCGDP	-0,978	-3,219 (0)	-2.768 **	-3.281 (0)
Azerbaijan	PCEC	-2,683	-2.556 (0)	-4.203 *	-2.347 (0)
	PCGDP	1.906	-2.857 (3)	-2.745 **	-2.731 (1)
Armenia	PCEC	-1.231	-2.104 (0)	-2.883 **	-1.942 (0)
	PCGDP	-0,780	-2.223 (0)	-2.874 **	-2.245 (0)

Note: *,** denote significiantly at the 5% , 10% level respectively.

Having established that all variables are integrated at the same order, the Engle-Granger's (EG) residual-based ADF test was conducted in present research. As the first step of the EG cointegration test, regression equation using the OLS method was estimated. The second step of the

EG procedure considered to check the stationarity of residuals by using the ADF test. Table 4 below represents the results from Engle-Granger (EG) cointegration test. These results indicate that long-run equilibrium exists between PCGDP and PCEC for only Armenia.

Table 4. Results for EG Cointegration Tests

Country	Model	ADF
Georgia	PCGDP = 9.381 - 0.410^{x} PCEC	-0,502 1^{x}
Azerbaijan	PCGDP = 12.725 - 0.811^{x} PCEC	-1,578 2^{x}
Armenia	PCGDP = -6.338 + 1.996* PCEC	-2,116 0*

Note: *,** denote significiantly at the 5% , 10% level respectively.^{x} denote insignificant.

After finding cointegration for Armenia, the causality among variables was investigated. As Granger (1988) points out, if there exists a cointegration vector between PCGDP and PCEC, there is causality among these variables at least in one direction. Thus, Granger causality test are employed to determine the causal relationships between PCGDP and PCEC. There are four possible outcomes regarding causal relationships between PCGDP and PCEC: unidirectional causality from PCGDP and PCEC or vice versa; bidirectional causality between the two variables; and, lack of any causal relationship.

In table III the causality test results between PCGDP and PCEC is reported for Armenia. Lag length is selected by using the SC criterion. The probability values for F statistics are given on the right side of Table 5 below. If these probability values are less than any α level, then the hypothesis would be rejected at that level. We found uni-directional causality running from PCGDP to PCEC for Armenia. The content of policy implications has been determined according to the direction of causality between these two variables.

Table 5. Results for Granger CausalityTests for Armenia

Null Hypothesis:	Lag	F-Statistic	Prob.	Result
PCEC does not Granger Cause **PCGDP**	1	2.81556	0.12151	
PCGDP does not Granger Cause **PCEC**		9.90136	0.03345	PCGDP $\Rightarrow$ PCEC

5. Conclusion

It is important to know the relationship between energy consumption and economic growth in order to have efficient design and implementation of the energy and environmental policies. Precisely for these countries that are facing constrained energy supply, energy conservation can help address energy shortage in addition to safeguard the environment. The policy of energy conservation may also allow non-renewable resources to be available for the next generations.

The conducted research examines the causal relationship between energy consumption and economic growth in Georgia, Azerbaijan and Armenia for the 1995–2009 periods. Using Engle-Granger cointegration and Granger causality tests for Georgia and Azerbaijan, it is found that these two variables are not cointegrated. In case of Armenia these two variables are cointegrated. Thus, causality analysis was carried out for Armeniacthe results of which reveal that there is unidirectional causality from per capita GDP to per capita energy consumption for Armenia.

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