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The Relationship between Energy Consumption and Economic Growth: Evidence from Azerbaijan

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ABSTRACT

The study investigates the causal relationship between energy consumption and economic growth in Azerbaijan using annual data covering the period from 1990 to 2015. We used Toda-Yamamoto causality test framework of vector autoregressive (VAR) model to test causal relationship between the variables. The results of this test show that there is bidirectional causality between energy consumption and economic growth. Findings of the study might be useful tool for the similar economies to give appropriate energy related policy decisions.

Keywords: Energy Consumption, Economic Growth, Toda-Yamamoto Causality Test, Azerbaijan
JEL Classifications: C22, Q43, Q48

1. INTRODUCTION

Energy consumption and economic growth have been known to be highly correlated. This relationship brought out the concerns such as environmental problems caused by economic growth, energy security and some others (Liddle and Lung, 2014). In this regard the type of the causal and directional relationship between these two indicators play significant role in making policy decisions in an economy. A vast literature devoted to this relationship, but the conclusion on the nexus is not unified, and four hypotheses (growth, conservative, feedback and neutral) dominate in the literature (Damette and Seghir, 2013; Hasanov and Mikayilov, 2017 inter alia). The growth hypothesis assumes that energy consumption causes economic growth. Consecutively, any decline in energy consumption as a result of conservation policies will be negatively affect the economic growth. The conservation hypothesis assumes that the economic growth is the main factor of energy consumption and therefore, economic growth will have followed by an increase in energy consumption. The feedback hypothesis postulates a bi-directorial causality: Energy consumption affects growth and vice versa. Finally, the neutrality hypothesis indicates no causal relationship between energy consumption and growth (Ahmed and Azam, 2016; Chen et al., 2007; Yoo, 2006; Hasanov et al., 2017). Obviously, the appropriate policy decisions vary depending the type of the relationship. For example, if energy consumption causes economic growth, then energy reduction policies could negatively affect the economy, while if no such causality exists between energy and GDP, then energy conservation and economic growth may be practiced together (Masih and Masih, 1997).

Taking into account the above mentioned factors, the objective of the current study is to investigate the causal relationship between energy consumption and economic growth in the case of Azerbaijan. The factors such as being the representative of former Soviet countries as well as oil-exporting developing countries have led us to investigate this relationship in the Azerbaijani case.

The contribution of the study listed as follow: (a) It studied the energy consumption-economic growth relationship in the case of Azerbaijan, which is rarely investigated example under energy-income framework, and is a good representative for the similar economies, (b) it uses the Toda-Yamamoto causality test, which to the best of our knowledge has not been applied to the Azerbaijani case.

The rest of the paper structured as follow: Section 2 briefly reviews the related literature, Energy Sector in Azerbaijan described in Section 3, the Section 4 gives the employed data and methodology, empirical results are given in Sections 5 and 6 concludes the paper.

2. LITERATURE REVIEW

In this section the similar studies devoted to the energy consumption-economic growth causality relationship are reviewed. For the sake of easiness, the reviewed literature results are summarized in the Table 1. As it can be seen from the Table 1, there are vast of studies in energy economics literature tried to understand causal relationship between a country's energy consumption and economic growth. The direction of causality can help the policymakers take the most appropriate decisions. Based on the empirical studies on the causal relationship between energy consumption and economic growth, there is evidence to support bidirectional or unidirectional causality, or no causality, between energy consumption and economic growth.

The results of the studies tabulated in Table 1 can be briefly categorized as follow.

Unidirectional causality running from economic growth to energy consumption was revealed by Keppler (2006) for India, by Ozturk et al. (2010) for low-income countries, by Binh (2011) for Vietnam, by Adom (2011) for Ghana, and by Souhila and Kourbali (2012) for Algeria, by Kalyoncu et al. (2013) for Armenia, by Lise and Montfort (2007), Özata (2010), Uzunöz and Akçay (2012) and Ümit and Bulut (2015) for Turkey.

In other hand, studies such as Keppler (2006) for China, Narayan and Smyth (2008) for G7 Countries, Apergis and Danuletiu (2012) for Romania, Karagöl et al. (2007), for Turkey found unidirectional causality running from energy consumption to economic growth.

Moreover, bidirectional causality was found by Apergis and Payne (2009) for 11 countries of the Commonwealth of Independent States, by Ozturk et al. (2010) for lower-middle income, by Lee and Lee (2010), Bekle et al. (2010) for 25 OECD Countries, by Pao et al. (2014) for Brazil, by Rezitis and Ahammad (2015) for South and Southeast Asian countries, by Vafaeirad et al. (2015) for 7 Asian countries, by Al-mulali and Mohammed (2015) for Emerging countries, Osigwe and Arawomo (2015) for Nigeria and Khobai and Roux (2017) for south Africa. In addition to them, Erdal et al. (2008), Kaplan et al. (2011), Akpolat and Altıntaş (2013), Bayar (2014), Çakmak (2015) for Turkey reached the similar conclusion.

In some studies, like Ozturk et al. (2010) for upper-middle income, Kalyoncu et al. (2013) for Georgia and Azerbaijan results indicated no causality between energy consumption and economic growth. Similarly, Jobert and Karanfil (2007), Ozturk and Acaravci (2010), Çetin and Seker (2012) for Turkey emphasized the same conclusion in their studies.

While considering these studies, it can be seen that different types of the methods were used in these studies, such as VAR, VECM, Granger Causality, Johansen-Juselius Cointegration, Toda-Yamamoto causality test and so on. As can be seen from the Table 1, if we focus on papers studying the relationship in the case of Azerbaijan, namely Apergis and Payne (2009), Bildirici and Kayıkçı (2012), Tang and Abosedra (2014), Senturk and Sataf (2015) and Hasanov et al. (2017) employed the panel estimation methods, which might not take into account the country specific features of the relationship. Only Kalyoncu et al. (2013) used time series data for individual countries, but they used relatively old data set, namely the study employed 1995-2009 interval. Hasanov et al. (2017) devoted to the energy-growth nexus in the oil exporting countries, including Azerbaijan, is a valuable study with the wide literature review and estimating the relationship for the mentioned countries. However, the study makes use of conventional Granger causality not Toda-Yamamoto approach. Taking into account the fact that there is not individual study investigating the energy use-income relationship in the case of Azerbaijan, the objective of the current paper is analyzing the relationship employing Azerbaijani data. We chose Azerbaijan as a representative for the similar countries. It can be seen representative for different country cases from different aspects. First, it is an oil-reach developing country, second, Azerbaijan is one of the former Soviet Union countries. From this perspective, the results of the study might be useful for the above mentioned economies.

3. ENERGY SECTOR IN AZERBAIJAN

To give some insights of Azerbaijani energy sector its general view is depicted in Figure 1 and Table 2.

As it can be seen from the Figure 1, the energy consumption sharply decreased in Azerbaijan for the period of 1990-1996. This decrease can be explained with different factors, such as the shutdown or weakining of the industry sector after the collapse of Soviet Union and the Nagorno-Karabakh war. For the 1996-2010 time span the relative increase with some volitility can be observed in energy consumption and eventually, it begin to increase in the period of 2010-2012. This increase (and decrease in some cases) can be explained with the employed energy policies for the appropriate time intervals.

The energy supply and consumtion for the period of 2010-2015 is given in the Table 2. For this period, the total energy consumption increased, while the supply of cruide oil, which has the biggest share in Azerbaijani energy sector, decreased and supply of natural gas increased as well.

4. METHODOLOGY AND DATA

In the study the Toda and Yamamota (1995) causality method is employed. Toda and Yamamoto (1995) test does not require knowledge of the integration and cointegration properties of the system. It can be applied even when there is no integration or stability, and when rank conditions are not satisfied 'so long as the order of integration of the process does not exceed the true lag length of the model' (Toda and Yamamoto, 1995).

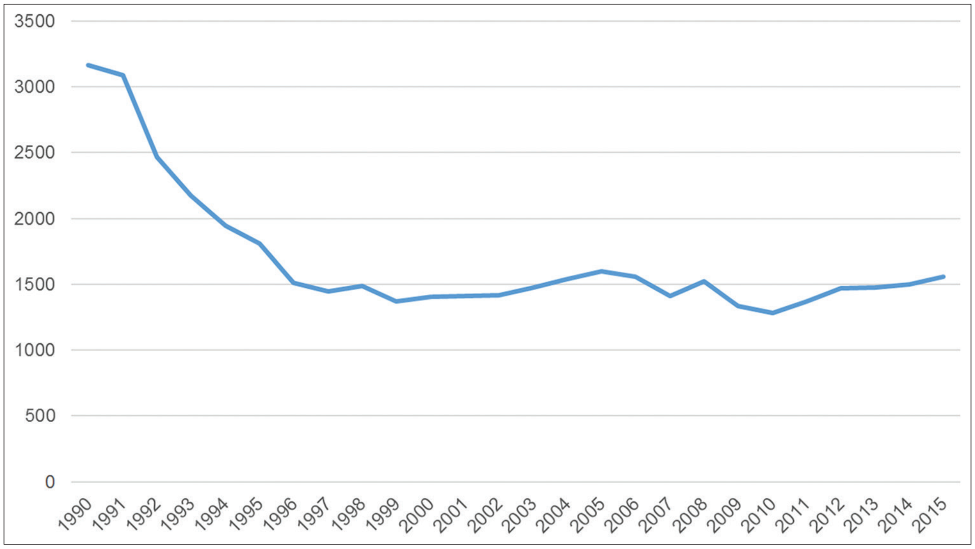
The method includes Modified Wald statistic for testing the significance of the parameters of VAR(k) model. Firstly, it is necessary to determine maximum order of integration of series, denoted by *dmax*. Secondly, it is necessary to determine optimal

Table 1: Similar studies in the literature

Author(s)	Method	Countries	Result
Keppler (2006)	Granger causality	China India	EC→GDP GDP→EC
Karagöl et al. (2007)	Bound test	Turkey	EC→GDP (in short run)
Lise and Van Montfort (2007)	Cointegration	Turkey	GDP→EC
Jobert and Karanfil (2007)	Cointegration, Granger temporal causality	Turkey	GDP----EC (general and in industry)
Erdal et al. (2008)	Johansen-Juselius Cointegration, Granger causality	Turkey	EC↔GDP
Narayan and Smyth (2008)	Multiv. Panel VECM	G7 countries	EC→GDP
Apergis and Payne (2009)	Multiv. Panel VECM	11 countries of the common wealth of Independent States	EC↔GDP
Soytas and Sari (2009)	Toda-Yamamoto causality test	Turkey	GDP----EC
Ozturk and Acaravci (2010)	ARDL bounds testing cointegration	Turkey	GDP----EC
Ozturk et al. (2010)	Panel causality	51 countries Low income Lower middle income Upper middle income	GDP→EC EC↔GDP GDP----EC
Lee and Lee (2010)	Multiv. Panel VECM	25 OECD Countries	EC↔GDP
Bekle et al. (2010)	Granger causality Test	25 OECD Countries	EC↔GDP
Özata (2010)	Granger causality, VECM	Turkey	GDP→EC
Binh (2011)	Tresh. cointegration, VECM	Vietnam	GDP→EC
Kaplan et al. (2011)	Granger causality test	Turkey	EC↔GDP
Adom (2011)	Toda Yamamoto Granger causality test	Ghana	GDP→EC
Kaplan et al. (2011)	Multiv. VECM, Granger causality	Turkey	EC↔GDP
Souhila and Kourbali (2012)	Granger causality test	Algeria	GDP→EC
Apergis and Danuletiu (2012)	Panel Cointegration and VECM	Romania	EC→GDP
Uzunöz and Akçay (2012)	Johansen cointegration, Granger causality	Turkey	GDP→EC
Çetin and Seker (2012)	Toda-Yamamoto causality test	Turkey	GDP----EC
Bildirici and Kayıkçı (2012)	Static panel data approach and GMM	CIS countries, including Azerbaijan	EC→GDP
Akpolat and Altıntaş (2013)	Johansen cointegration, VECM	Turkey	EC↔GDP
Kalyoncu et al. (2013)	The Engle-Granger cointegration, Granger Causality	Georgia, Azerbaijan Armenia	GDP----EC GDP----EC GDP→EC
Bayar (2014)	ARDL, Toda-Yamamoto causality	Turkey	EC↔GDP
Pao et al. (2014)	Granger Causality	Brazil	EC↔GDP
Tang and Abosedra (2014)	Panel GMM, Panel FE and RE OLS	24 Mena countries, including Azerbaijan	EC→GDP
Rezitis and Ahammad (2015)	Panel vector autoregression, Panel Granger causality	South and Southeast Asian countries	EC↔GDP
Vafaeirad et al.(2015)	Panel cointegration, Panel VECM	7 Asian countries	EC↔GDP
Al-mulali and Mohammed (2015)	Dynamic regression, Granger causality	Emerging countries	EC↔GDP
Senturk and Sataf (2015)	Panel FMOLS, Panel DOLS, Panel VECM	Turkish countries, including Azerbaijan	EC↔GDP
Osigwe and Arawomo (2015)	ECM	Nigeria	EC↔GDP
Ümit and Bulut (2015)	Co-integration test	Turkey	GDP→EC
Khobai and Roux (2017)	VECM, Granger causality	South Africa	EC↔GDP
Hasanov et al. (2017)	Panel Granger-causality	10 oil-exporting countries, including Azerbaijan	GDP→EC
Çakmak (2015)	VECM, Granger Causality	Turkey	EC↔ GDP (in long-run)

EC→GDP means that the causality runs from energy consumption to growth (GDP). GDP----EC means that the causality runs from growth to energy consumption. EC↔GDP means that bi-directional causality exists between energy consumption and growth. GDP----EC means that no causality exists between energy

Figure 1: Total energy consumption in Azerbaijan (kg of oil equivalent per capita)



Source: World Bank

Table 2: Energy supply and consumption in Azerbaijan (2010-2015)

	2010	2011	2012	2013	2014	2015
Total energy supply - thousand tonnes of oil equivalent (TOE)	12,566.5	13,594.9	14,390.0	14,630.6	15,085.5	15,569.4
Primary production of all energy products	68,254.6	62,541.5	60,973.9	61,699.5	61,132.0	61,084.2
Crude oil (with NGL)	52,312.5	46,949.4	44,632.7	44,717.7	43,295.9	42,835.5
Natural gas	15,555.6	15,265.2	16,086.9	16,696.1	17,565.1	17,947.3
Renewables and wastes	386.5	326.9	254.3	285.7	271.0	301.4
Energy consumption per capita, TOE/person	1.4	1.5	1.6	1.6	1.6	1.6
Energy capacity						
Energy consumption of per GDP (kg of oil equivalent/1000 manat)	467.4	513.9	532.3	511.2	514.2	527.1
Electro-capacity						
Electricity consumption of per GDP (kg of oil equivalent/1000 manat)	46.4	50.9	60.7	59.2	61.6	63.1
Electricity use per household, kWt hour	2,972.8	3,015.0	3,269.8	3,334.7	3,577.3	3,849.1

Source: The State Statistical Committee of the Republic of Azerbaijan

lag of VAR Model. Thirdly, it is necessary to estimate *(k+dmax)th* order of VAR. The estimination of VAR*(k+dmax)* guarantees the asymptotic chi-square distribution of the Wald statistic. Lastly the hypothesis is tested using a standart Wald statistic test which has an asmptotic chi-square distribution with *m* degress of freedom. According to Toda and Yamamota (1995) causality test model can be written as follows:

$$LY_t = \alpha_0 + \sum_{i=1}^{k}\alpha_{1i}LY_{t-i} + \sum_{j=k+1}^{d_{max}}\alpha_{2j}LY_{t-j} + \sum_{i=1}^{k}\phi_{1i}LE_{t-i} + \sum_{j=k+1}^{d_{max}}\phi_{2j}LE_{t-j} + v_{1t}$$

$$LE_t = \beta_0 + \sum_{i=1}^{k}\beta_{1i}LE_{t-i} + \sum_{j=k+1}^{d_{max}}\beta_{2j}LE_{t-j} + \sum_{i=1}^{k}\delta_{1i}LY_{t-i} + \sum_{j=k+1}^{d_{max}}\delta_{2j}LY_{t-j} + v_{2t}$$

Here, LY and LE are logged gdp and logged energy consumption, *k* is optimal lag order, *d* is the maximum order of integration of the series, and v_{1t} and v_{2t} are error terms.

We used an a annual data of per capita GDP (GDP_pc) and per capita energy consumption (Enuse_pc) from 1990 to 2015. In this paper, per capita energy consumption is denominated with kg oil equivalent and per capita GDP denominated with 2000 US $. Two data set have been taken from The State Statistical Committee of the Republic of Azerbaijan and World Bank. The series were transformed into log form.

5. EMPIRICAL RESULTS

Before conducting the causality testing it is important to determine the order of integration of the series (*dmax*) and the optimal lag length (*k+dmax*), in order to avoid spurious causality or spurious absence of causality. Using Augmented Dickey-Fuler (ADF) unit root test, we found that the *GDP_pc* is non-stationary at its level but Enuse_pc is stationary at level, being integrated of order zero, *I(0)*. On the other hand *GDP_pc* is stationary at second difference, being integrated of order two, *I(2)*[1]. Therefore, the maximum order of integration for the variables in the system is two *dmax* = 2. Results of unit root tests are presented in Table 3.

1 Mikayilov et al. (2017) also found GDP variable to be I(2) as a result of Phillips and Perron test.

The second step in testing for causality is to investigate the optimum lag length (*p*) chosen by *LR, AIC, FPE, SC and HQ* criteria. In order to determine the optimal lag interval in the study, a VAR model containing all dependent variables was estimated with a randomly selected lag interval and determination test of lag interval was applied to the residuals. The Table 4 reports the optimal lag length of 3 (k = 3) out of a maximum of 4 lag lengths as selected by all criteria is found to be 3.

Additionally, Lagrange Multiplier (LM) test was also performed to understand whether there is no autocorrelation problem in the error terms of VAR model. H_0 hypothesis of LM test indicates that there is an autocorrelation problem. Since probability value of the third lag is more than 0.05, this null hypothesis cannot be rejected and it was identified that there is not an autocorrelation problem. The details of this test were demonstrated in Table 5.

To ensure the stability of the VAR model, AR roots must be smaller than 1. As it can be seen from Figure 2, it was determined that all inverse roots are in the unit circle. Owing to this situation, it was identified that VAR model provides stability requirement.

Figure 2: Inverse roots of AR characteristic polynomial

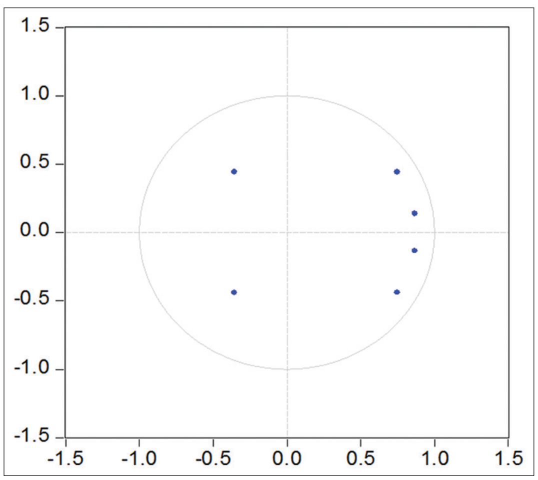


Table 3: ADF test results

Variable	Actual value			Result
	Panel A: Level	Panel B: 1st difference	Panel C: 2nd difference	
Enuse_pc	−3.884759***			İ(0)
GDP_pc	−1.208794	−1.997748	−6.561979***	İ(2)

Maximum lag number is taken 2; *.** and *** accordingly indicates rejection of null hypothesis at 10%, 5% və 1% significance levels; critical values are taken from the table prepared by MacKinnonun (1996). Time period: 1990-2015.

Moreover, White test was used to determine if there is heteroscedasticity problem in the model. In this test, the null hypothesis explains that there is no homoscedasticity. The details of this test were explained in Table 6. As it can be seen, this null hypothesis cannot be rejected because probability value is more than 0.05. In other words, it was determined that there is not heteroscedasticity problem in this model.

The final step in this study is to verify the direction of causality between energy consumption (*Enuse_ pc*) and economic growth (*GDP_pc*) using the Toda and Yamamoto causality test. The empirical results of Granger Causality test based on methodology is estimated through MWALD test and reported in Table 7.

According to Toda Yamamota causality test "*Enuse_pc* does not Granger Cause *GDP_pc*" null hypothesis rejected and also "*GDP_pc* does not Granger Cause *Enuse_pc*" null hypothesis rejected. Consequently, there is observed bi-directional causality between energy consumption and economic growth. Our finding of bidirectional causality is the same with the findings of Apergis and Payne (2009) and Senturk and Sataf (2015) and differs that of Bildirici and Kayıkçı (2012) and Tang and Abosedra (2014), who found unidirectional causality running from energy consumption to economic growth and differs Kalyoncu et al. (2013) result of no causal relationship and also, that of Hasanov et al. (2017) finding with causality running from gdp to energy consumption.This may be because of using different methods and periods.

6. CONCLUSION

Explaining the relationship between energy consumption and economic growth can play a significant role in setting and adjustment of policies on energy sector. Given the close relationship between Energy consumption and economic growth in selected countries, determination of quality of the relationship between these two variables helps effectively to explain the policies of the energy sector.

This study examined the causal relationship between energy consumption and economic growth in Azerbaijan using annual data covering the period from 1990 to 2015 within a vector autoregressive (VAR) framework. Applying a modified version of the Granger causality test due to Toda and Yamamoto, we found bidirectional causality between energy consumption and economic growth.

If bidirectional causality is found, economic growth may demand more energy whereas more energy consumption may induce

Table 4: Lag interval tests

Lag	LogL	Information Criteria				
		LR	FPE	AIC	SC	HQ
0	−11.93144	NA	0.012166	1.266494	1.365680	1.289859
1	39.76134	89.28753	0.000160	−3.069213	−2.771656	−2.999118
2	47.37148	11.76111	0.000117	−3.397407	−2.901479	−3.280581
3	59.59044	16.66223*	5.69e-05*	−4.144586*	−3.450286*	−3.981029*
4	62.00599	2.854741	6.95e-05	−4.000545	−3.107874	−3.790258

Table 5: Lagrange multiplier test results

Lag	LM statistics	Probability
1	4.171287	0.3833
2	2.944115	0.5672
3	1.475307	0.8310
4	7.348087	0.1186
5	2.459707	0.6519
6	4.696459	0.3199
7	2.522293	0.6406
8	1.660984	0.7978
9	5.715623	0.2214
10	9.303060	0.0540
11	5.878493	0.2084
12	5.220248	0.2654

Table 6: White test results

Chi-square	df	Probability
45.96976	48	0.5564

Table 7: Toda Yamamoto test results

Null hypothesis	Lag (k)	k+dmax	Chi-square test	Conclusion
Enuse_pc does not Granger *Cause Gdp_pc*	3	5	22.44202 (0.0001)*	Reject
Gdp_pc does not Granger Cause *Enuse_pc*	3	5	9.179782 (0.0270)*	Reject

*Significance at the 5% level

economic growth. Energy consumption and economic growth may complement each other and energy conservation measures may negatively affect economic growth. Based on the findings, we therefore, recommend the policies that promote energy consumption and economic growth be introduced.

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