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The Relationship between Renewable Energy Consumption and Economic Growth in Azerbaijan

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ABSTRACT

This article examines the causal relationship between renewable energy consumption (REC) and economic growth (EG) in the case of Azerbaijan using annual data from 1992 to 2015. The Toda-Yamamoto causality test framework of vector autoregressive model is utilized to test the causal relationship between the variables. The results of this test reveal that there is unidirectional causality running from EG to REC. The study's findings might be a helpful tool for Azerbaijani policymakers and oil-rich economies to make renewable energy-related policy decisions.

Keywords: Renewable Energy, Toda-Yamamoto Causality Test, Economic Growth, Azerbaijan
JEL Classifications: C22; Q43; Q50; O13

1. INTRODUCTION

Energy is an important variable for economic growth (EG). For producer energy is a main input. Price hikes of this input directly increase the production cost of this item. Consumption of energy is an important item in the household budget. At the same time, energy consumption declines and any interruption with non-renewable energy supply, which is a victim of irregular jobs and households, poses serious risks for energy prices. The use of non-renewable energy at the same time is linked to environmental problems such as climate change, the rapid rise of greenhouse gas emissions, CO_2 and methane and global warming (Fotourehchi, 2017). The International Energy Agency (IEA, 2009) shows that energy supply trends are still economically, environmentally and socially unsustainable. This global nature of energy problems requires proper management and use of renewable energy sources (Mukhtarov et al., 2021; Karacan et al., 2021) Renewable energy is generally defined as energy derived from the solar, wind, geothermal energy, tide and waves, wastes and biomass. Unlike non-renewable energy, renewable energy is clean, safe and inexhaustible. Given the increasing demand and limited supply, it is inevitable that renewable energy supplies will increase steadily (Apergis and Danuletiu, 2014).

The relationship between EG and renewable energy consumption (REC) has been explored in number of studies by different researchers. According to the empirical researches on the causal relationship between REC and EG, there is evidence to support bidirectional or unidirectional causality, or no causality, between REC and EG. Ocal and Aslan (2013) explored the relationship between EG and REC in the case of Turkey. They used data from 1990 to 2010 and reached a unidirectional causality running from EG to REC. Also, existence of unidirectional causality running from EG to REC was revealed by Sadorsky (2009) for 18 emerging countries, Pirlogea and Cicea (2012) for Romonia, Salim et al. (2014) for OECD countries. In contrast, some researches conducted by Apergis and Danuletiu (2014), Brini et al. (2017), Fotourehchi (2017), Magazzino (2017), Ito (2017), Khobai and Le Roux (2018), Can and Korkmaz (2019) discovered unidirectional causality running from REC to EG.

In addition, Al-Mulali et al. (2013) revealed the similar outcomes by employing multivariate panel data model in the case of Latin American economies. Also, Shahbaz et al. investigated the relationship between GDP, REC, capital and labor for Pakistani case. The empirical findings confirmed presence of bidirectional causal link between GDP and REC. Additionally, similar outcomes was concluded by numerous studies studied by Apergis and Payne (2010a; 2010b), Apergis and Payne (2011a; b), Apergis and Payne (2012), Al-Mulali et al. (2013), Pao and Fu (2013), Al-Mulali et al. (2014), Shafiei and Salim (2014) Lin and Moubarak (2014), Kahia et al. (2016), Amri (2016), Saidi and Ben Mbarek (2016), and Paramati et al. (2017).

Moreover, the casual relationship between EG and REC was studied by Payne (2009) for United States. He concluded that there is no relationship between REC and EG. Menegaki (2011) for 27 European economies, Smiech and Papiez (2014) for 17 European Union memebers, Bélaïd and Youssef (2017) for Algeria, Ozcan and Ozturk (2019) revealed that there is no causal link between REC and EG.

Mukhtarov et al. (2017) only studied whether there was a causal relationship between energy consumption and EG for Azerbaijani case, whereas Mukhtarov et al. (2018) explored the effect from financial development and EG to energy consumption, but did not addressed REC. In addition, Mukhtarov et al. (2020 a; b) found that income does have a positive effect on REC for Azerbaijan.

As can be seen from the literature, a few researches devoted to examine the REC -EG nexus in Azerbaijan. Considering all the above-mentioned facts, the main purpose of this article is to fill in this gap by employing Toda-Yamamota causality test to observe causality relationship between REC and EG in Azerbaijan which is the 20th country in the world in terms of displayed oil reserves, the 3rd largest oil producer economy between the former Soviet Union members in 2019, and the 86th biggest economy in the world and the 5th largest economy among the former Soviet Union members in terms of GDP—Azerbaijan (Mukhtarov et al., 2020a). The factors such as being the representative of former Soviet countries as well as oil-exporting developing countries blessed also with abundant renewable energy resources 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-EG relationship in the case of Azerbaijan, which has not been 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 is rarely applied to the Azerbaijani case.

2. METHODOLOGY AND DATA

We analyze causal relationship between REC and EG employing the Toda and Yamamota (1995) causality test in this study. The Toda and Yamamoto (1995) test does not need knowledge of the system's integration and cointegration characteristics. It may be employed even if there is no integration or stability, and when rank requirements are not met, as long as the process's order of integration does not exceed the model's real lag length. (Toda and Yamamoto, 1995, p. 225).

For assessing the significance of the parameters of the vector autoregressive (VAR) (k) model, the technique includes the Modified Wald statistic. First, the maximum order of series integration, indicated by $d_{\max}$, must be defined. Second, the Var Model's optimum lag must be defined. Third, the (k+d_{max})th order of VAR must be estimated. The asymptotic chi-square distribution of the Wald statistic is guaranteed by evaluation of VAR (k+d_{max}). Finally, the hypothesis is checkedby employing a standart Wald statistic test has an asmptotic Chi-square distribution with m degress of freedom. Based on Toda and Yamamota (1995) causality test the functional specifications can be described as follows:

$$LY_t = \alpha_0 \sum_{i=1}^{k} \alpha_{1i} LY_{t-i}$$

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

$$LE_t = \beta_0$$

$$+\sum_{i=1}^{\kappa} \beta_{1i} LE_{t-i} + \sum_{i=\kappa+1}^{d_{\max}} \beta_{2j} LE_{t-j} + \sum_{i=1}^{\kappa} \delta_{1i} LY_{t-i} + \sum_{i=\kappa+1}^{d_{\max}} \delta_{2j} LY_{t-j} + \nu_2$$

Where, LY and LE are logged EG and logged REC, accordingly, k denotes optimal lag order, d denotes the maximum order of integration of the series, and v_{1t} and v_{2t} are error terms.

We construct a annual data of EG and REC from 1992 to 2015. In this article, REC is renewable energy consumption as percentage of total final energy consumption. EG is measured by real GDP per capita (US dollars at 2010 prices). Both data set were compiled from World Bank. The used variables were converted into a log format.

3. EMPIRICAL RESULTS AND DISCUSSION

To avoid spurious causality or absence of causality, it is necessary to identify the order of integration of the series ($dmax$) and the appropriate lag length (k+d_{max}) for performing the causality test. For this purpose, Augmented Dickey-Fuller (augmented Dickey–Fuller [ADF] - Dickey and Fuller, 1981) unit root test was employed and we reached that the variables are non-stationary at their levels but are stationary at first difference, being integrated of order one, I (1). Results of ADF unit root tests are given in Table 1. As a result, the variables in the system have a maximum order of integration of one, d_{max}=1.

Table 1: ADF unit root test results

	REC	EG
Level	–2.157	–1.2886
	(0.225)	(0.617)
First difference	–5.425	–2.989
	(0.000)	(0.0509)

Notes: The critical values for unit-root test are from Mackinnon (1996). "p-values" are in parenthesis, REC: Renewable energy consumption, EG: Economic growth, ADF: Augmented Dickey Fuller

Table 2: The VAR residual diagnostics

Panel A: Serial correlation LM test[a]			Panel B: stability test[d]		Panel C: Normality test[b]				Panel D: Heteroscedasticity test[c]			
Lags	LM-Statistic	P-value	Modulus	Root	Statistic	χ^2	d.f	p-value	White	χ^2	d.f.	P-value
1	2.7559	0.5995	0.5454	0.545	Jarque-Bera	12.91	9	0.166	Statistic	38.92	36	0.339
2	4.2455	0.8343	0.4546	0.258–0.373i								
3	9.0764	0.6964	0.4546	0.258+0.373i								

Panel E: Lag interval tests						
Lag	LogL	Information criteria				
		LR	FPE	AIC	SC	HQ
0	10.039	NA	0.0024	–0.3512	–0.0550	–0.2767
1	44.521	53.97	0.0001	–3.0018	–2.5081	–2.8777
2	3.264	12.16*	0.0001*	–3.414*	–2.723*	–3.2405*
3	5.890	3.1967	0.0001	–3.2948	–2.406	–3.0713

[a]The null hypothesis in the serial correlation LM test is that there is no serial correlation at lag order 2nd of the residuals; [b]VAR stability test results show that no roots of characteristic polynomial are outside the unit circle; cSystem normality test with the null hypothesis of the residuals are multivariate normal; χ^2 shows Chi-squared; d.f. impies degree of freedom; Estimation period: 1992-2015

Table 3: Toda-Yamamoto test results

Null hypothesis	Lag(k)	k+dmax	Chi-square test	Conclusion
EG does not Granger cause REC	2	3	6.243129 (0.0441)*	Reject
REC does not Granger cause EG	2	3	4.854919 (0.0883)*	No Reject

*Significance at the 5% level, REC: Renewable energy consumption, EG: Economic growth

The second stage for analysis the casual test is to look into the optimal lag length (p) as determined by the LR, AIC, FPE, SC, and HQ criteria. A VAR model including all endogenous variables was estimated using a randomly determined lag interval, and a determination test of lag interval was applied to the residuals to identify the optimal lag interval in the research. The Panels E of Table 2 reports the optimal lag length of 2 (k=2) out of a maximum of 3 lag lengths as selected by all criteria is found to be 2. Panels A through D in Table 2 report that the VAR has worthy features as it is stable, the residuals do not denote serial correlation and heteroscedasticity issue and they are normally distributed.

Ultimately, Toda and Yamamoto causality test was utilized to confirm the direction of causality between REC and EG. The estimation outcomes of Toda and Yamamoto causality test results are presented in Table 3.

According to Toda and Yamamota causality test "REC does not Granger Cause EG" null hypothesis cannot be rejected, whereas "EG does not Granger Cause REC" null hypothesis is rejected at 5% significance level. As a result, unidirectional causal link has been found between renewable energy use and EG. This result means that EG may boost REC in Azerbaijan. My findings are in line with Sadorsky (2009) for 18 emerging countries, Ocal and Aslan (2013) in the case of Turkey, Pirlogea and Cicea (2012) for Romonia, Salim et al. (2014) for OECD countries. In the case of Azerbaijan, Mukhtarov et al. (2020a; b) also, found the positive impact of EG on REC. Moreover, the obtained results are in line with the traditional expectation for Azerbaijan

4. CONCLUSION

Using yearly data from 1992 to 2015 and a VAR framework, this study investigated the causal link between renewable energy use and EG in Azerbaijan. We discovered unidirectional casual link running from EG to renewable energy use employing a modified version of the Granger causality test developed by Toda and Yamamoto. If unidirectional causality implies that Azerbaijan can use its rising revenues to increase renewable energy sources. As a result of the findings, we propose implementing policies that encourage to increase the share of renewable energy use in the total consumption. The findings of this paper will help academics and policymakers understand the importance of renewable energy in Azerbaijan and other emerging oil-rich economies in order to achieve sustainable development goals.

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