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Asymmetric Causality Relationship between Energy Consumption and Economic Growth: Sample of Selected Turkish Republics

Enerji Tüketimi ve Ekonomik Büyüme Arasındaki Asimetrik Nedensellik İlişkisi: Seçilmiş Türk Cumhuriyetleri Örneği

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ÖZ

Bu çalışmanın amacı Azerbaycan, Kazakistan, Türkmenistan ve Özbekistan olmak üzere 4 adet Türk Cumhuriyetinde enerji kullanımı ile GSYİH arasındaki nedensellik ilişkisinin incelenmesidir. Değişkenler arasındaki ilişki, 1990 – 2018 dönemi için, literatürde yer alan birçok çalışmadan farklı olarak asimetrik nedensellik testi ile analiz edilmiştir. Analizlerin sonuçları Azerbaycan ekonomisinde "büyüme hipotezinin" Özbekistan ve Kazakistan ekonomilerinde ise "geri besleme" hipotezinin geçerli olduğunu ortaya koymaktadır. Türkmenistan için ise elde edilen sonuçlar, iktisadi açıdan genel bir çıkarım yapılmasına izin vermemektedir.

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ABSTRACT

This study aims to investigate the causality relationship between energy consumption and GDP in 4 Turkish Republics including Azerbaijan, Kazakhstan, Turkmenistan, and Uzbekistan. Unlike many studies in the literature, the relationship between the variables is analyzed by asymmetric causality test for the period between 1990 and 2018. The results of the analyses reveal that the Growth hypothesis is valid in Azerbaijan economy while the Feedback hypothesis is valid in Uzbekistan and Kazakhstan economies. However, the results obtained for Turkmenistan do not allow making a general conclusion from economic aspects.

1. Introduction

The industrial revolution, in which the use of machines increased significantly compared to the labor factor in the production processes, raised the importance of energy sources more than ever. The industrial revolution that took place along with the 19th century changed the balance of power in the world in favor of the countries that have

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energy sources and use them effectively and efficiently. Energy, which is now used as the basic input of many production activities, has also been the key determinant of economic growth. In modern economies, the use of energy assumes significant roles in the development of industries by increasing economic efficiency (Asghar, 2008: 167). In the studies carried out in the early 2000s, 50% of industrial growth was attributed to the efficient use of energy with a 10% share in total costs (Barney et al. 2002: 27).

Many factors, especially the growing population on a global scale, increase the energy demand. By the year 2018, primary energy consumption in the world reached to 138.6 billion tons. World energy consumption increased by 2.9% in 2018 compared to the previous year and has increased by 1.5% on average in the last decade. Nevertheless, the consumption increase in renewable energy sources was approximately 15% compared to the year 2017 (BP Statistical Review, 2019: 2).

The increasing importance of energy use has also caused that an important part of economic researches focused on this subject. In particular, the mutual relationship between energy consumption and economic growth was attempted to be measured for different countries - regions through different econometric models. These studies are generally tested 4 different hypotheses. The first one is called *Growth hypothesis* that is valid for energy-dependent countries and the causality relationship between the two variables is established from energy consumption to economic growth. The second one is called *Conservation Hypothesis*, and the causality relationship is established from economic growth to energy consumption. In countries where the estimation results of the econometric model are like this, economic growth increases energy consumption, however, the reverse situation is not observed. The third hypothesis is called *Feedback Hypothesis* that can be explained as the combination of the two previous hypotheses, there is a bi-directional relationship between energy consumption and economic growth. The fourth hypothesis is the *Neutrality hypothesis* that indicates no relationship between economic growth and energy consumption.

The causality relationship between economic growth and energy consumption is tested in the literature using different econometric models within the scope of the hypotheses discussed. While causality analyses are usually used in these models, the main distinction between them originates from the structural approaches of researchers to the dataset. Their difference is related to the assumption of linear and nonlinear structures in the series. The majority of linear models are formed through Granger / Toda Yamamato causality, cointegration, ARDL, ECM, VECM. Panel cointegration and Panel causality tests are generally used in studies with a high number of countries. In nonlinear models, threshold cointegration (Hu and Lin, 2008; Shouhila et al., 2012; Binh, 2011), wavelet transformation (Aslan et al., 2001), and asymmetric causality (Hatemi-J et al., 2011; Chen et al., 2017) tests were used.

This study firstly aims to investigate the asymmetric causality relationship between energy consumption and economic growth in selected Turkish Republics. The included countries are Azerbaijan, Kazakhstan, Uzbekistan and Kyrgyzstan. The reason for choosing these countries can be related to two reasons; Turkey's influence in these regions is relatively high due to the cultural affinity, and high market potential in these regions since they are relatively new states and their population is growing. Therefore, determining and examining their economic structures is important for possible sustainable economic cooperations. Also, we aimed to develop a comprehensive literature review for the next studies by systematically investigating other relevant studies in the international literature considering their findings. The results obtained from the literature review showed that linear methods were used in most of the studies. However, in today's global age, information flow is very fast and the economies of the countries are very affected by each other. This situation may cause the structures of the series to move away from linearity. Therefore, it is important to consider non-linearity in order to obtain reasonable results. In this respect, it is hoped that our study makes an original contribution to the literature by considering non-linearities. The results of our study show that the variables are non-linear and that different hypotheses are valid for different countries. In the second section of our study, the relevant literature is reviewed. In the third section, after the method we use is introduced, the dataset is investigated. After the results obtained from the analysis are presented in the fifth section, conclusion and discussion are made in the last section.

2. Literature Review

Energy plays a very important role in today's economies since it, directly and indirectly, affects the productivity of labor and capital input used in production processes. In this context, the relationship between economic growth and the supply and use of energy has attracted the interest of researchers for a long time. In particular, the negative impact of the energy crisis experienced in the 1970s on economies caused most of the economic studies were shifted to this field. The study of Kraft and Kraft (1978) is considered to be a leading study among the relevant studies. In this study carried out for the US economy, the causality relationship between economic growth and energy consumption was investigated using the data between the years 1947 and 1974. In the study, a one-way causality relationship was found from GDP to energy consumption and it was concluded that the "conservation hypothesis" was valid.

Although many studies have been carried out on the subject since Kraft and Kraft (1978), no consensus has been reached on the direction of the relationship between

economic growth and energy consumption by the researchers. For instance, in their study, Akarca and Long (1979) found a one-way causality relationship from energy consumption to GDP in the US, unlike Kraft and Kraft (1978). Yu and Hwang (1984) also concluded that the *"neutrality hypothesis"* was valid, in other words, there was no causal relationship between GDP and energy consumption. Also, there are many studies supporting the *"Growth hypothesis"* for the USA (Akarca and Long, 1979; Bowden and Payne, 2009; Hatemi J and Uddin 2012; Aslan et al., 2014; Arora and Shi, 2016). Similarly, in the studies carried out for England, while Arol et al. (1987b) and Yu and Choi, (1985) concluded that the neutrality hypothesis was valid, Altunbaş and Kapusuzoğlu (2011) concluded that the *"conservation hypothesis"* was valid for England in the period between 1987 and 2007. On the other hand, Destek et al. (2017) analyzed G-7 countries in their study where Oil, Natural Gas, and Coal consumption were included in the model as energy variables. In conclusion, while economic growth increased both oil and natural gas consumption in Germany, it increased only oil in England and only coal in the US. As it is seen, while the results may vary greatly even in the analyses performed for a single country, differences may also arise in the analyses performed for the countries that have the same level of development and are similar in many respects.

Another original aspect of this study can be said to be related to the literature review. Different conclusions reached in the studies in the relevant international literature were summarized more extensively and systematically compared to other studies. The findings from 175 countries[1] belonging to 100 studies examining the causality relationship between GDP and energy consumption carried out between 1978 and 2017 are presented in tables below considering their associated hypothesis. When the results are examined carefully, it can be understood that different results were revealed even in the studies carried out for a single country, as it was previously mentioned. Studies supporting the Conservation Hypothesis by determining that GDP is the cause of energy consumption, and studies supporting the Growth Hypothesis by determining that energy consumption is the cause of GDP are presented in Table 1.

Table 1. Literature Related to Conservation and Growth Hypotheses

GDP => EC (Conservation Hypothesis)	
• Mehrara (2007) - 11 Oil Exporting Countries	• Öztürk (2017) - Morocco
• Öztürk (2017) - Algeria	• Yakubu and Jelilov (2017) - Nambia
• Eddrief-Cherfi and Kourbali (2012) - Algeria	• Fatai et al. (2004) - New Zealand
• Kalyoncu et al (2013) - Armenia	• Asghar (2008) - Pakistan
• Fatai et al. (2004) - Australia	• Zeshan and Ahmed (2013) - Pakistan
• Al-Iriani (2006) - Bahrain	• Aslan (2013) - Portugal
• Zhang and Cheng (2009) - China	• Al-Iriani (2006) - Qatar
• Baek and Kim (2011) - G-20 Economies	• Al-Iriani (2006) - Saudi Arabia
• Adom (2011) - Ghana	• Öztürk (2017) - Saudi Arabia
• Abaidoo (2011) - Ghana	• Nayan et al (2013) - Selected 23 Countries
• Huang et al (2008) - High income Countries	• Asghar (2008) - Sri Lanka
• Aslan (2013) - Iceland	• Hatemi-J and Irandoust (2005) - Sweeden
• Ghosh (2002) - India	• Yoo (2006) - Thailand
• Cheng (1999) - India	• Kapusuzoglu and Karan (2010) – Turkey[5]
• Masih and Masih (1996) - Indonesia	• Karanfil (2008) - Turkey
• Soares et al (2014) - Indonesia	• Lise and Montfort (2007) - Turkey
• Yoo (2006) - Indonesia	• Altunbas and Kapusuzoğlu (2011) - UK
• Zamani (2007) - Iran	• Al-Iriani (2006) - Uman
• Soytas and Sari (2003) - Italy	• Al-Iriani (2006) - United Arab Emirates
• Soytas and Sari (2003) - Korea	• Abosedra and Baghestani (1989) - USA
• Yu and Choi (1985) - Korea	• Arora and Shi (2016) – USA[6]
• Al-Iriani (2006) - Kuwait	• Aslan et al (2014) – USA[8]
• Özturk et al. (2010) - Low Income Countries	• Kraft and Kraft (1978) - USA
• Ang (2008) - Malaysia	• Binh (2011) - Vietnam
• Huang et al (2008) - Middle Income Countries	• Çetintaş (2016) - 17 Transition Country[2]
• Chen et al. (2017) - China[10]	• Sharma (2010) - 66 Countries
• Abaiddo (2011) - Emerging Economies	

GDP <= EC (Growth Hypothesis)	
• Joo et al (2014) - Chile	• Soytas and Sari (2003) - Japan[2]
• Alaali et al (2015) - 130 Country	• Öztürk (2017) - Lebanon
• Lee (2005) - 18 Developing Countries	• Asghar (2008) - Nepal
• Aslan (2013) - 20 OECD Country	• Yakubu and Jelilov (2017) - Nigeria
• Arbex and Perobelli (2010) - Brazil	• Aqeel and Butt (2001) – Pakistan[1]
• Shiu and Lam (2004) - China	• Yu and Choi (1985) - Philippines
• Zou and Chau (2006) – China[4]	• Apergis and Danuletiu (2012) - Romania
• Öztürk (2017) - Egypt	• Wolde-Rufael (2004) - Shanghai
• Ang (2007) - France	• Morimoto and Hope (2004) - Sri Lanka[3]
• Soytas and Sari (2003) – France[2]	• Lee and Chang (2005) - Taiwan
• Narayan and Smyth (2008) - G-7 Countries	• Lee and Chang (2007) - Taiwan
• Soytas and Sari (2003) - Germany[2]	• Odhiambo (2009) - Tanzania
• Yakubu and Jelilov (2017) - Ghana	• Öztürk (2017) - Tunisia
• Ho and Siu (2007) - Hong Kong	• Soytas and Sari (2003) - Turkey[2]
• Fatai et al. (2004) - India	• Soytas at all (2001) - Turkey
• Masih and Masih (1996) - India	• Akarca and Long (1979) - USA
• Asafu-Adjaye (2000) - India	• Aora and Shi (2016) – USA[7]
• Asafu-Adjaye (2000) - Indonesia	• Aslan et al (2014) – USA[9]
• Fatai et al. (2004) - Indonesia	• Bowden and Payne (2009) - USA
• Meidani and Zabihi (2014) - Iran	• Hatemi-J and Uddin (2012) - USA
• Öztürk (2017) - Iran	• Erol and Yu (1987 (b)) - West Germany
• Chen et al. (2017) China[11]	• Altınay ve Karaöl (2005) - Turkey[3]
• Kasperowicz (2014) - Poland	

1-From electricity, 2-Long Term, 3-From electricity supply 4-From oil / at long and short term 5- To electricity 6-1990's 7- 2000's 8-Short Term 9-Middle-Long Term 10- Symmetric and aysmmetric granger causality test / to coal 11- Aysmmetric granger causality from coal / Symmetric test from oil - aysmmetric positive^{oil} to negative^{GDP}

Studies supporting the Feedback Hypothesis by determining that there is a bidirectional relationship between GDP and energy consumption, and studies supporting the Neutrality Hypothesis by determining that there is no relationship between energy consumption and GDP are presented in Table 2.

Table 2. Literature Related to Feedback and Neutrality Hypotheses

GDP <=> EC (Feedback Hypothesis)	
• Rezitis and Ahammad (2015) - 9 Asian Countries	• Ebohon (1996) - Nigeria
• Campo and Sarmiento (2013) - 10 Latin American Countries	• Doğan et al (2017) - OECD Countries
• Apergis and Payne (2009) - 11 Commonwealth of Independent States	• Öztürk (2017) - Oman
• Belke et al. (2011) - 25 OECD Countries	• Masih and Masih (1996) - Pakistan
• Lee and Lee (2010) - 26 OECD Countries	• Fatai et al. (2004) - Philipins
• Chontanawat et al (2008) - 30 OECD and 70 Non-OECD countries[2]	• Asafu-Adjaye (2000) - Philippines
• Soytas and Sari (2003) – Argentina[1]	• Shahbaz at all (2013) – Romania[6]
• Mozumder and Marathe (2007) - Bangladesh	• Glasure and Lee (1997) - Singapore
• Quedraogo (2010) - Burkina Faso[5]	• Yoo (2006) - Singapore
• Ghali and El-Sakka (2004) - Canada	• Glasure and Lee (1997) - South Korea
• Yuan et al. (2010) - China	• Oh and Lee (2004) - South Korea
• Zachariadis and Pashourtido (2007) - Cyprus	• Hu and Lin (2008) – Taiwan[3]
• Hondroyiannis et al. (2002) - Greece	• Hwang and Gum (1991) - Taiwan
• Paul and Bhattacharya (2004) - India	• Masih and Masih (1997) - Taiwan
• Erol and Yu (1987 (b)) - Italy	• Yang (2000) - Taiwan
• Erol and Yu (1987 (b)) - Japan	• Ebohon (1996) - Tanzania
• Glasure (2002) - Korea	• Fatai et al. (2004) - Thailand
• Masih and Masih (1997) - Korea	• Hoa (1993) - Thailand
• Yoo (2005) - Korea	• Asafu-Adjaye (2000) - Thailand
• Huang et al (2008) - Low Income Countries	• Belloumi (2009) – Tunisia[4]
• Yoo (2006) - Malaysia	• Erdal et al (2008) - Turkey
• Rathanayaka et al. (2018) - China	• Öztürk (2017) - United Arab Emirates
	• Ozturk et al. (2010) - Lower Middle-Income Countries

GDP <≠> EC (Neutrality Hypothesis)	
• Kalyoncu et al (2013) - Azerbaijan	• Yakubu and Jelilov (2017) - South Africa
• Öztürk (2017) - Bahrain	• Yakubu and Jelilov (2017) - Togo
• Asghar (2008) - Bangladesh	• Altinay and Karagol (2004) - Turkey
• Yakubu and Jelilov (2017) - Benin	• Halicioglu (2009) - Turkey
• Yakubu and Jelilov (2017) - Bostwana	• Jobert and Karanfil (2007) - Turkey
• Erol and Yu (1987 (b)) - Canada	• Soytas and Sari (2009) - Turkey
• Yakubu and Jelilov (2017) - Ethiopia	• Erol and Yu (1987 (b)) - UK
• Erol and Yu (1987 (b)) - France	• Yu and Choi (1985) - UK
• Kalyoncu et al (2013) - Georgia	• Öztürk et al. (2010) - Upper middle income
• Asghar (2008) - India	• Akarca and Long (1980) - USA
• Magazzino (2016) - Italy	• Cheng (1995) - USA
• Yakubu and Jelilov (2017) - Kamerun	• Erol and Yu (1987 (a)) - USA
• Masih and Masih (1996) - Malaysia	• Payne (2009) - USA
• Öztürk (2017) - Malta	• Stern (1993) - USA
• Masih and Masih (1996) - Philippines	• Yu and Choi (1985) - USA
• Yu and Choi (1985) - Poland	• Yu and Hwang (1984) - USA
• Masih and Masih (1996) - Singapore	• Yu and Jin (1992) - USA

1-Short term 2-Higher impact in developed countries 3- Energy consumption growth is higher than economic growth 4-Long Term 5-To/from electricity at long term 6-Long Term

The differences in the analysis results are mainly due to 3 reasons. They are listed as the following (Hatemi J et al. 2005: 88):

(i). Differences in institutional structures and economic policies of the countries
(ii). Different models used in empirical analysis
(iii). Periodic differences in analyses

When the studies on Turkish Republics are examined, it appears that they are very few compared to the literature. In the study in which Apergis and Payne (2009) examined 11 countries that were separated from Russia and gained independence (Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan were included in the study), which was the first one of those studies, a one-way causality relationship (Growth hypothesis) from energy consumption to GDP in the short term and a two-way causality relationship (Feedback hypothesis) in the long term was found. Kalyoncu et al. (2013) concluded that the neutrality hypothesis was valid for Azerbaijan. Çetintaş (2016) included 17 emerging economies involving Kazakhstan and Kyrgyzstan in his study and found that a one-way causality from growth to energy consumption in the long term. Mudarissov and Lee (2014) concluded that the growth hypothesis was valid for Kazakhstan.

3. Methodology

In this study, the causality test developed by Hatemi J (2012a) was used. This test takes into account potential asymmetries in the series and allows separating the causal impacts of positive and negative shocks (Shahbaz et al., 2017). This feature is thought to be very functional since asymmetric positive and negative shocks may have different causal impacts (Hatemi-J, 2012b). Moreover, the reaction of the players in the market to the new news may differ depending on whether the news is positive or negative (Hatemi-J, 2012a), and this is more prone to the real-world system. In this method, Hatemi-J uses bootstrapping simulation technique because it is necessary to take into account and evaluate the autoregressive conditional heteroscedasticity (ARCH) effects (Tugcu et al., 2012). In addition, he obtains critical values and Mwald statistics with bootstrap simulations (Tugcu and Topcu, 2018), which provide more accurate critical values due to leverage corrections (Hatemi-J and Uddin, 2012). Another advantage of the bootstrap simulation technique is that the series do not have to be normally distributed. This is a great convenience since the financial time series are often not normally distributed and vary over time (Hatemi-J, 2012a). Economic and financial series may also have nonlinear structures due to high volatility and economic crisis (Bildirici and Türkmen, 2015). Sudden changes in economic structure, industrial production, and investor heterogeneity may also cause nonlinear patterns in the series (Ajmi et al., 2013). Therefore, the asymmetric causality test, which is a nonlinear method, provides great advantages in determining econometric relationships.

This method embodies a Toda and Yamamoto (1995) process and therefore the series do not have to be stationary, however the maximum degree of integration (dmax) should be known (Umar and Dahalan, 2016). The dmax value is the maximum difference that must be taken for any variables that are subject to the causality test to become stationary. For instance, if one of the two variables becomes stationary when the second difference is taken, the dmax value is set to 2 for this analysis. Unit root tests are used to determine this maximum integration degree (dmax) and additional lag(s) is added to unrestricted VAR models if the series contains any root (Hatemi-J and Uddin, 2012).

4. Data

The sample included 4 Turkish republics which are Azerbaijan, Kazakhstan, Turkmenistan and Uzbekistan. The remaining Turkish republics were excluded from the sample since per capita energy consumption data could not be reached for these countries.

The dataset used in the study consisted of 29 observations on an annual basis covering the periods between 1990 and 2018. GDP refers to GDP per capita based on constant 2010 US$, while EC refers to energy consumption per capita in Gigajoule. The GDP variable was derived from Worldbank (2019) database, while the EC variable was derived from the BP (2019) database. Descriptive statistics of the variables used in the study are presented in Table 3. When the mean values of the variables were analyzed, it was observed that Kazakhstan had the highest GDP, while Turkmenistan had the highest energy consumption. In the application of the analysis, the logarithms of the series are taken, because better distribution properties can be obtained in this way (Shahbaz et al., 2017).

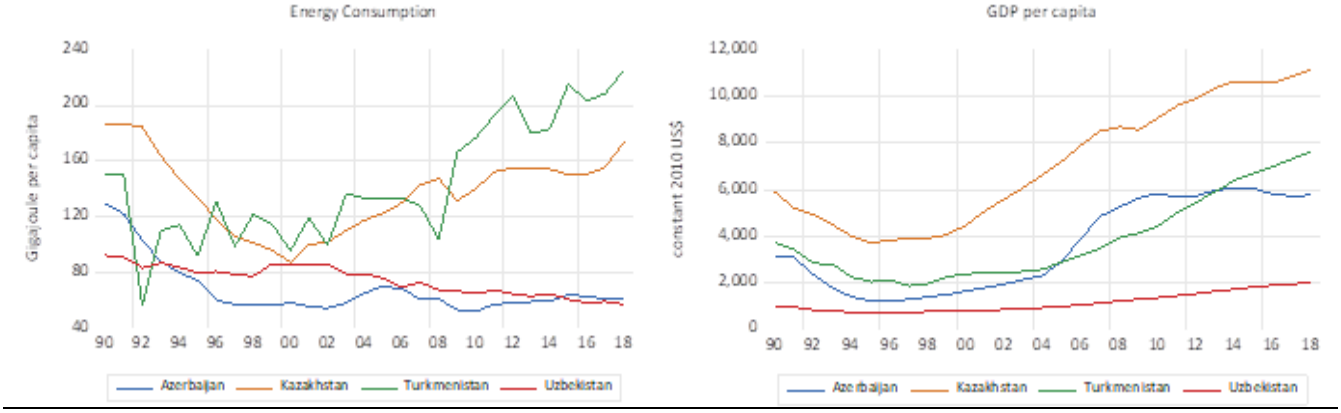
Table 3. Descriptive Statistics of the Variables

	EC AZ.	EC KAZ.	EC TUR.	EC UZB.	GDP AZ.	GDP KAZ.	GDP TUR.	GDP UZB.
Mean	67.7	137.9	144.1	74.6	3577.7	7096.6	3838.0	1164.4
Median	60.7	142.8	133.5	77.2	3096.4	6647.6	3181.0	999.9
Maximum	129.1	186.5	225.4	92.1	6072.5	11165.5	7647.9	2026.5
Minimum	51.9	87.0	56.0	56.8	1234.9	3738.4	1876.3	730.8
Std. Dev.	19.4	28.1	43.6	10.6	1927.1	2642.2	1804.8	422.2
Skewness	2.10	-0.01	0.24	-0.11	0.13	0.16	0.83	0.77
Kurtosis	6.49	2.11	2.16	1.73	1.27	1.48	2.33	2.19
Jarque-Bera	36.1	0.94	1.13	2.00	3.69	2.92	3.93	3.69
Probability	0.00	0.62	0.56	0.36	0.15	0.23	0.14	0.15
Observations	29	29	29	29	29	29	29	29

Source: BP, 2019; Worldbank, 2019.

The time-series graph of the variables in our study is presented in Figure 1. When the energy consumption variable is analyzed, it can be said that there is an increasing trend in the energy consumption of Turkmenistan and Kazakhstan. There was a break in Kazakhstan's consumption in 2000 and a return to previous high consumption levels began. The large oil deposit discovered in the Caspian Sea during these years may have a role in this trend shift (Brauer, 2004:43). On the other hand, there is a decreasing trend in the energy consumption of Azerbaijan and Uzbekistan. When the historical movement of the GDP per capita variable is examined, in parallel with energy consumption, Kazakhstan's GDP value is also entering an increasing trend in the early 2000s. Turkmenistan also follows an increasing trend after the similar period. There is an increasing trend for Uzbekistan, but this rate of increase is very low. Azarbeycan, on the other hand, followed an increasing momentum until 2010, and then entered a shrinkage trend.

Figure 1. Graphical Display of the Variables



Source: BP, 2019; Worldbank, 2019.

5. Results

Since the method used follows Toda and Yamamoto (1995) process, there is no requirement to be stationary, but the maximum order of integration value must be known. To determine this value, augmented Dickey-Fuller (Dickey and Fuller, 1979) and Fourier ADF (Enders and Lee, 2012) unit root tests were applied to each series and the results are presented in Table 4. Since the asymmetric causality analyzes are applied separately for each country between GDP and Energy consumption variables, unit root in one of these two data is sufficient to determine the dmax value as 1. According to the results of both tests, the value of dmax was0 for Azerbaijan while it was1 for Kazakhstan and

Uzbekistan. However, the findings of the two tests on Turkmenistan were contradicted. While the ADF test indicated 0 for dmax value, Fourier ADF test indicated 1. In this case, the dmax value for Turkmenistan was determined to be 0 considering the results of Fourier ADF unit root test which is considered to be more reliable for nonlinear time series. Therefore, the value of dmax was 0 for Azerbaijan and Turkmenistan while it was1 for Kazakhstan and Uzbekistan.

Table 4. ADF and Fourier Unit Roots Tests of the Variables

		Variable	Level		First Difference		Conclusion
			Intercept	Trend and Intercept	Intercept	Trend and Intercept	
ADF	GDP	AZ	-1.38	-5.45***	-3.49**	-2.86	I(0)
		KAZ	-1.19	-2.52	-2.79*	-1.92	I(1)
		TUR	-0.68	-2.63	-4.96***	-2.33	I(1)
		UZ	-1.89	-1.78	-2.87*	-2.02	I(1)
	EC	AZ	-4.20***	-3.54*	-2.95*	-3.50**	I(0)
		KAZ	-1.60	-1.61	-2.85*	-3.66**	I(1)
		TUR	-0.37	-5.54***	-9.92***	-9.49***	I(0)
		UZ	--0.23	-2.34	-2.04	-6.95***	I(1)
FOURIER	GDP	AZ	-0.75 (1)	-4.66* (1)	-3.33 (1)	-3.86 (1)	I(0)
		KAZ	-3.04* (2)	-3.23 (3)	-1.52 (1)	-6.44*** (1)	I(0)
		TUR	-1.61 (3)	-6.08*** (1)	-3.93** (1)	-3.98 (1)	I(0)
		UZ	-2.69 (3)	-6.09*** (1)	-4.79*** (1)	-3.68 (1)	I(0)
	EC	AZ	-4.84*** (3)	-4.06** (3)	-3.57** (2)	-4.26* (1)	I(0)
		KAZ	-1.77 (1)	-2.21 (2)	-3.63* (1)	-3.52 (1)	I(1)
		TUR	-2.94 (1)	-4.46** (1)	-9.70*** (3)	-9.37*** (3)	I(0)
		UZ	1.58 (1)	-4.00 (1)	-5.12*** (3)	-6.29*** (2)	I(1)

ADF CVs -3.69 for ***1%, -2.97 for **5%, -2.62 for *10% at Intercept. -4.33 for ***1%, -3.58 for **5%, -3.22 for *10% at Trend and Intercept. AIC is used in the lag selection. Fourier CVs for K=3: -3.77 for ***1%, -3.07 for **5%, -2.71 for *10% at Intercept, -4.45 for ***1%, -3.78 for **5%, -3.44 for *10% at Trend and Intercept. For K=2: -3.97 for ***1%, -3.27 for **5%, -2.91 for *10% at Intercept, -4.69 for ***1%, -4.05 for **5%, -3.71 for *10% at Trend and Intercept. For K=1: -4.42 for ***1%, -3.81 for **5%, -3.49 for *10% at Intercept, -4.95 for ***1%, -4.35 for **5%, -4.05 for *10% at Trend and Intercept. AIC is used in the lag selection. K is the number of Fourier.

Since the asymmetric test is a nonlinear method, the nonlinear structures in the series need to be determined. For this purpose, various tests should be applied to the residuals of the models by separating the deterministic elements for each series. In order to separate the deterministic parts, the most appropriate ARMA model was determined and estimated for each series. Then, the findings of non-linearity were investigated by applying Ljung and Box (1978), BDS (Brock et al., 1987) Independence, ARCH LM, and normality tests to the residuals of the models. The results obtained from this investigation are presented in Table 5. According to the results, non-linear structures were found in all variables except the energy consumption variables of Kazakhstan and Uzbekistan. However, it did not constitute an obstacle to the implementation of the analyses since the GDP variables of these countries had non-linear structures.

Table 5. Several Nonlinearity Test Results

	Best ARMA Model*	AIC Val.	Corr. of Res.	Corr. of Squared Res.	ARCH LM Test	BDS Independence Test	Normality Test
EC AZ.	(2, 0)	-2.12	✓	✗	✗	✓	✗
GDP AZ.	(4, 1)	-2.19	✓	✗	✗	✓	✓
EC KAZ.	(2, 2)	-2.31	✗	✗	✗	✗	✗
GDP KAZ.	(4, 0)	-3.84	✓	✓	✗	✗	✗
EC TUR.	(2, 2)	-2.92	✓	✗	✗	✓	✓
GDP TUR.	(4, 3)	-2.39	✓	✗	✗	✓	✓
EC UZ.	(4, 0)	-3.02	✗	✗	✗	✗	✗
GDP UZ.	(3, 0)	-4.22	✓	✗	✗	✓	✗

GAUSS econometric software code written by Hatemi-J (2012a) was used in the analysis. As the initial values, the maximum number of lags was chosen as 3 since the data frequency was annual, the maximum number of bootstrap simulations in the calculation of critical values was chosen as 1000, and the information criterion was selected as Akaike Information Criterion (AIC).

Asymmetric causality tests were applied for each country and the results are presented in Table 6. According to the results for Azerbaijan, positive shocks in energy consumption were the cause of positive shocks in GDP, and negative shocks in energy consumption were the cause of negative shocks in GDP. When the causalities from GDP to energy consumption were examined, causality

relationships were determined from negative shocks to negative shocks and from negative shocks to positive shocks. In the results obtained for Kazakhstan, positive shocks in energy consumption were identified as the cause of positive shocks in GDP. Conversely, positive shocks in GDP were the cause of positive shocks in energy consumption, and negative shocks in GDP were the cause of negative shocks in energy consumption. The results obtained for Turkmenistan were relatively complex compared to other results. Negative shocks in energy consumption were the cause of both negative shocks and positive shocks in GDP. On the other hand, positive shocks in GDP were the cause of negative shocks in energy consumption. For Uzbekistan, negative shocks in energy consumption were the cause of negative shocks in GDP, and positive shocks in GDP were the cause of positive shocks in energy consumption.

Table 6. Asymmetric Causality Test Results

	EC to GDP				GDP to EC			
	+ to +	+ to -	- to -	- to +	+ to +	+ to -	- to -	- to +
Azerbaijan	9.394	0.496	5.948	0.147	2.139	0.197	9.356	12.925
	[0.002]	[0.481]	[0.051]	[0.701]	[0.144]	[0.657]	[0.009]	[0.000]
Kazakhstan	6.877	0.023	0.001	0.126	8.390	1.542	5.675	0.043
	[0.009]	[0.878]	[0.974]	[0.722]	[0.004]	[0.214]	[0.017]	[0.835]
Turkmenistan (ADF)	0.042	2.388	7.480	6.245	0.399	11.305	0.182	2.415
	[0.838]	[0.122]	[0.006]	[0.012]	[0.528]	[0.001]	[0.670]	[0.120]
Turkmenistan (F)	2.954	15.2	0.380	2.047	0.782	8.678	2.333	3.788
	[0.086]	[0.000]	[0.538]	[0.152]	[0.376]	[0.003]	[0.127]	[0.052]
Uzbekistan	0.012	0.227	9.642	0.021	2.784	0.000	1.198	0.056
	[0.914]	[0.634]	[0.002]	[0.886]	[0.095]	[0.995]	[0.274]	[0.813]

The fact that negative (positive) shocks on energy consumption in Azerbaijan also have the same impact on GDP indicates that the *Growth hypothesis* is valid in terms of energy policies. In this context, it is concluded that Azerbaijan is a country with high energy dependence in terms of economic growth. Similarly, the fact that negative shocks on GDP also lead to negative shocks in energy consumption indicates that the use of energy decreased along with the slowing of growth dynamics and that energy-saving policies to be implemented in Azerbaijan will significantly reduce economic growth rates since they confirm the dependence of economic structure on energy. The fact that positive shocks on both GDP and energy consumption in Kazakhstan also have the same impacts on the other variable indicates that the *Feedback hypothesis* is valid. GDP with an increasing trend will increase the energy demand, and the increasing energy use will accelerate economic growth. The fact that negative shocks on energy consumption in Uzbekistan have negative impacts on GDP indicates that energy consumption is important for the national economy. An energy bottleneck to be experienced for the country will negatively affect the national economy. In this case, the *Growth hypothesis* will be valid in terms of negative shocks for the economy of Uzbekistan. Nevertheless, since the fact that positive shocks on GDP also have a positive impact on energy consumption shows that the increasing economic growth will increase the energy demand, it indicates that the most general conclusion to be reached for the economy of Uzbekistan is that the *Feedback hypothesis* is valid. The fact that positive shocks in energy consumption have both negative and positive impacts on GDP makes it difficult to reach conclusive results for Turkmenistan. However, one of the most important hypotheses in econometric models is to *accept that other variables are constant*. In this context, the fact that sudden increases in energy consumption had an impact on GDP in both directions indicates that Turkmenistan's economy was highly affected by external factors except for energy consumption during the analysis period. The fact that positive and negative shocks on GDP had a negative impact on energy consumption also supports this result.

6. Conclusions

The increasing use of energy in production processes significantly affects countries' decisions on energy policies. Therefore, decision-makers should be able to accurately predict the results of policies before implementing them. Wrong decisions to be made on energy supply/demand, which may have many direct and indirect impacts on national economies, may lead to irrecoverable situations. In this context, especially the negative effects of energy crises that took place in previous periods on national economies directed academic research to measure the direction and severity of the relationship between energy supply/demand and economic performance. In many relevant studies, it was attempted to reveal results within the framework of different models for different country/country groups.

In this study, the relationship between energy consumption and GDP for 4 Turkish Republics as Azerbaijan, Kazakhstan, Uzbekistan, and Turkmenistan, was investigated. The Turkic Republics, which gained their independence with the collapse of the Soviet Union, form a market with great potential for investors with a very large surface area, rich natural resources, and a young population. Therefore, Turkey is seeking closer cooperation with the Turkic Republics which lean towards the political assistance of Turkey (Cornell, 2011:280). Using these collaborations and cultural ties, it develops strategies to increase the zone of influence in the region and establish economic cooperation (Yücel and Ruysdael,

2002:198). For this reason, determining the economic structure and growth factors in the countries of the region is important in establishing sustainable relations in order to benefit from the market potential and to make the right investment decisions (Bal, 2018).

The analyzes are carried out for the period between 1990 and 2018 within the frame of asymmetric causality tests. In conclusion, it was determined that

(i). The *Growth Hypothesis* was valid in Azerbaijan and that energy conservation policies would have negative impacts on economic growth in Azerbaijan,

(ii). The *Feedback Hypothesis* was valid for Kazakhstan economy and that GDP and energy consumption affected each other mutually,

(iii). The *Growth Hypothesis* was valid in Uzbekistan in case of negative shocks in energy consumption, however, the most general conclusion to be reached was that the *Feedback Hypothesis* was valid when it was considered that positive shocks in GDP also increased energy consumption,

(iv). External factors other than energy were effective on economic growth in Turkmenistan.

Studies conducted on the same sample and findings parallel to our results are very limited in the literature. Our study uses nonlinear causality analysis that takes into account nonlinear structures in variables as a method different from the previous. In the analyzes we tested the linearity, most of the variables have non-linear structures, and applying linear analysis with such data may cause misleading results. In addition, although these countries are geographically and culturally similar, their economic structures are different from each other. Also, countries' responses to negative and positive shocks may not be symmetrical. For this reason, we applied our analysis individually, considering that it is more appropriate to analyze independently.

From this point, Apergis and Payne (2009) found validity of the Growth hypothesis in the short term for a sample including Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan, but we determined symmetrical validity of the hypothesis only for Azerbaijan. Positive shocks in energy consumption cause positive shocks in GPD, and negative shocks in energy consumption cause negative shocks in GPD. Therefore, the implementation of energy conservation policies for Azerbaijan may generate an obstacle to sustainable economic growth. For Turkmenistan and Uzbekistan, there is only a relationship between negative shocks, and negative shocks in energy consumption cause negative shocks in GPD. For this reason, reducing energy consumption in these countries may have negative consequences for growth, but an increase in growth cannot be achieved by increasing energy consumption. This situation may indicate inefficiencies in sectors and production policies in the countries. Uzbekistan, positive shocks in GPD cause positive shocks in energy consumption. This shows that other factors other than energy are more effective in increasing GDP and it can be said that it points to a reserved potential for the country. If the positive effect of energy consumption can be transferred to GPD growth, a high acceleration can be achieved in the country's economic development. Kalyoncu et al. (2013) concluded validity of the Neutrality hypothesis for Azerbaijan, which indicates insignificant relationship between variables. However, this may be due to the non-linear structures in the variables which weren't taken into account. Çetintaş (2016) found validity of the Conservation hypothesis for Kazakhstan and Kyrgyzstan. Findings partially coincide with the results of our study. According to our results, positive shocks in Kazakhstan's GDP are the cause of positive shocks in energy consumption, and negative shocks in its GDP are the cause of negative shocks in energy consumption. However, as an advantage of the asymmetric method we used, we determined a causality relationship from positive shocks in energy consumption to positive shocks in GDP as well. Therefore, the validity of the Feedback hypothesis can be mentioned for the country. The country's energy conserving policies may adversely affect its growth policies. Mudarissov and Lee (2014) concluded that the growth hypothesis was valid for Kazakhstan. According to our results, positive shocks in energy consumption are the cause of positive shocks in GDP and contribute to growth. However, the relationship between negative shocks couldn't be determined. On the other hand, different from the researchers, positive shocks in GDP are identified as the cause of positive shocks in energy consumption, and negative shocks in GPD are determined as the cause of negative shocks in energy consumption. In this respect, the validity of the Feedback hypothesis can be mentioned. It should also be kept in mind that energy-conserving policies may negatively affect the growth of this country as well. The differentiation of the findings from the literature may be due to the differences in the variables used, the different time period under consideration or the differences in method used. Our findings are thought to be original in that they mainly take into account non-linear structures and examine relationships asymmetrically.

It is considered that this study will contribute to the literature at three significant points. The first one of them is that the relevant studies that have been carried out for a long time and that are included in the international literature were summarized systematically, and an extensive literature review was included. Secondly, when the studies investigating the causality relationship between energy consumption and GDP were examined, it was found that very few studies were carried out in the Turkish Republics. In this respect, it is considered that it will contribute to a significant deficiency in the literature. Finally, the studies that constitute the majority of the literature were carried out within the framework of linear

models. In this study, the relationship between energy consumption and economic growth was examined within the framework of asymmetric causality tests, and the results were obtained within the framework of these models.

Notes

[1] There are more than one analysis results of the same country in many different studies.

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