A LITERATURE SURVEY ON RELATIONSHIP BETWEEN RENEWABLE ENERGY CONSUMPTION AND ECONOMIC GROWTH

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ARTICLE INFO

Review Article

Received: *06 May 2020*

Accepted: *30 June 2020*

doi:10.5937/ekoPolj2003991C

UDC 655.413:[620.92:330.354

Keywords:

renewable energy consumption, economic growth, GDP, causality, literature survey

JEL: *O13, Q42, Q43, Q56*

ABSTRACT

The purpose of this paper is to provide an extensive empirical literature review on the relation between renewable energy consumption and economic growth. The survey included 50 papers, most of which are published in major energy journals, to ensure the high-quality review. This literature review includes period, countries, methodology and research results. Also, the survey included policy recommendation for renewable energy policymakers depending on results obtained by authors. The general observation from reviewed literature is the absence of any clear consensus regarding the relationship between renewable energy and economic growth, which can be contributed to various factors.

Introduction

The climate change agreement, known as the Paris Agreement, signed in 2016, aims to limit the increase in global average temperature to well below 2°C above pre-industrial levels, increase its ability to adapt to adverse impacts and foster climate resilience and develop low greenhouse gas emissions, in a way that does not compromise food production. In addition, The Paris Agreement requires all Parties to align financial flows with the needs of development accompanied by low greenhouse gas emissions and enhanced climate resilience. At the heart of the Paris Agreement are nationally determined contributions for each signatory country as part of the reduction of greenhouse gas emissions. Each climate plan reflects the Party's ambition to reduce

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harmful emissions, taking into account its domestic circumstances and capabilities (UN, 2020). These targets implicitly state that there is a need to move to a low-carbon energy sector, supported by estimates that renewable energy, together with an increase in energy efficiency, can provide a 90% reduction in carbon dioxide emissions by 2050 (IRENA, 2020).

Over the last 10 years, a substantial amount of research has been done on the relationship between renewable energy consumption and economic growth. Many of the papers written on this topic focus on different countries, time periods, and econometric models used in the analysis, and thus the empirical results obtained by the studies reviewed are varied (Drăgoi et al., 2018). It is safe to say, given the literature available in the above field, that no definitive conclusion has been reached regarding the causal link between renewable energy and economic growth.

By reviewing the extensive literature on energy and economic growth, four causal hypotheses can be identified: growth hypothesis, conservation hypothesis, feedback hypothesis and neutrality hypothesis (Adewuyi & Awodumi, 2017; Ozturk, 2010; Payne, 2010; Sebri, 2015; Squalli, 2007)

[1] **Growth hypothesis** suggests that there is one-way causality between energy consumption and economic growth. "In the context of the Granger - causality, the growth hypothesis is supported if an increase in energy consumption causes an increase in real GDP. The policy implications of the growth hypothesis suggest that energy conservation-oriented policies may have detrimental impact on economic growth" (Payne,2010).

[2] **Conservation hypothesis** is supported if the Granger test confirms one-way causality, that is, if an increase in real GDP causes an increase in energy consumption. This hypothesis suggests that energy savings policies, such as greenhouse gas reduction and energy efficiency enhancement policies, will not have an impact on GDP. "However, it is possible that if a growing economy constrained by political, infrastructural or mismanagement of resources could generate inefficiencies and the reduction in the demand for goods and services, including energy consumption. If such case, an increase in real GDP may have a negative effect on energy consumption" (Payne, 2010)

[3] **The feedback hypothesis** suggests that energy consumption and economic growth are interdependent and supplementary. In this case, any increase (decrease) in energy consumption results in an increase (decrease) in GDP and vice versa. Therefore, restrictive energy policies will prevent economic growth and in the same way, any increase in GDP will boost energy demand (Ozturk, 2010; Sebri, 2015).

[4] **The neutrality hypothesis** is supported in case where is no causality between energy consumption and GDP, and therefore neither a conservative energy policy nor an energy expansion policy has any effect on economic growth.

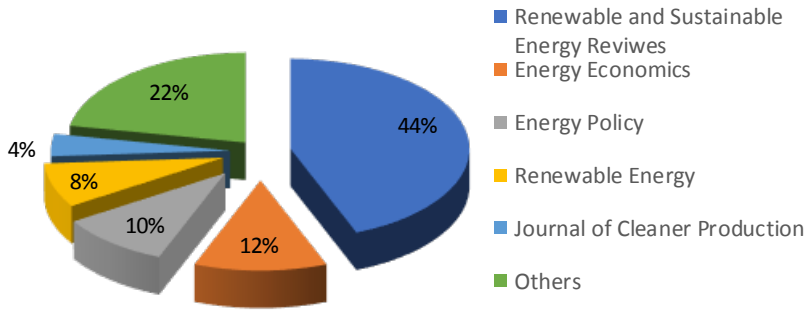
> "Neutrality hypothesis views energy consumption as a small component of real GDP and therefore energy consumption should not have a significant impact on economic growth" (Payne, 2010).

The aim of this paper is to provide an overview of the available empirical literature on the causal link between renewable energy consumption and economic growth for the period 2009-2020. Although numerous papers that investigate the relationship between energy and economic growth are available, the authors believe that a literature survey that focuses solely on renewable energy-economic growth nexus is needed. This way the contribute to future research, by collecting and reviewing existing literature in this field, will be given. Also, the contribution of this paper is to provide significant information for renewable energy policymakers based on overview of past research and empirical results.

Materials and methods

For the purpose of this research, 50 papers are selected as a sample, 47 of which are published in journals with Impact Factor (IF) using online databases. The search criteria for the selection included only empirical studies focusing on renewable energy - economic growth, in order to ensure the best review on this subject. The representation of the journals based on the number of selected papers used in this research can be shown in the following chart.

Figure 1. Journal share based on selected papers



Source: Authors' calculations

From the total of 16 journals included in this research, 81% is with Impact Factor. Articles published in Renewable and Sustainable Energy Reviews comprises 44% of our sample, and also significant share of articles are published in Energy Economics, Energy Policy, Renewable Energy and Journal of Cleaner Production. Articles published in Others section are Ecological Economics, Applied Energy, International Journal of Hydrogen Energy, Energy Reports, Energy Strategy Reviews, Journal of Renewable and Sustainable Energy, Applied Energy, Energy Sources, Part B: Economics, Planning and Policy, Economics Bulletin, Procedia Economics and Finance and International Economics.

Results and discussions

The literature collected for this paper includes 50 papers, most of which have been published in the most renowned energy journals, to provide the highest quality analysis possible. The authors have focused on papers based on empirical research that cover the topic of renewable energy and economic growth. Table 1 presents literature in chronological order on the relationship between renewables and economic growth, including the period in which the survey was conducted, the countries are taken as a sample, the methodology used, and the results of empirical research. By examining Table 1, it can be concluded that the results obtained by the studies presented are mixed. "This lack of consensus can be attributed to the heterogeneity of climate conditions, varying energy consumption patterns, the structure and stages of economic development within a country, alternative econometric methodologies approaches, the presence of omitted variable bias along with the varying time horizons of the studies conducted" (Payne, 2010).

Table 1. Summary of empirical studies on renewable energy consumption-economic growth nexus

	Author(s)	Period	Country	Methodology	Causality relationship
1	(Sadorsky, 2009b)	1980-2005	G7 countries	Panel cointegration, Fully modified OLS, Dynamic OLS, Seemingly Unrelated regression (SUR)	GDP » REC
2	(Sadorsky, 2009a)	1994-2003	18 emerging countries	Ordinary least squares (OLS), Fully modified OLS, Dynamic OLS	GDP » REC
3	(Bowden & Payne, 2010)	1949-2006	USA	Toda-Yamamoto causality test	REC ≠ GDP (long run)
4	(Apergis, Payne, Menyah, & Wolde-Rufael, 2010)	1984-2007	19 developed and developing countries	Cointegration, Granger causality	REC « » GDP (short run)
5	(Apergis & Payne, 2010)	1985-2005	20 OECD countries	Panel cointegration test, Granger causality	REC « » GDP
6	(Apergis & Payne, 2010)	1992-2007	13 Eurasia countries	Panel cointegration test, Granger causality	REC « » GDP (long run)
7	(Fang, 2011)	1978-2008	China	OLS model	REC » GDP
8	(Menegaki, 2011)	1997-2007	27 European countries	One-way random effect model, Panel causality test	REC ≠ GDP
9	(Apergis & Payne, 2011a)	1990-2007	16 emerging countries	Panel cointegration test	GDP » REC (short run) REC « » GDP (long run)

	Author(s)	Period	Country	Methodology	Causality relationship
10	(Apergis & Payne, 2011b)	1980-2006	6 Central American countries	Panel cointegration and panel ECM	REC « » GDP (long and short run)
11	(Tiwari, 2011)	1960-2009	India	Structural VAR approach	REC « » GDP
12	(Yildirim, Saraç, & Aslan, 2012)	1949-2010	USA	Toda-Yamamoto causality test, Bootsrap-corrected causality test	REC » GDP (biomass) REC ≠ GDP
13	(Apergis & Payne, 2012)	1990-2007	80 countries	Panel cointegration and panel ECM	REC « » GDP (long and short run)
14	(Bildirici & Özaksoy, 2013)	1960-2010	10 countries	ARDL, vector error-correction models	GDP » REC (Austria, Turkey) REC » GDP (Hungary, Poland) REC « » GDP (Spain, Sweden, France) REC « » GDP (all countries)
15	(Al-mulali, Fereidouni, Lee, & Sab, 2013)	1980-2009	108 countries	FMOLS model	REC « » GDP (79% countries) REC ≠ GDP (19% countries) GDP » REC (2% countries)
16	(Ocal & Aslan, 2013)	1990–2010	Turkey	ARDL, Toda-Yamamoto causality test	GDP » REC (negative)
17	(Magnani & Vaona, 2013)	1997-2007	20 Italian regions	Panel error correction	REC » GDP
18	(Pao & Fu, 2013)	1980-2010	Brazil	ECM-based causality test	REC « » GDP (short run) REC ≠ GDP (long run)
19	(Al-mulali, Fereidouni, & Lee, 2014)	1980-2010	18 Latin American countries	Pedroni cointegration Test, DOLS, VECM Granger causality	REC » GDP (long run) REC « » GDP

	Author(s)	Period	Country	Methodology	Causality relationship
20	(Sebri & Ben-Salha, 2014)	1971-2010	BRICS countries	ARDL, VECM Granger causality	REC « » GDP
21	(Lin & Moubarak, 2014)	1977–2011	China	ARDL, Johansen cointegration, Granger causality	REC « » GDP (long run)
22	(Halkos & Tzeremes, 2014)	1990-2011	36 countries	Local linear estimator,Nonparametric analysis	REC » GDP (advanced economies)
23	(Azlina, Law, & Nik Mustapha, 2014)	1975-2011	Malaysia	Error correction model	GDP » REC
24	(Bilgili, 2015)	1981-2013	USA	Wavelet analysis	REC » GDP
25	(Shahbaz, Loganathan, Zeshan, & Zaman, 2015)	1972Q1–2011Q4	Pakistan	ARDL, Rolling widow approach (RWA), VECM Granger causality	REC « » GDP
26	(Ibrahiem, 2015)	1980-2011	Egypt	ARDL	REC « » GDP
27	(Chang et al., 2015)	1990-2011	G7countries	The Emirmahmutoglu and Kose causality methodology.	REC « » GDP (all countries) REC ≠ GDP (Canada, Italy, US) GDP » REC (France, UK) REC » GDP (Germany, Japan)
28	(Dogan, 2015)	1990-2012	Turkey	ARDL, Johansen cointegration test, Gregory–Hansencointegration test with Structural break	REC ≠ GDP (short run) REC » GDP (long run)
29	(Inglesi-Lotz, 2016)	1990-2010	OECD countries	Pedroni cointegration test	REC » GDP
30	(Destek, 2016)	1971-2011	Newly industrialized countries	Asymmetric causality test	GDP » REC (South Africa, Turkey, India) REC ≠ GDP (Brazil, Malaysia)

	Author(s)	Period	Country	Methodology	Causality relationship
31	(Hamit-Haggar, 2016)	1991-2007	11 Sub-Saharan African countries	Panel cointegration, OLS, DOLS, FMOLS, DSUR	REC » GDP
32	(Alper & Oguz, 2016)	1990-2009	8 new EU countries	Asymmetric causality test, ARDL	REC ≠ GDP (Cyprus, Estonia, Hungary, Poland, Slovenia) GDP » REC (Czech Republic) REC » GDP (Bulgaria)
33	(Cherni & Essaber Jouini, 2017)	1990-2015	Tunisia	ARDL, Granger causality test	REC « » GDP
34	(Destek & Aslan, 2017)	1980-2012	17 emerging countries	Bootstrap panel causality	REC » GDP (Peru) REC ≠ GDP (12 countries) REC « » GDP (Greece, South Korea)
35	(Ito, 2017)	2002-2011	42 developed countries	Generalized method of moments (GMM), pooled mean group (PMG) technique	REC » GDP (long run)
36	(Rafindadi & Ozturk, 2017)	1971Q1-2013QIV	Germany	Clemente-Montanes-Reyesdetrened structural break test, Bayer-Hanck combined cointegration test, ARDL	REC « » GDP
37	(Amri, 2017a)	1990-2012	72 countries	Dynamic-simultaneous equation panel data approach	REC « » GDP (all countries, developing, developed countries)
38	(Kahia, Aïssa, & Lanouar, 2017)	1980-2012	11 MENA Net Oil Importing Countries (NOICs)	Panel error correction model	REC « » GDP REC » GDP
39	(Furuoka, 2017)	1992-2011	Baltic countries	Panel cointegration test, panel causality test.	GDP » REC

	Author(s)	Period	Country	Methodology	Causality relationship
40	(Brini, Amara, & Jemmali, 2017)	1980-2011	Tunisia	ARDL, Granger causality test	GDP » REC (negative)
41	(Amri, 2017b)	1980-2012	Algeria	ARDL	REC » GDP
42	(Koçak & Şarkgüneşi, 2017)	1990-2012	9 Black Sea and Balkan countries	Heterogeneous panel causality	REC » GDP (Bulgaria, Greece, Macedonia, Russia, Ukraine) REC « » GDP (Albania, Georgia, Romania) REC ≠ GDP (Turkey)
43	(Saad & Taleb, 2017)	1990-2014	12 European Union countries	Granger causality, Panel vector error correction model	GDP » REC (long run) REC « » GDP (short run)
44	(Bao & Xu, 2019)	1997-2015	30 provinces and 7 geographical regions	Bootstrap panel causality test	REC » GDP (4 provinces) GDP » REC (9 provinces, 4 geographical regions) REC « » GDP (1 province)
45	(Zafar, Shahbaz, Hou, & Sinha, 2019)	1990-2015	APEC countries	Westerlund cointegration test,Continuously Updated Fully Modified Ordinary Least Square (CUPFM)	REC « » GDP
46	(Aydin, 2019)	1980-2015	26 OECD countries	Dumitrescu-Hurlin panel causality test, Croux and Reusens frequency domain causality test	REC « » GDP
47	(Maji, Sulaiman, & Abdul-Rahim, 2019)	1995-2014	15 West African countries	Panel dynamic ordinary least squares (DOLS)	REC » GDP negative

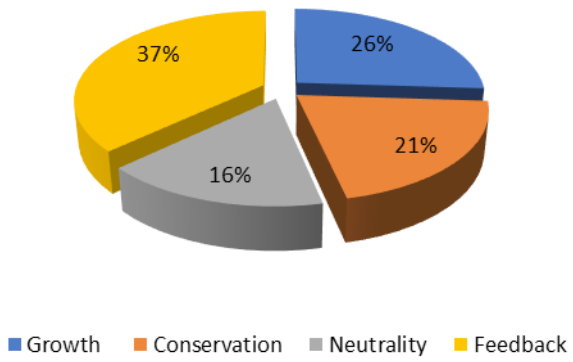
	Author(s)	Period	Country	Methodology	Causality relationship
48	(Ozcan & Ozturk, 2019)	1990-2016	17 emerging countries	Bootstrap panel causality test	REC ≠ GDP (16 countries) REC » GDP (Poland)
49	(Alvarado et al., 2019)	1972-2014	19 countries of Latin America	Pedroni and Westerlund cointegration techniques, Dumitrescu and Hurlin causality test	REC « » GDP
50.	(Rahman & Velayutham, 2020)	1990-2014	5 South Asian countries	Pedroni and Kao tests, FMOLS and DOLS estimation techniques, Dumitrescue-Hurlin	GDP » REC

Source: Authors

Notes: REC » GDP, GDP » REC, REC « » GDP, REC ≠ GDP indicates growth, conservation, feedback and neutrality hypothesis respectively.

The selected literature can be divided on the basis of the empirical results obtained, i.e. the causal link between renewable energy sources and economic growth. The majority of papers reviewed confirm the relationship between renewable energy consumption and economic growth, only the direction of the relationship is different, while fewer studies confirm the neutrality hypothesis, indicating that there is no relationship between the two variables.

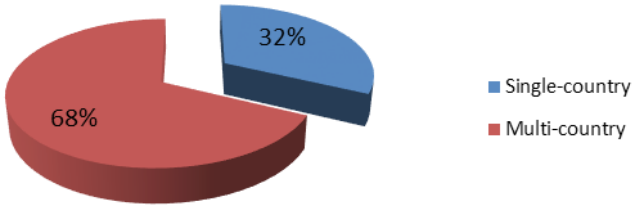
Figure 2. Hypothesis for renewable energy-economic growth nexus (in %)



Source: Authors' calculations

Taking into account the collected literature presented in Table 1, it can be said that in the past 10 years, research related to renewable energy and economic growth has been dominated by multi-country (68%) over single-country (32%) studies, which is consistent with previous literature reviews (Adewuyi & Awodumi, 2017).

Figure 3. Multi-country vs single-country studies (in %)



Source: Authors' calculations

Based on our review of selected literature, 86% of reviewed studies have confirmed the need to enhance investments in renewable energy sources. The authors also suggested the introduction of adequate policies that would encourage the development of renewable sources.

Review of literature supporting growth hypothesis

Fang was among the first to test the impact of electricity consumption from renewable sources on China's economic well-being for the period 1978-2008. Using multivariate Ordinary Least Squared (OLS) results were obtained that confirm the growth hypothesis, that is, "1% increase in consumption from renewable sources increases GDP by 0.12%" (Fang, 2011). Amri also researched the causal link between renewable energy and economic growth for an individual country. The Autoregressive Distributed Lag (ARDL) test shows that there is a unidirectional relationship in Algeria that goes from renewable sources to GDP in the long run. Policymakers should enhance investments in renewable energy (Amri, 2017b). Bilgili used wavelet coherence and wavelet partial coherence analyses to test the relationship between renewable energy and economic growth, for the period 1981-2013. The author obtained empirical results showing that consumption from renewable sources has a considerable effect on industrial production and hence on economic growth (Bilgili, 2015).

One of the multi-country studies was done by a group of authors for 18 Latin American countries for the period 1980-2010. Using the panel Dynamic Ordinary Least Squares (DOLS) and the Vector Error-Correction (VEC) Granger causality model they obtained results that show that the consumption of energy from renewable sources has a significant effect on economic growth compared to the consumption from non-renewable sources. Looking at the results of this study, the advice to the analyzed countries would be to increase investments in renewable energy sources in order to increase the share of electricity from renewable sources (Al-mulali et al., 2014). Using the Pedroni cointegration test, Inglesi-Lotz conducted a study for 34 OECD countries in 1990-2010, with estimates as follows: "an increase of 1% of renewable energy consumption will increase GDP by 0.105% and GDP per capita by 0,1%, while increasing the share of renewable energy in the energy mix of countries will increase GDP by 0.089% and GDP

per capita by 0.09%"(Inglesi-Lotz, 2016). The policy recommendation is promoting consumption from renewable energy. Ito explored the link between carbon dioxide emissions, renewable, and non-renewable sources of consumption and economic growth for 42 developed countries. Research has shown that renewable energy sources make a positive contribution to long-term economic growth. Such results suggest that developing countries should invest in the development of the renewable energy sector. In this way, they increase energy autonomy and create sustainable economic growth as well as employment. However, for developing countries in order to achieve these goals, it is essential that these countries receive financial and technological assistance from developed countries (Ito, 2017). Similar results were obtained by Magnani and Vaona, who worked to measure the effects of renewable energy production on 20 Italian regions. Using various econometric methods, the authors have shown that energy production encourages economic growth, and policies promoting the use of renewable energy sources should be adopted (Magnani & Vaona, 2013). A group of authors investigated the impact of renewable energy on economic growth in 15 West African countries using the panel ordinary dynamic least squares (DOLS) from 1995-2014. The results showed that there is a negative impact, that is, renewable energy consumption is slowing economic growth in these countries (Maji et al., 2019).

Review of literature supporting conservation hypothesis

The first author to address the topic of renewables and economic growth was Sadorsky, and he has confirmed the conservation hypothesis in his two papers, for emerging countries and the G7 countries. Although the observation period is different, both studies have shown that an increase in GDP per capita is a major driver of renewable energy consumption (Sadorsky, 2009a, 2009b). Furuoka explored the relationship between electricity consumption from renewable sources and economic growth for the Baltic countries in 1992-2011. Statistical analysis obtained empirical results in favor of the conservation hypothesis for all observed three countries - Estonia, Latvia and Lithuania. The results thus obtained suggest that the Baltic countries' governments are free to implement conservation policies without impeding economic development (Furuoka, 2017). Rahman and Velayutham also researched a group of South Asian countries and came up with similar results for all 5 countries observed. Conservation hypothesis has been confirmed, and the authors believe that energy policies should be designed in a way that supports and promotes increased use of energy from renewable sources (Rahman & Velayutham, 2020). Some single-country studies also support conservation hypothesis. Ocal and Aslan did research for Turkey, Azlina, Law and Mustapha for Malaysia, and Brini, Amara and Jemmali for Tunisia, and in all three cases empirical results confirmed conservation hypothesis. However, in developing countries, there is a possibility that economic growth may be adversely affected by the impact of renewables, precisely because of large and expensive investments. This claim is supported by the empirical results obtained for Tunisia and Turkey, which confirmed the negative effect on economic growth coming from renewable energy consumption (Azlina et al., 2014; Brini et al., 2017; Ocal & Aslan, 2013).

Review of literature supporting feedback hypothesis

Aperagis and Payne tested the causal relationship between renewable energy consumption and economic growth on several occasions. They chose a panel of 20 OECD countries,13 Eurasia countries, 6 Central American countries, and 80 countries in four different papers. These studies examine the renewable consumption-economic growth nexus over a different period of time, nevertheless, feedback hypothesis was confirmed for all the above (Apergis & Payne, 2010, 2011b, 2012). Investigating the causal relationship between economic growth and renewable energy consumption in BRIC countries for the period 1971-2010, Sebri and Ben-Salhagot obtained the results that support the feedback hypothesis. "The empirical evidence from the ARDL approach indicates that renewable energy consumption has a positive effect on economic growth and vice versa" (Sebri & Ben-Salha, 2014). Group of authors investigated renewable energy consumption effects on economic growth using the Westerlund cointegration test in the period 1990-2015 for Asia-Pacific Economic Cooperation (APEC) countries. "This empirical evidence suggests that countries should increase investment in renewable energy sectors and plan for development in renewable energy for sustainable energy growth" (Zafar et al., 2019). Aydin explored the relationship between renewable and non-renewable electricity consumption and economic growth using two different panel causality approaches in order to make a comparison. Results for 26 OECD countries, confirmed the feedback hypothesis, so the author indicates that "policy-makers should promote renewable electricity consumption to ensure energy security, reduce energy dependence, and encourage economic growth" (Aydin, 2019).

Pao and Fu used Brazil yearly statistics for the period 1980-2010 to examine the causal relationship between GDP and four types of energy consumption. Authors used vector error correction models and revealed the following: "A unidirectional causality from non-hydroelectric renewable energy consumption to economic growth and bi-directional causality between economic growth and total renewable energy consumption" (Pao & Fu, 2013). Results from this study suggest that economic growth plays an important role in renewable sector development. On the other hand, the expansion of renewable projects can enhance Brazil's economic growth. That being said, policymakers should include incentive mechanisms in their strategies for renewable energy development. (Pao & Fu, 2013). Lin and Moubarak explored renewable consumption and economic growth nexus in China using ARDL approach and Johansen cointegration techniques. The results showed bidirectional causality between variables, which implies that the growing economy in China is favorable for the development of the renewable energy sector, and at the same time, renewable consumption helps to boost economic growth (Lin & Moubarak, 2014). Group of authors used ARDL and a rolling window approach to investigate economic growth and renewable energy consumption in Pakistan. The study results detected a feedback effect between these variables (Shahbaz et al., 2015). Ibraheim also got similar results for Egypt, where the result confirmed the feedback hypothesis. The author suggests investments as well as a clear and comprehensive strategy for renewable energy development (Ibrahiem, 2015).

Review of literature supporting neutrality hypothesis

Bowden and Pyne used Toda-Yamamoto long-run causality test to explore the relationship between renewable energy consumption by sector and economic growth in the USA. For the period of 1949-2006, they found "the absence of Granger-causality between commercial and industrial renewable energy consumption and real GDP, respectively" (Bowden & Payne, 2010). The group of authors found similar results for the USA in the period 1949-2010. They explored the relationship between GDP and different kinds of renewable energy by applying a Toda–Yamamoto procedure and bootstrap-corrected causality test. Only one causality was found biomass-waste-derived energy consumption to real GDP, while for total renewable energy consumption and other kinds of renewable energy, the neutrality hypothesis was confirmed (Yildirim et al., 2012). Menegaki investigated the causal relationship between renewable energy and economic growth for 27 European countries in a multivariate panel framework over the period 1997–2007 using a random effect model. Empirical results support the neutrality hypothesis which implicates that renewable energy consumption has no effect on economic growth in Europe (Menegaki, 2011). Dogan also investigated electricity consumption from renewable energy and economic growth in Turkey and found the evidence of neutrality hypothesis. Since the author found that only consumption from non-renewable sources stimulate GRP growth, a suggestion for Turkish government is a reduction of electricity share from renewable sources (Dogan, 2015).

Review of literature with mixed results across counties

In this section, the findings of multi-country studies on the causal relationship between renewable energy consumption and economic growth relationship are summarized. The results are mixed across different countries therefore it cannot be argued that either of these studies supports a certain hypothesis. Bildirici and Ozaksoy investigated the causality between biomass energy consumption and economic growth in 10 European countries by using the Autoregressive Distributed Lag bounds testing approach and vector error-correction models. The results support the conservation hypothesis for Austria and Turkey and growth hypothesis for Hungary and Poland. Bidirectional causality was found for Spain, Sweden, and France (Bildirici & Özaksoy, 2013). Group of authors investigated the bi-directional long-run relationship between renewable energy consumption and GDP growth in countries with different income. "The results revealed that 79% of the countries have a positive bi-directional long-run relationship between renewable energy consumption and GDP growth. On the other hand, 19% of the countries showed no long-run relationship between the variables, while 2% of the countries showed a one-way long-run relationship from GDP growth to renewable energy consumption, and from renewable energy consumption and GDP growth" (Al-mulali et al., 2013). Although results vary across countries, it is found that the higher the income countries are, the bi-directional relationship is significant Group of authors investigated if there is a causal relationship between renewable energy consumption and economic growth in G7 countries, for the period 1990-2011. "The empirical results support the existence of a bi-directional causal

relationship for overall panel. However, looking at the individual results for each country, the neutrality hypothesis is confirmed for Canada, Italy and the US; while for France and UK there is unidirectional causality from GDP to renewable energy, and the opposite for Germany and Japan" (Chang et al., 2015). Koçak and Şarkgüneşi explored renewable energy and economic growth nexus in the Black Sea and Balkan countries for the period of 1990-2012. The research has shown the following: "…there is a long term balance relationship between renewable energy consumption and economic growth and renewable energy consumption has a positive impact on economic growth. Heterogeneous panel causality analysis results support growth hypothesis in Bulgaria, Greece, Macedonia, Russia and Ukraine; feedback hypothesis in Albania, Georgia and Romania; neutrality hypothesis in Turkey and according to the panel data set including all nine countries the results support feedback hypothesis" (Koçak & Şarkgüneşi, 2017). Authors are of the opinion that policies promoting renewable energy consumption should be supported in Black sea and Balkan. Bao and Xu investigated the linkage between renewable energy consumption and economic growth in China's provinces and regions. For the purposes of this paper section, we consider that this study is a multi-country study, although it is based on one county. The study results show no causality in 53% of provinces and 43% of geographical regions for the nexus of renewable energy consumption and economic growth (Bao & Xu, 2019). Alper and Oguz investigated the causality between economic growth and renewable energy in 8 new EU countries and they found mixed results across countries. The empirical results "support the neutrality hypothesis for Cyprus, Estonia, Hungary, Poland, Slovenia, conservation for Czech Republic and growth for Bulgaria" (Alper & Oguz, 2016). Destek and Aslan also investigated renewable energy – economic growth nexus for a group of emerging counties for the period 1980-2012. The results showed no causality for 12 countries, growth effect is found for Peru, conservation effect for Colombia and Thailand and feedback effect for Greece and South Korea (Destek & Aslan, 2017).

Conclusions

This survey provides a review of empirical literature related to the causal relationship between renewable energy consumption and economic growth. Understanding the causal link between renewable energy consumption and economic growth plays an important role in defining renewable energy policies. The goal was to consolidate the results found by various authors and thus propose some ideas for renewable energy policy-makers. Also, a path for future researchers in this field is made, since this paper is the only one that deals exclusively with renewable energy consumption-economic growth nexus. Based on the literature reviewed, the findings from various studies are at least contradictory. While some authors found causal relationship running from renewable energy to economic growth and vice versa, from economic growth to renewable energy, there are others that found no causal relationship. As mentioned earlier, a possible reason for these inconsistent results hides in selected countries, periods of time and econometric techniques used in studies. However, based on the research which includes 50 papers, only 16% of total results supports neutrality hypothesis, which means that

causality between renewable energy consumption and economic growth was found in most of the studies.

Based on findings of this article, it can be argued that in most cases, energy policies should be oriented towards the expansion of energy use from renewable sources. The need for renewable energy expansion can be viewed from two different angles. Promoting and investing in renewable energy projects can lead to the fulfillment of Sustainable Development Goals, in order to fight against climate change. Furthermore, increased consumption from renewable sources can help countries who are dependent on energy import to reduce their expenses and what is more important, to become self-reliant.

On the other hand, the importance of investing in renewable energy can be justified by their positive effect on economic growth. In the majority of studies, reviewed for the purpose of this literature survey, consumption from renewable energy can lead to an increase in economic growth. That being said, in general, energy policies should promote renewable energy development, except in cases where a negative impact on economic growth was found. In those cases, a possible solution is to find an adequate ratio of renewables and non-renewables.

Conflict of interests

The authors declare no conflict of interest.

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