CAUSALITY BETWEEN ENERGY CONSUMPTION AND ECONOMIC GROWTH: LITERATURE REVIEW

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Abstract

Although the mainstream theory of economic growth pays little (or no) attention to the role of energy in economic growth, during the last two decades there have been a number of papers dealing with the causality between economic growth and energy consumption. Strong interdependence and causality between economic growth and energy consumption is a stylized economic fact, but the existence and direction of causality is still not clearly defined. Broadly speaking, all papers could be divided in two groups. The first one consists of papers that argue that energy is a crucial input of production and a necessary requirement for economic and social development. On the other hand, the other group of papers argued that energy has no significant impact. The lack of consensus on whether economic growth results in energy consumption or is energy consumption the stimulant of economic growth has aroused the curiosity and interest among economists and analysts to investigate the direction of causality between these variables. The results of such studies are often contradictory. This can be explained by different econometric methodologies, different data set and different countries' characteristics. Although new and more sophisticated econometric methods for (better) identification and understanding of causality were developed over the years, an increasing number of published empirical studies regarding interconnectedness of energy consumption and GDP still have inconsistent results. A lack of compliance on what kind of causal relationship actually exists can result in inadequate implementation of appropriate economic and energy policy. Therefore, the aim of this paper is to give an overview of the existing literature with subsequent conclusions and guidelines for future research.

Keywords: energy consumption, economic growth, causality literature.

1. INTRODUCTION

After the financial sector, energy sector is probably the largest global industry with the broadest impact on other sectors of the economy since all economic activity depends on energy either in urban or rural areas. The matter of secure energy supply is important due to raising awareness of the impact of human and economic activities on the environment and climate change. Energy availability stands as a prerequisite for the functioning of the economy and it significantly affects production costs of most goods. Given the undisputed theoretical and practical importance of energy, it can be stated that this factor represents an important foundation for economic growth and development. Although a strong interdependence and causality between economic growth and energy consumption represents a stylized economic fact, the existence and direction of causality is still not clearly defined. This thematic area has been the subject of empirical research for the last several decades, although with no consensus on whether economic growth causes energy consumption or whether energy consumption acts as a stimulus of economic growth. The reasons for inconclusive results can be attributed to differences among countries, statistical techniques employed, time horizons and data sets. In the context of energy sector reform, knowing the direction and intensity of causal relationship represents an important foundation for design and implementation of the appropriate economic and energy policy. Although new and more sophisticated econometric methods for (better) identification and understanding of causality were developed over the years, an increasing number of published empirical studies regarding interconnectedness of energy and GDP still has inconsistent results. Therefore, the aim of this paper is to give an overview of the available existing literature with subsequent conclusions and guidelines for future research.

The rest of the paper is organized as follows: Section 2 presents a review on energy consumption-economic growth causality literature while Section 3 gives remarks on the studied causality literature. Final section gives the conclusion and recommendations for further research in the field of interconnectedness between energy consumption and economic growth.

2. LITERATURE REVIEW ON ENERGY CONSUMPTION (EC)-GROWTH NEXUS

The existence of a causal link between energy consumption and economic growth nowadays is mainly an accepted thesis, and at the same time, an interesting topic of many empirical studies worldwide. The causal link between energy consumption and economic growth can be synthesized into four possible hypothesis: 1) the growth hypothesis that asserts unidirectional causality from energy consumption to economic growth; 2) the conservation hypothesis which postulates unidirectional causality from economic growth to energy consumption; 3) the neutrality hypothesis that suggests the absence of a causal relationship between energy consumption and economic growth; 4) the feedback hypothesis that emphasizes the interdependent relationship between energy consumption and economic growth in which causation runs in both directions.

Kraft and Kraft (1978) wrote the pioneering and one of the most frequently quoted papers on causality between energy consumption and economic growth. In this paper, the authors investigated the direction of the causal link between gross national product (GNP) and energy consumption in the United States for the period 1947-1974. Using Sims causality test they found that there was a unidirectional causality running from GNP to energy consumption.

Akarca and Long (1979) reinvestigated the energy consumption-growth nexus in the United States. Using monthly data (from January 1973 to March 1978) and Granger's causality test, they found a negative causality running from energy consumption to employment. In another study, also on the example of the North American economy but this time for the period 1950-1970, Akarca and Long (1980) used Sims causality test and did not find any statistically significant interdependence. The absence of a causal link between energy consumption and economic growth/employment in the United States has also been confirmed by the research carried out by Yu and Hwang (1984), Yu and Choi (1985), Erol and Yu (1987a), and Yu et al. (1988).

Besides USA, Erol and Yu (1987b) have conducted an empirical analysis on the example of six developed industrialized countries for the period 1950-1982 using Sims and Granger causality test. Depending on the analysed country, Erol and Yu (1987b) proved the existence of all four possible hypothesis: Italy and Germany (GDP→EC), Canada (GDP←EC), Japan (GDP↔EC), France and United Kingdom (no causality).

Masih and Masih (1996) also proved the existence of all four possible hypothesis (using Johansen-Juselius procedure and vector error correction model) but on the example of six developing countries: Indonesia (1960-1990; GDP→EC), India (1955-1990; GDP←EC), Pakistan (1955-1990; GDP↔EC), Philippines (1955-1991; no causality), Malaysia (1955-1990; no causality) and Singapore (1960-1990; no causality).

A detailed chronological review of available empirical research regarding the interconnectedness between energy consumption and economic growth is available in Table 1. In addition, all analysed countries are classified according to the OECD membership criteria.

Table 1. Summary of literature review for energy consumption (EC) and economic growth (GDP)

Study	Country	Period	Methodology	Results
OECD member countries				
Stern (2000)	USA	1948-1994	Johansen-Juselius, static and dynamic cointegration analysis	GDP←EC
Hondroyiannis	Greece	1960-	Johansen-Juselius;	GDP↔EC

et al. (2002)		1996	cointegration; VEC	
Soytas and Sari (2003)	8 countries[1]	1950-1992	Johansen-Juselius; cointegration; VEC, VD	mixed results
Ghali and El-Sakka (2004)	Canada	1961-1997	Johansen-Juselius; cointegration; VEC, VD	GDP↔EC
Oh and Lee (2004a)	South Korea	1970-1999	Johansen-Juselius; cointegration; VEC	GDP↔EC
Oh and Lee (2004b)	South Korea	1981-2000	Johansen-Juselius; cointegration; VEC	GDP→EC
Hatemi-J and Irandoust (2005)	Sweden	1965-2000	Granger causality test (*bootstrap*[2] approach)	GDP→EC
Lee (2006)	11 countries[3]	1960-2001	Toda-Yamamoto causality test	mixed results
Soytas and Sari (2006)	G-7 countries[4]	1960-2004	Johansen-Juselius; cointegration; VEC, GVD	mixed results
Jobert and Karanfil (2007)	Turkey	1960-2003	Johansen-Juselius; no cointegration; VAR	no causality
Lee and Chang (2007)	24 countries[5]	1965-2002	panel VAR, GMM, IR	GDP↔EC
Mahadevan and Asafu-Adjaye (2007)	6 countries[6]	1971-2002	Pedroni, cointegration, panel VEC	GDP↔EC
Sica (2007)	Italy	1960-2001	Engle-Granger, cointegration, Granger causality test, VEC	GDP←EC
Chiou-Wei et al. (2008)	2 countries[7]	1954-2006	Johansen-Juselius, cointegration, VEC, VAR	no causality
Erdal et al. (2008)	Turkey	1970-2006	Johansen-Juselius, cointegration, Granger causality test	GDP↔EC
Huang et al.	26 countries[8]	1972-	panel VAR, GMM	GDP→EC **(-)**

[1] France (GDP←EC), Italy (1953-1991; GDP→EC), Japan (GDP←EC), Canada (no causality), Germany (GDP←EC), Turkey (GDP↔EC), USA and United Kingdom (no causality).
[2] Re-sampling the basic set of data to obtain more robust critical values relevant to the acceptance (or rejection) of the null hypothesis (Efron, 1979.).
[3] Belgium (GDP←EC), France, Italy and Japan (GDP→EC), Canada (1965-2001; GDP←EC), Netherlands (GDP←EC), Germany (1971-2001: no causality), USA (GDP↔EC), Sweden (no causality), Switzerland (GDP←EC) and United Kingdom (no causality).
[4] France (1970-2002; GDP←EC), Italy and Japan (GDP↔EC), Canada (GDP↔EC), Germany (1971-2002; GDP→EC), USA (GDP←EC) and United Kingdom (GDP↔EC).
[5] Australia, Austria, Belgium, Denmark, Finland, France, Ireland, Island, Italy, Japan, Canada, Luxembourg, Mexico, Netherland, Norway, New Zealand, Germany, Portugal, USA, Spain, Sweden, Switzerland, Turkey and United Kingdom.
[6] Australia, Japan, Norway, United Kingdom, USA and Sweden.
[7] USA and South Korea.
[8] Australia, Austria, Belgium, Denmark, Finland, France, Greece, Ireland, Island, Italy, Israel, Japan, Canada, China, Luxembourg, Netherlands, Norway, New Zealand, Germany, Portugal, Singapore, USA, Spain, Sweden, Switzerland and United Kingdom.

(2008)		2002		
Karanfil (2008)	Turkey	1970-2005	Johansen-Juselius, cointegration, VEC	GDP→EC
Lee et al. (2008)	22 OECD member countries[9]	1960-2001	Pedroni, cointegration, panel VEC	GDP↔EC
Narayan and Smyth (2008)	G-7 countries[10]	1972-2002	Pedroni and Westerlund, cointegration, panel VEC	GDP←EC[11]
Bartleet and Gounder (2010)	New Zealand	1960-2004	ARDL approach, cointegration, VEC	GDP→EC
Belke et al. (2010)	25 OECD member countries[12]	1981-2007	Johansen-Juselius modified test, cointegration, panel VEC	GDP↔EC
Lee and Chien (2010)	G-7 countries[13]	1960-2001	Toda-Yamamoto causality test, IR, VD	mixed results
Ozturk and Acaravci (2010)	4 countries[14]	1980-2006	ARDL approach, cointegration, VEC	GDP↔EC
Tsani (2010)	Greece	1960-2006	Toda-Yamamoto causality test	GDP←EC
Altunbas and Kapusuzoglu (2011)	United Kingdom	1987-2007	Johansen-Juselius, no cointegration, Granger causality test	GDP→EC
Zikovic and Vlahinic-Dizdarevic (2011)	10 countries[15]	1980-2007	Johansen-Juselius, cointegration, VEC	mixed results
Yildirim and Aslan (2012)	17 OECD member countries[16]	1960-2009	Toda-Yamamoto causality test (*bootstrap* approach)	mixed results
Non-OECD member countries				

[9] Australia, Austria, Belgium, Denmark, Finland, France, Greece, Ireland, Island, Italy, Japan, Canada, Netherlands, Norway, New Zealand, Germany, Portugal, USA, Spain, Sweden, Switzerland and United Kingdom.
[10] France, Italy, Japan, Canada, Germany, USA and United Kingdom.
[11] Narayan and Smyth (2008) also determined the intensity of the causal relationship. Therefore, a 1% increase in energy consumption leads to an increase in GDP ranging from 0.12 to 0.39%.
[12] Australia, Austria, Belgium, Czech Republic, Denmark, Finland, France, Greece, Ireland, Italy, Japan, South Korea, Canada, Luxembourg, Hungary, Mexico, Netherlands, Germany, Poland, Portugal, USA, Slovakia, Spain, Sweden and United Kingdom.
[13] France (GDP→EC), Italy (GDP←EC), Japan (GDP→EC), Canada (1965-2001; GDP←EC), Germany (1971-2001; no causality), USA (no causality) and United Kingdom (GDP←EC).
[14] Albania, Bulgaria, Hungary and Romania.
[15] Belgium, Denmark, Ireland, Norway and Sweden (GDP→EC); Austria, Czech Republic and Slovakia (GDP←EC); Finland and Switzerland (no causality).
[16] Australia (1964-2009; GDP→EC), Austria (1971-2009; no causality), Denmark (1969-2009; no causality), Finland (1971-2009; no causality), France (1960-2009; no causality), Ireland (1971-2009; GDP→EC), Italy (1971-2009; GDP↔EC), Japan (1971-2009; GDP←EC), Canada (1971-2009; GDP→EC), Norway (1972-2009; GDP↔EC), New Zealand (1971-2009; GDP↔EC), Germany (1971-2009; no causality), USA (1971-2009; no causality), Spain (1971-2009; GDP↔EC), Sweden (1962-2009; no causality), Turkey (1970-2009; no causality) and United Kingdom (1971-2009; no causality).

Glasure and Lee (1997)	South Korea and Singapore	1961-1990	Engle-Granger, cointegration, VEC	GDP↔EC
Aqeel and Butt (2001)	Pakistan	1955-1996	Engle-Granger, no cointegration, Granger causality test (Hsiao's version)	GDP→EC
Soytas and Sari (2003)	4 countries[17]	1950-1992	Johansen-Juselius, cointegration, VEC, VD	mixed results
Paul and Bhattacharya (2004)	India	1950-1996	Engle-Granger and Johansen-Juselius, cointegration, Granger causality test, VEC	GDP↔EC
Lee (2005)	18 countries[18]	1975-2001	Pedroni, cointegration, panel VEC	GDP←EC
Lee and Chang (2005)	Taiwan	1954-2003	Johansen-Juselius, cointegration, weak exogenity test	GDP↔EC
Lee and Chang (2007)	16 countries[19]	1965-2002	panel VAR, GMM, IR	GDP→EC
Mahadevan and Asafu-Adjaye (2007)	14 countries	1971-2002	Pedroni, cointegration, panel VEC	GDP↔EC (net exporters of energy[20]) GDP←EC (net importers of energy[21])
Akinlo (2008)	11 countries[22]	1980-2003	ARDL approach, cointegration (7 countries), VEC, VAR (4 countries)	mixed results
Chiou-Wei et al. (2008)	7 countries[23]	1954-2006	Johansen-Juselius, cointegration (1 country), VEC, VAR (6 countries)	mixed results
Yuan et al. (2008)	China	1963-2005	Johansen-Juselius, cointegration, VEC, IR	GDP↔EC

[17] Argentina (1950-1990; GDP↔EC), Indonesia (1960-1992; no causality), South Korea (1953-1991; GDP→EC), Poland (1965-1994; no causality).
[18] Argentina, Chile, Philippines, Ghana, India, Indonesia, South Korea, Kenya, Colombia, Hungary, Malaysia, Mexico, Pakistan, Peru, Singapore, Sri Lanka, Thailand and Venezuela.
[19] Argentina, Chile, Philippines, Ghana, India, Indonesia, Kenya, Colombia, Malaysia, Nigeria, Pakistan, Peru, Singapore, Sri Lanka, Thailand and Venezuela.
[20] Net exporters of energy: Argentina, Indonesia, Kuwait, Malaysia, Nigeria, Saudi Arabia, Venezuela.
[21] Net importers of energy: Ghana, India, South Africa, South Korea, Senegal, Singapore, Thailand.
[22] VEC: Gambia, Ghana and Senegal (GDP↔EC), Sudan and Zimbabwe (GDP→EC), Cameroon and Ivory Coast (no causality); VAR: Congo (GDP→EC), Nigeria, Kenya and Togo (no causality).
[23] VEC: Taiwan (GDP←EC); VAR: Thailand (no causality), Philippines and Singapore (GDP→EC), Hong Kong, Indonesia and Malaysia (GDP←EC).

Apergis and Payne (2009)	6 countries[24]	1980-2004	Pedroni, cointegration, panel VEC	GDP←EC[25]
Belloumi (2009)	Tunisia	1971-2004	Johansen-Juselius, cointegration, VEC	GDP↔EC
Gelo (2009)	Croatia	1953-2005	Granger causality test, VAR	GDP→EC
Odhiambo (2009)	Tanzania	1971-2006	ARDL approach, cointegration, VEC	GDP←EC
Imran and Siddiqui (2010)	Bangladesh, India and Pakistan	1971-2008	Kao, cointegration, panel VEC	GDP←EC
Odhiambo (2010)	South Africa, Kenia and Congo	1972-2006	ARDL approach, cointegration, VEC	GDP↔EC
Vlahinic-Dizdarevic and Zikovic (2010)	Croatia	1993-2006	Johansen-Juselius, cointegration, VEC	GDP→EC
Binh (2011)	Vietnam	1976-2010	Engle Granger and Johansen-Juselius, cointegration, VEC	GDP→EC
Kakar and Khilji (2011)	Pakistan	1980-2009	Johansen-Juselius, cointegration, VEC	GDP←EC
Shuyun and Donghua (2011)	China (provinces)	1985-2007	Pedroni, cointegration, panel VEC	GDP↔EC
Zikovic and Vlahinic-Dizdarevic (2011)	12 countries[26]	1993-2007	Johansen-Juselius, cointegration, VEC	mixed results
Borozan (2013)	Croatia	1992-2010	Johansen-Juselius, no cointegration, VAR, block exogeneity Wald test, IR, VD	GDP←EC[27]
Countries classified by income level – World Bank criteria				
Huang et al. (2008)	56 countries[28]	1972-2002	panel VAR, GMM	no causality (low income countries)

[24] Guatemala, Honduras, Costa Rica, Nicaragua, Panama and Salvador.
[25] Apergis and Payne (2009) also determined the intensity of the causal relationship. Therefore, a 1% increase in energy consumption leads to a 0.28% increase in GDP.
[26] Croatia, Latvia, Lithuania, Moldavia and Slovenia (GDP→EC); Bosnia and Herzegovina, Bulgaria and Malta (GDP←EC); Albania, Cyprus, Estonia and FYR Macedonia (no causality).
[27] Borozan (2013) also determined the intensity of the causal relationship. Therefore, a 1% increase in energy consumption leads to a 0.75% increase in Croatia's GDP. This result differs from the one Gelo (2009) obtained in his earlier empirical research: unidirectional causality running from GDP to energy consumption whereas a 1% increase in Croatia's GDP leads to 0.51% increase in total energy consumption.
[28] The sample consists of 19 low income countries, 22 lower-middle income countries and 15 upper-middle income countries. For detailed list of countries see Huang et al. (2008).

				GDP→EC (middle income countries)
Ozturk et al. (2010)	51 countries[29]	1971-2005	Pedroni, cointegration. panel VEC	GDP→EC (low income countries) GDP↔EC (middle income countries)
Other causality studies				
Wolde-Rufael (2004)	Shanghai[30]	1952-1999	Toda-Yamamoto causality test	GDP←EC

Note that causal directions reported in Table 1 incorporate both short-run and long-run causality. VAR = vector autoregression model; ARDL approach = autoregressive distributed lag approach; VEC = vector error correction model; VD = variance decomposition; IR = impulse response; GVD = generalized variance decomposition; GMM = generalized method of moments.

Source: Jakovac and Vlahinic Lenz (2016, pp. 60-66)

The studies listed in Table 1 include most countries of the world (both developed and developing ones). Over time, various empirical studies have focused on different countries or groups of countries (sometimes only one country was analysed by many different authors), time periods, main variables (or their substitutes) and quantitative methods. The results of such studies are often contradictory, and the lack of consensus on this matter could result in inadequate selection and implementation of economic and energy policies.

When the analysed countries were divided into OECD Member countries and non-OECD countries it was found that in both groups prevails the direction of causality (with or without feedback nexus) running from GDP to energy consumption. Specifically, in the case of OECD countries, the results of the causality analysis show that in 45.63% of cases GDP affects energy consumption compared to 42.72% of cases where causality runs from electricity consumption to GDP. In the case of non-OECD countries, it has been found that GDP affects energy consumption in 48.57% of cases compared to 42.86% of cases where it is found that causality runs from energy consumption to economic growth.

The so-called conservation hypothesis (i.e. unidirectional causality running from economic growth to energy consumption), suggests that the economy is relatively less dependent on energy and that maintaining the same level of energy consumption (using measures such as reduction of greenhouse gas emissions, energy efficiency improvement or energy demand management policies) will have a marginal impact on economic growth. In such a situation, policy makers can, for example, reduce the tax burden in order to attract the potential investors, or they can increase budget spending.

3. REMARKS ON THE STUDIED CAUSALITY LITERATURE

The reason why it is important to investigate the relationship between energy consumption and economic growth is straightforward: the implementation of economically efficient energy policies and the prediction of the impacts of various energy and economic policies requires an understanding of which of these variables causes the other. The increasing interest of researches on the energy consumption-growth nexus is obviously reflected by the increasing number of studies concerned with this subject. Consequently, such studies have gained impetus especially within the last 10 years resulting in voluminous but divided literature.

[29] The sample consists of 14 low income countries, 24 lower-middle income countries and 13 upper-middle income countries. For detailed list of countries see Ozturk et al. (2010).
[30] Municipality in China.

Thereby, at the present it is quite difficult to summarize the status of our knowledge regarding this causal relationship (Karanfil, 2009).

Although new and more sophisticated econometric methods for (better) identification and understanding of causality were developed over the years, an increasing number of published empirical studies regarding interconnectedness of energy and GDP still has inconsistent results. These diverse results arise due to the different data set (i.e. variable selection and time periods of the studies), model specification, alternative econometric methodologies and different countries' characteristics such as different indigenous energy supplies, different political and economic histories, different political arrangements, different institutional arrangements, different cultures and different energy policies (Ozturk, 2010; Payne, 2010). As pointed out by Karanfil (2008), in developing countries the investigation on the linkage between energy consumption and official GDP may not give reliable results mainly due to the unrecorded economic activities that hinder the correct measurement of the official GDP.

By looking at the empirical studies on energy consumption-economic growth nexus presented in Table 1, it can be concluded that a large number of these studies is focused on developed and developing countries as well as on the so-called emerging economies. Studies related to transition countries of Europe and Central Asian countries (especially the so-called commonwealth of independent states which includes the former Soviet republics) are numerically inferior in relation to the rest of the world. The reason is found primarily in the fact that these countries in the early 1990s began an economic transformation from a centrally-planned to a market-oriented economy, thus limiting the availability of data needed to implement robust and high-quality analysis.[31]

Most of the studies that have conducted the research on causality analysis between energy consumption and economic growth used the so-called bivariate framework. To be more precise, 53.97% of examined studies use bivariate framework while the remaining 46.03% of studies use multivariate framework. A common problem associated with bivariate analysis is the possibility of omitted variable bias, drawing into question the validity of the inferences of a causal relationship (Payne, 2010). Bivariate models, despite their usefulness because they can be applied in countries where only limited data are available, represent only a rough approximation of reality. On the other hand, the use of a multivariate model may be better founded in economic theory, it can help avoid econometric problems caused by afore-mentioned potential omitted variable bias and offers multiple causality channels that may remain hidden under a bivariate approach (Zachariadis, 2007).

Most of the studies that we have observed[32] do not examine the sign (positive or negative) nor the intensity of the causal link between electricity consumption and gross domestic product (the magnitude of the coefficients associated with the causality tests). It was also found that the growth hypothesis appears 31 times, the conservation hypothesis 32 times, the neutrality hypothesis 42 times and the feedback hypothesis 27 times.[33]

4. CONCLUSION AND RECOMMENDATIONS FOR FURTHER RESEARCH

The energy–growth nexus is a well-studied topic in the energy economics literature nowadays. However and as already stated, numerous empirical studies have yielded different and sometimes conflicting results. In order to avoid this shortcoming and to make future empirical results as robust and as representative as possible (and more interesting to potential interested parties), and to determine as precisely as possible the causal relationship between energy consumption and GDP, further research is needed. This calls for new approaches in terms of newer data sets (i.e. longer time series and other potential control variables) and sophisticated econometric methods.

In the future, according to Apergis and Payne (2009), it may be interesting to investigate multivariate causality between energy consumption and GDP and, depending on the data availability and reliability, to use other control variables such as labour and capital. It may also be interesting to use data on:

1) total population (to reflect the overall demographic corpus of one country and the needs of every

[31] In all examined studies, except panel data analysis, the number of observations ranges (in average) from 35 to 45 units of time (mostly years), which ultimately results in a relatively small sample when it comes to time series analysis.
[32] Except those of Kraft and Kraft (1978), Akarca and Long (1979), Huang et al. (2008), Narayan and Smyth (2008), Apergis and Payne (2009), Gelo (2009), Sharma (2010), Vlahinic-Dizdarevic and Zikovic (2010) as well as Borozan (2013).
[33] In the study by Payne (2010), 101 studies were surveyed (covering the period from 1978-2008) and the conclusions were the following: a) 58 studies rely on bivariate causality tests; b) across the 56 countries reported, the results for the specific countries surveyed show that 29.2% supported the neutrality hypothesis, 19.5% the conservation hypothesis, 23.1% the growth hypothesis and 28.2% the feedback hypothesis.

individual for energy);

2) government expenditures (since public investments in public utilities such as energy have an influence on energy production/consumption and economic growth);

3) financial development (since well-functioned financial institutions and financial markets represent an important condition for the development of energy sector);

4) carbon dioxide emissions (since the integration of data on CO_2 emissions in the causality analysis would help to better identify the interactions between energy production/consumption and economic growth);

5) a dummy variable (as a reflection of the recent economic crisis).

Future research on this topic can potentially gain importance if one (or a combination) of the following several econometric methods is applied:

1) nonlinear threshold regression model by which one can determine to which particular levels (limits) energy consumption actually affects GDP and by doing so one can “prescribe” economic and energy policies to those before and after the critical limits;

2) the leveraged bootstrap technique which is highly applicable when dealing with relatively small samples;

3) panel approach (combination of time series and cross sectional data) since panels provide more informative data, more variability, less collinearity among the variables, more degrees of freedom and greater efficiency in econometric estimates.

Ultimately, this remains a challenge for present and future research on this topic. According to Karanfil (2009) and Ozturk (2010), research papers using the same methods with the same variables but with a different time period examined have no more potential to make a contribution to the existing causality literature. These studies just increase the number of conflicting results and nothing more. Thus, authors should focus on new approaches and perspectives rather than employing usual methods based on a common set of variables. As indicated by Karanfil (2009), authors should keep in mind that policy makers are not interested about the examined time period nor the methodology used by a researcher. Policy makers are only interested in the robustness and the consistency of the final causality results.

Therefore, until researchers get sound, robust, uniformed and non-conflicting empirical results using some of the above-mentioned recommendations, governments have to be careful in implementing the appropriate policies.

5. ACKNOWLEDGEMENT

This article has been fully supported by the Croatian Science Foundation under the project number IP-2013-11-2203.

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