The link between energy consumption and economic growth: Evidence from transition economies (1985-2017)

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The Link between Energy Consumption and Economic Growth: Evidence from Transition Economies (1985-2017)

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Abstract

Economies around the world are on the move to ensure sustainable economic development and a clean atmosphere through the use of renewable energy sources. The importance of energy to all human aspects has been spiking as the world keeps evolving. This has made an exciting field of research to major academicians towards providing sound measures to governments in areas of developing the society at large. Using a systematic method of literature review, this work analyses the energy trend, as well as the energy-growth nexus research, carried out in transition economies. The concluding result after the systematic review shows that (14%) of the study confirms the growth hypothesis, (54%) feedback hypothesis, (9%) neutrality hypothesis, and (23%) conservation hypothesis.

Keywords: Energy, economic growth, resources, transition economies, systematic review.

1. Introduction

Energy is one of the most fundamental factors in achieving sustainable economic growth and development. As a result of the accelerated increase in energy demand, there has been the search for alternative energy sources as the number of fossil fuels keeps diminishing and fails to meet up demand (Apaydin, Gungor and Tagdogan, 2019). Presently, countries around the world are on the path to fully ensure the operations of renewable energy to reduce electricity price fluctuations, environmental pollution, and degradation, amongst others. Unexpected high growth in the renewables market, in terms of investment, new capacity, and high growth rates in developing countries, have changed the landscape for the energy sector (Schiffer, 2016). This brought about improvements seen in falling prices and the increased decoupling of economic growth and GHG emissions. Developing countries usually use fossil fuels as a source of energy leading to a two-fold energy challenge i.e., providing essential energy services and ensuring energy sustainability (Ahmed and Shimada, 2019). The relevance of energy on growth has made it highly researchable in different regions of the world. The energy sector is seen as a robust natural monopoly as a result of its essential nature for economic development. With the industrial revolution, economic growth around the world has been accompanied by massive consumption of energy, at least from the viewpoint of the theory of resource endowment (Luo, Lu, Wang, and Yang, 2019). Resource endowment theory holds that countries across have an abundance of different types of resources, which may determine the path to follow to achieve the desired economic growth and development. In the work of Afia (2019), it has been stressed that since energy consumption is a means of satisfying all our essential needs by improving our living conditions, it can be considered as a vital source of happiness for humans.

Countries have moved stages in power sector reforms to ensure competitiveness (Yin, Yan, Lei, Baležentis, and Streimikiene, 2019). The debate on the energy-growth nexus has been a topic of discussion since the late 1970s. This nexus since then examines four hypotheses on the causal relationship between energy consumption and economic growth (Arminen and Menegaki, 2019). Several works researched in this field of study around the world have concluded the presence of a causal relationship between energy and economic growth. As a result, this work shall later find if this exists for transition economies as well. The work of Bercu, Paraschiv and Lupu (2019) diverted a little and showed evidence of the importance of good governance in an economy towards reviving the efficient energy sector in stimulating growth. The majority of transition economies are going through the problems of poor management in the overall economy, which have led countries to fail in relieving energy crises that bring about a further hindrance to development prospects, corruption, and inefficiency.

In this paper, more emphasis is laid on the relationship between energy consumption and economic growth in transition economies. A lot of researches have been made in this field however, only little single country research has been made on transition economies. The categorization of transition economies around the world is evolving. Transition economies until recently have been considered the countries of central and eastern Europe and the former Soviet Union. Transition economies are those countries that are changing from a centrally planned economy to a market economy by undergoing structural transformations. Hence, this study looks into the proper definition of transition economies, select the countries from around all continents, and find out if there is a particular consensus on this area of study. This work aims to serve as a

guide to policymakers of the energy sector and the government as well. This is precisely on the areas of energy reforms and crises as this is the most challenging problems of the energy sector the transition economies are faced.

2. Literature Review

2.1 Concepts

Transition to a market economy involves profound economic changes and sometimes political change as well (Dana and Ramadani, 2015). In Asia, the transition was not all-round; it retained the existing political system while transforming the economies. While in Europe, the process combined both economic changes with political transformation resulting in more complexity. According to Trivic and Petkovic (2015) the heart of the transitional process is institutional building, and Institutions are perceived as the rules or regulations that structure political, economic, and social interaction while institutional environment comprises formal, informal institutions and an enforcement mechanism.

Poland, Hungary, and Bulgaria and countries of the former Soviet Union with its satellite states in the late 1980s after the collapse of communism have been on the move to embrace market capitalism and abandon central planning. The transition of economies is the process of undergoing a set of structural transformations to develop market-based institutions, i.e., a general change from a centrally planned economy to a market economy. The first ingredients of transition process, according to IMF (2000), are; Liberalization, Macroeconomic stabilization, Restructuring and privatization, Legal and institutional reforms. The countries have faced severe short-term difficulties, and longer-term constraints on development. Although the countries had mobilized labor and capital for industrialization, it failed to keep up with modern economies of the time (Aslund, 2008). Civil wars and military conflicts aggravated the process in some countries. Countries that adopted the radical form of transition had a fast result where the system changed almost overnight. These are countries like; Poland, Czech Republic, Estonia, Latvia, Lithuania, and Russia in the early 1990s and Georgia in the 2000s. The radical process brought about transition crises deepened by the banking crises (1996–1998) in the countries that embarked the process which resulted in the fall in GDP for about 35–50%, fallen industrial output, destruction of some manufacturing industries, high inflation, and unemployment (Gurkov, 2015). While those that settled with the gradual process of transition, mostly Asian countries and Mongolia led to more unfortunate results. However, a gradual transition has proven to be very successful in weak agrarian economies; China, Vietnam, Laos, and Cambodia. The formal end of the transition for ten countries came as a result of joining the European Union (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia). Although, these countries still entail some features of socialist economies in regard to work attitude and labor legislation. The most common characteristics of transition economies which pose as challenges are; rising unemployment, lack of entrepreneurship and skills, rising inflation, corruption, lack of a sophisticated legal system, lack of infrastructure, moral hazard, inequality amongst others. Poland and the Soviet Union towards the end of communism experienced hyperinflation with other transition economies facing some economic and social problems like; like inefficiency, stagnated growth rates as mentioned by (Aslund, 2008).

Haller (2012) gave a comprehensive definition of economic growth stating that it is the process of increasing the sizes of national economies, the macro-economic indications, especially the

GDP per capita, in an ascendant but not necessarily linear direction, with positive effects on the economic-social sector, while development shows how growth impacts on the society by increasing the standard of life. With a high rate of economic growth came the rise in the production of goods and services rises, unemployment rate reduction, and the overall improvement in the standard of life. In the analysis of economic growth, economists emphasize the need to increase capital equipment, which means that the amount of capital per worker is continuously increasing (Ivic, 2015). In the modern world, efficient production highly takes into account the use of technology and energy to ensure the proper working or usage of such technology. Thus, this brings about the energy link to economic growth.

The first evidence of coal being burned as fuel dates back to approximately 2,400 years (Energy, 2014). We use energy in our daily activities for transportation, cooking, heating and cooling rooms, manufacturing, lighting, and entertainment. We rely on energy to make our lives comfortable, productive, and enjoyable (NEED, 2018). These critical aspects of life as; economic security, environmental quality, quality of life, national security, population, socio-economic status, and global partnerships are all impacted by energy choices. The economy, energy, and the environment are three important elements for the development of nations because the use of energy is vital to the world economy in the present and the future (Gómez and Rodríguez, 2019). Thus, this marks the critical nature of energy use in society. The global world is on the move to fully transform to the use of renewable energy although the energy transition towards cleaner energy production is not moving at the anticipated speed (Schiffer, 2016). This is the energy obtained from virtually inexhaustible sources, which is compared to the lifetime of the Sun and replenish naturally over small time scales relative to the human life span (Energy, 2014). The primary sources of energy are; fossil fuels, i.e., non-renewable energy in the form of coal, oil and natural gas, and renewables as; nuclear power, biomass energy, wave energy, hydroelectric energy, tidal energy, hydrogen energy, geothermal energy, solar and wind energy.

2.2 Theoretical Review

Energy use and domestic material consumption alongside investments are decisive factors that shape the production process as they influence the economic efficiency levels and the economic gains (Popescu *et al.* 2019). Among the vast economic theories and models of production, the famous Cobb Douglas production function provides a clear understanding of such variables in generating economic growth as it shows the technological relationship between the quantities of inputs that will yield a particular amount of output. However, this model takes into account only labour and capital as inputs. An extension, the Solow model, aims at explaining long-run economic growth which also came with a limitation of treating technology exogenously, this weakness was further recognized by Paul Romer in his model. In the Romer model, technology is treated differently, as an endogenous variable. When infused with energy use, it becomes vital in production. As stressed by Amin and Alam (2018), technology can be said to be related to energy, and thus, energy has an indirect role in the production process, according to the mainstream growth theory. Given that several works have proven the importance of energy in strengthening the industrial structure, the dynamic simulation model, just as was used in China, is worth mentioning. According to Han, Lin, Zhang and Farnoosh (2019), The E&I-SD model could serve as a guide to policymakers towards planning the coordinated development of energy structure and industrial structure strategies by using the information of simulation and prioritizing uncertainties through driving the E&I-SD mode from the economic, energy and

environmental perspectives. Bottom-Up Techno-Economic Models focuses on specific energy market characteristics, the impact of policies on a sector, and the costs and challenges of technological change. Top-Down computable general equilibrium models, on the other hand, represent the whole economy instead of only energy sectors and thus capture the feedback effects across the economy.

2.3 Empirical Literature

There is a vast difference between the main focus of works in this field of study. Some researchers based solely on causal relationships, some on long-run relationships, some on short-run relationships, others on combinations of two or all. Also, some works are limited to single-country research, some continental research, while some a group of transition countries or emerging markets research. Further, another difference these works may possess is the type of energy used i.e., renewable or nonrenewable, period, data, and variable types, as well as the econometric technique used in concluding results.

On the causal relationships between energy consumption and economic growth, several works shall be discussed following the methodology applied to arrive at the final results. The granger causality test proposed by Engle-Granger is used in investigating causality between variables in a time series, i.e., it helps in determining whether a time series is useful in forecasting another. The four popular hypotheses in the energy-growth nexus are; growth hypothesis, conservation hypothesis, feedback hypothesis, and neutrality hypothesis. The growth hypothesis says there is a unidirectional causality and that energy consumption is what brings about economic growth. Conservation hypothesis asserts a unidirectional causality and economic growth are what bring about energy consumption. The feedback hypothesis believes in bi-directional causality, i.e., energy consumption and economic growth are interdependent. The neutrality hypothesis holds that there is no causality between energy consumption and economic growth. The following works shall be summarized and categorized under these hypotheses.

Country specific studies on energy-growth nexus follows. Having studied on Turkey for the period 1965-2017, Apaydin, Gungor and Taġdogan (2019) used the nonlinear autoregressive distributed lag (NARDL) and found a direct correlation between renewable energy consumption and economic growth. Ghoshray, Mendoza, Monfort, Ordoñez (2018) employed the Flexible Fourier form from 1949 to 2014 and found the evidence of the growth hypothesis for the US economy as opposed to a linear methodology, which returns neutrality hypothesis. Agbanike *et al.* (2019) investigated the causal interactions between oil price, energy consumption, and carbon dioxide (CO2) emissions in Venezuela. They found the Neutrality hypothesis using Autoregressive distributed lag bounds approach from 1971 to 2013. A work by Chandio *et al.* (2019) showed a long-run relationship between the consumption of industrial energy and economic growth in Pakistan. The causality test shows feedback hypothesis for industrial sector oil consumption and economic growth, and conservative hypothesis for economic growth to industrial electricity consumption, industrial gas consumption to industrial electricity consumption, and industrial oil consumption to industrial electricity consumption. Amin and Alam (2018) analyzed the relationship between energy consumption and sectoral output in Bangladesh. The Granger Causality tests reveal that at the aggregate level, there is a unidirectional causality running from GDP to energy consumption, confirming the conservative hypothesis. Research on the economy of Lithuania shows the presence of a long-run equilibrium relationship between residential electricity consumption per capita and GDP (Stundziene and

Kontautiene, 2018). Cheng and Liu (2019) analyzed the influence of different energy consumption on economic growth in China using a lagged variable regression model. It has been concluded that clean energy has the highest contribution rate to economic growth.

There have been several energy-growth nexus researches made on multi-country studies, some of which are discussed as follow; Arminen and Menegaki (2019) examined the causal relationship between economic growth, energy consumption, and carbon dioxide emissions and found a bidirectional causality using the simultaneous equations framework in 67 High income and upper middle-income countries from 1985-2011. Using a panel methodology, Bercu, Paraschiv and Lupu (2019) analyzed the long-term relationship between energy consumption, economic growth and good governance for 14 Central and Eastern European countries, over the period 1995–2017 and the result validates the hypothesis of the energy-led growth theory. TheVo, HongVo, and Le (2019) investigated the causal link between carbon dioxide (CO2) emissions, energy consumption, renewable energy, population growth, and economic growth from 1971 to 2014 for ASEAN countries. They found that Malaysia, the Philippines, and Thailand comply with the neutrality hypothesis while Indonesia and Myanmar are following the conservation hypothesis. Armeanu, Gherghina and Pasmangiu (2019) using panel data regressions, discovered the conservation hypothesis for short-run and growth hypothesis in the long-run for some renewable sources of energy in 11 Central and Eastern European states over the period 2000 to 2016. Using panel data analysis of 47 different countries from 2001 to 2014 by Afia (2019), result shows that energy consumption has a significant positive direct impact on economic growth and indirectly on happiness. Deonanan and Ramkissoon (2018) investigated 13 Caribbean small island developing states using a multivariate model from 1980 to 2011 and found that Antigua & Barbuda, Haiti, and Trinidad & Tobago (growth hypothesis), St. Kitts & Nevis (conservation hypothesis) remaining nine countries (neutrality hypothesis). The research result that came out of China, India and G7 countries on causality by LiuID, Lei, Zhang and Du (2019) for the period of 1965 to 2017 using Multi spatial convergent cross-mapping (CCM) is that Italy, Japan, France, China and India (feedback hypothesis) Germany, Canada, UK and US (growth hypothesis). Marques, Fuinhas and Marques (2019) having conducted continental research for the period 1970 to 2016 found America and the Asia Pacific (neutrality hypothesis) Europe and Central Asia and in Africa and the Middle East (conservation hypothesis). Liu and Liang (2019) examined the relationships between energy consumption, biodiversity, and economic growth in China, Cambodia, Laos, Myanmar, Thailand and Vietnam using autoregressive distributed lag (ARDL), and the result confirmed a strong, and robust causal correlation from economic growth to biocapacity and vice versa. Using dynamic panel data models, Sharma (2010) investigated the impact of electricity and non-electricity variables on economic growth in 66 countries from 1986 to 2005 and found a positive relationship between energy variables and economic growth. Ahmed and Shimada (2019) examined the effect of renewable energy consumption on sustainable economic development and found the presence of feedback hypothesis for the 30 emerging and developing countries from 1994 to 2014. Using panel data and bibliometric analysis, Zaharia *et al.* (2019) analyzed factors influencing energy consumption in the context of sustainable development and show that greenhouse gas emissions and gross domestic product, amongst other factors, have a positive relationship with both primary and final energy consumption. Saddam (2015) reveals the following result for OIC countries. A negative relationship between GDP and electricity consumption for Saudi Arabia, long run positive relationship for UAE, Libya, Malaysia and Algeria even though its growth does not largely come from industries of high energy use. Josheski, Lazarov, Koteski and Sovreski (2011) investigated

the relationship between GDP per capita growth, energy production, energy consumption per capita, productivity in energy sector and population in 220 countries from 1980 to 2002. Results show negative relationship between energy consumption and GDP, and positive relationship between energy production, energy sector productivity and GDP. Results from examining the relationship between renewable energy and economic growth in 25 European countries show that there is a presence of higher correlation between the variables in countries of higher GDP than with those of lower GDP (Ntanos *et al*, 2018). Bhattacharya, Paramati, Ozturk and Bhattacharya, (2016) investigated the top 38 renewable energy consumption countries from 1991 to 2012 using the panel estimation technique. Results show long run positive significant relationship in 57% of the research countries. Tan and Hong (2018) focused on 5 ASEAN countries which are; Indonesia, Malaysia, Philippines, Thailand and Vietnam. They employed the dynamic heterogeneous panel approach and proved the presence of positive and significant relationship between energy consumption and economic in both short and long run in these countries.

Mercan and Karakaya (2015) investigated the casual relationships among economic growth, energy consumption and CO2 emissions for selected eleven OECD countries from 1970 to 2011. Result shows the presence of cross section dependency and long-term cointegration. Shahbaz, Sarwa, Chen and Malik (2017) studied the relationship between economic growth, electricity consumption, oil prices, capital, and labor in 157 countries from 1960 to 2014. The results show the presence of cointegration and feedback effects among the variables.

3. Methodology

In this work, a systematic review of literature shall be carried out on the relationship between energy consumption and industrial growth. This will be across transition economies of the world. Articles on both single country and multi-country studies were selected. Precisely, both qualitative and quantitative review of published works made up the systematic review. In particular, we selected relevant studies by searching three scholarly electronic databases. These databases included: JSTOR, web of science, academia, and EBSCO. The keywords used in the literature search included: energy, renewable energy, economic growth, development, transition economies, and energy consumption.

Studies that merely investigated either energy consumption or economic growth, and not both were excluded, as well as those that did not investigate the nexus between energy consumption and economic growth. However, studies that simultaneously examined the effect of energy consumption on economic growth and other variables (e.g., environmental pollution, financial development) have been taken into consideration. Categorically, other excluded studies were those written in languages other than English as the search is restricted to English literature only. Time frame was not used as a basis for inclusion as all studies that meet the criteria mentioned above were considered regardless of the period covered in the studies. However, much importance was given to studies that include 1985 to 2017 as part of the time frame of analysis. This is to have a wider pool of studies to select from. Also, more emphasis was laid on studies that used economic growth as a dependent variable and energy consumption as an independent variable.

Constraints associated with this method may be restriction to English literature, year of publications, and failure to consider other databases alongside the four databases selected. A review of non-English publications would have deepened the research base. Furthermore, this

review is not broad as other offline published works on the energy-growth nexus were not included.

4. Results

The recent energy-growth nexus research carried out in transition economies shall be discussed in this section. By searching electronic databases using our inclusion requirements, not a large number of studies relevant to the criteria of selection have been found. After reviewing the papers, 24 related studies investigating the effect of energy consumption on economic growth were selected. Of these, 11(46 percent) were cross country and panel studies, while the remaining 13 (54 percent) were country-specific studies.

The following mentions a summary of the Multi-country studies reviewed in this work. From 1970 to 2013, Kablamaci (2017) investigated 91 countries using the Toda Yamamoto augmented Granger non-causality testing procedure and found the presence of growth hypothesis in 21 countries, conservation hypothesis in 31 countries, feedback hypothesis in 16 countries and neutrality hypothesis in 23 countries. Ozturk, Aslan, and Kalyoncu (2010) employed the panel cointegration and causality to analyze 51 (low, middle, high income) countries from 1971 to 2005. Energy consumption and GDP are cointegrated for all three income group countries. For the granger causality test, there is the presence of a conservative hypothesis for low-income countries and feedback hypothesis for middle-income countries. Another research was carried out on the 28 countries of the European Union spanning from 1995 to 2015 (Soava, Mehedintu, Sterpu, and Raduteanu, 2018). The empirical results suggest a positive impact of renewable energy consumption on economic growth, and emphasize bidirectional or unidirectional Granger causalities between the two macroeconomic indicators, for each country in the panel. The ARDL bounds testing approach to cointegration and vector error correction model (VECM) were used to examine the long-run and causal relationships. Sebri and Salha (2013) found that there exist long-run equilibrium relationships among the competing variables and feedback hypothesis in the BRICS countries. Apergis, Payne, Menyah, and Rufael (2010) researched 19 developed and developing countries. Results show that having used panel error correction model using the time frame 1984 to 2007, there exist a feedback hypothesis for nuclear and renewable energy consumption on economic growth.

Salim, Hassan, and Shafiei (2014) investigated OECD countries using panel cointegration techniques from 1980 to 2011. Results show the presence of cointegration among the variables, bidirectional causality between GDP and non-renewable energy (feedback hypothesis), and unidirectional causality between GDP and renewable energy (conservative hypothesis) in the short run. Yildirim, Seda, and Demirtas (2019) found the presence of Feedback hypothesis for China, Russia, India, and Brazil by applying the cointegration and FMOLS test from 1990 to 2014. Cowan, Chang, Lotz, and Guptaa (2014) examined the causal link between electricity consumption, economic growth, and CO2 emissions in the BRICS countries from 1990 to 2010. Results show that feedback hypothesis holds for Russia, conservation hypothesis for South Africa, neutrality hypothesis holds for Brazil, India, and China. Marinas, Dinu, and Cristian Socol (2018) analyzed the causal relationship between renewable energy consumption and economic growth in central and eastern European countries from 1990 to 2014. Results of long-run causality are as follows; Bulgaria, Estonia, Latvia, Lithuania, Poland, Slovakia, Slovenia (feedback hypothesis), Czech Republic, and Romania (conservation hypothesis), Hungary

(neutrality). Yardimcioglu, Gurdal, and Besel (2016) investigated the relationship between energy consumption and economic growth in the G8 countries from 1989 to 2015 using Dumitrescu and Hurlin Granger Causality method. Results show that there is a conservative hypothesis in G8 Countries during the period under review. Ozturk and Acaravci (2010) investigated the causal relationship between energy consumption and GDP in Albania, Hungary, Romania and Bulgaria. The following results were found; Hungary (feedback hypothesis) Albania, Romania, Bulgaria (neutrality hypothesis)

For the country-specific studies reviewed in this work, Chen, Xie, and Liao (2018) examined the causal relationship between energy consumption and economic growth for twenty-nine provinces of China using the panel Granger causality analysis. They found out the presence of bidirectional causality in 16 provinces, and unidirectional causality in 11 provinces and no causality in 2 provinces. However, using critical bootstrap values, the conservation hypothesis is found to apply to China. Ha, Tan and Goh (2018) also investigated the direction of causality in china using the Toda-Yamamoto test with bootstrapped critical values from 1953 to 2013. The growth hypothesis is found in the short run while following the feedback hypothesis in the long-run. Zhixin and Xin (2011) investigated the Chinese economy from 1980 to 2008 using co-integration and granger causality test. The results are in line with the feedback hypothesis. Apergis and Danuletiu (2012) studied the relationship between energy consumption and economic growth in Romania from 2000 to 2011. The results reveal the presence of co-integration, short-run, and long-run growth hypothesis. Another analysis from the period 1980 to 2011 shows the existence of bidirectional causality between electricity consumption and economic growth in Romania (Shahbaz, Mutascu and Tiwari, 2012). Also, from 1965 to 2007, Pirlogea and Cicea (2011) showed that there exists a feedback hypothesis between economic growth and only hydropower as a source of energy in Romania. Zhang (2011) investigated Russia and found the presence of feedback hypothesis for the period under review. Burakov and Freidin (2017) employed the vector error correction model (VECM) for Russian economy from 1990 to 2014. Results are in line with the conservation hypothesis. Long, Ngoc, and My (2018) investigated Vietnam from the period 1990 to 2015. Results show that electricity consumption positively impacts economic growth in Vietnam in both short term and long term. Kasperowicz (2014) focused his studies on the economy of Poland for the period of 1996 to 2012. Having tested for causality, he found that the result is in line with the feedback hypothesis. Gurgul and Lach (2012) investigated the causal interdependencies between electricity consumption and GDP in Poland from 2000 to 2009. They found the presence of feedback hypothesis between total energy consumption and economic growth. By employing the ADRL modus operandi, results from investigating Vietnam shows the presence of co-integration and feedback hypothesis (Clottey, Sun, Amissah and Mkumbo, 2018). And lastly, Djula (2013) examined the causal relationship between energy consumption and GDP in Croatia. Using bivariate autoregression and granger causality test, results confirm the presence of growth hypothesis.

Summary of works reviewed stating the method, period, countries studied and final causal relationship findings.

Study	Method	Period	Countries	Findings
(Kablamaci, 2017)	Toda Yamamoto augmented Granger non-causality testing procedure	1970 to 2013	91 countries	21 countries (growth hypothesis) 31 countries (conservation hypothesis *Albania, China and Bulgaria*) 16 countries (feedback hypothesis) 23 countries (neutrality hypothesis).
Chen, Xie and Liao (2018)	Panel Granger causality analysis	1985–2011	China	Conservation hypothesis
(Ha, Tan and Goh, 2018)	Toda-Yamamoto test with bootstrapped critical values	1953 to 2013	China	The growth hypothesis is found in the short run while following the feedback hypothesis in the long run
Zhang (2011)	State-space analysis	Undefined	Russia	Feedback hypothesis
Kasperowicz (2014)	Causality test	1996-2012	Poland	Feedback hypothesis
Ozturk, Aslan and Kalyoncu (2010)	Panel co-integration and causality test	1971 to 2005	51(low-income group, lower middle-income group and upper middle-income group countries	Presence of cointegration for all three income group countries. Conservation hypothesis for low-income countries (*China*). Feedback hypothesis for middle-income countries (*Hungary*).
Apergis and Danuletiu (2012)	Cointegration and error correction model	2000-2011	Romania	Presence of long-run relationship. Growth hypothesis
Burakov and Freidin (2017)	Vector error correction model VECM	1990-2014	Russia	Conservation hypothesis
(Soava, Mehedintu, Sterpu and Raduteanu, 2018)	Panel data techniques	1995 to 2015	28 countries of the European Union	(Countries of concern)Presence of cointegration. Growth hypothesis (*Estonia, Hungary,*

				Romania, Slovenia) Conservation hypothesis (*Bulgaria, Latvia*) Feedback hypothesis (*Czech Republic, Croatia, Lithuania, Poland, Slovakia*)
Long, Ngoc and My (2018)	Toda-Yamamoto approach and autoregressive distributed lag approach	1990-2015	Vietnam	Positive relationship in both short and long run Growth hypothesis
Sebri and Salha (2013)	ARDL bounds testing approach Vector error correction model (VECM)	1971-2010	BRICS countries	Presence of long-run relationship. Feedback hypothesis for all (*Russia and China*)
Apergis, Payne, Menyah and Rufael (2010)	Panel error correction model	1984-2007	19 developed and developing countries	Feedback hypothesis for nuclear and renewable energy consumption on economic growth (*Bulgaria and Hungary*)
Salim, Hassan and Shafiei (2014)	Panel co-integration technique	1980-2011	OECD countries	Feedback hypothesis between GDP and non-renewable energy. Conservation hypothesis between GDP and renewable energy (*Hungary and Poland*)
Yildirim, Seda and Demirtas (2019)	Cointegration and FMOLS test	1990-2014	Brazil Russia India China South Africa Turkey	Feedback hypothesis for all (*Russia and China*)
(Clottey, Sun, Amissah and Mkumbo, 2018)	Autoregressive distributed lag (ADRL) Vector autoregressive model (VAR)	1985 to 2017	Vietnam	Presence of co-integration. Feedback hypothesis.
(Shahbaz, Mutascu and Tiwari, 2012)	Co-integration and causality test	1980-2011	Romania	Feedback hypothesis

Pirlogea and Cicea (2011)	Co-integration test and causality test	1965-2007	Romania	Growth hypothesis
Zhixin and Xin (2011)	Co-integration and granger causality test	1980 to 2008	China	Feedback hypothesis
Ozturk and Acaravci (2010)	ARDL bounding testing approach	1980-2006	Albania Romania Hungary Bulgaria	Hungary (feedback hypothesis) Albania, Romania, Bulgaria (neutrality hypothesis)
Gurgul and Lach (2012)	Granger causality test	2000-2009	Poland	Feedback hypothesis between total electricity consumption and GDP
Cowan, Chang, Lotz and Guptaa (2014)	Panel causality analysis	1990– 2010	BRICS countries	Feedback hypothesis for Russia Conservation hypothesis for South Africa. Neutrality hypothesis holds for Brazil, India and China.
Marinas, Dinu, and Cristian Socol (2018)	Auto regressive distributed lag ARDL	1990-2014	Central and eastern European countries	Bulgaria(feedback) Czech republic(conservation) Estonia(feedback) Hungary(neutrality) Latvia(feedback) Lithuania(feedback) Poland(feedback) Romania(conservation) Slovakia (feedback) Slovania (feedback)
Yardimcioglu, Gurdal and Besel (2016)	Dumitrescu and Hurlin Granger Causality method	1989 to 2015	G8 countries	Conservation hypothesis (*Russia*)
Djula (2013)	bivariate autoregression and granger causality test	1992 to 2010	Croatia	Growth hypothesis

5. Discussion of Results and Issues

Variables

The type of review employed in this study shows that researchers on energy-growth nexus have used different proxies as indicators for economic growth. The most commonly used variable is GDP. Others used GDP growth rate, GNI per capita, and GDP per capita. On the other hand, the proxy for energy is different for most studies. Some works used a combination of both renewable and nonrenewable energy sources. Others focused on the separate or single use of electricity, crude oil, natural gas, nuclear energy.

Econometric Methods

Recent literatures on the relationship between energy consumption and economic growth have employed different econometric methods in testing the relationship between the two variables. The most popular methods used are ARDL and panel data models. Others include; OLS method, Fully Modified OLS, Dumitrescu and Hurlin Granger Causality method, lagged variable regression model, Toda-Yamamoto approach, State-space analysis, vector error correction model (VECM) and VAR.

Areas for Further Research

Having searched for journals to be adequately reviewed, it has been found that there is a gap in this field of study. The need for single-country research on the energy-growth nexus in transition economies is highly recommended. Transition economies are now a group of nations to be highly focused on their entire structural transformation in the economy. The majority of the transition economy countries have only been investigated in a multi-country studies which do not give detailed information on all countries gathered in the research. Out of the works reviewed, only four countries (China, Vietnam, Romania, and Poland) have been investigated separately. While the total number of transition countries are 35. Hence, the recommendation for further research is on the relationship between energy (renewable and non-renewable) consumption, industrial output, and economic growth as a single country research for transition economies.

6.0 Conclusion

The energy growth nexus has been a significant topic of debate over decades ago. This is because countries of the world are all moving towards achieving global sustainable development goals. This area specifically focuses on the use of clean energy, sustainable cities, and communities as well as climate action towards a better living environment for all.

The present study provided a systematic review of the empirical literature on energy growth nexus. This work reviewed 24 research papers published as either articles in journals or working papers. Out of these studies, the majority of the works indicated that energy consumption significantly improves economic growth. The causal relationship result is inconclusive. In combining results for transition economies in both specific and multi country studies, about (54%) is in line with the feedback hypothesis meaning both energy consumption and economic growth impact on another. (23%) is in line with the conservation hypothesis i.e., economic growth impacts energy consumption. (14%) shows the evidence of growth hypothesis in the sense that energy consumption influences economic growth

and (9%) follows the neutrality hypothesis meaning there is no causal relationship between energy consumption and economic growth. The difference in results in these works may be a result of the time frame, methodology, variables, and in case of multi studies, countries selected.

As findings from the work are inconclusive, single country research results may give policy implications according to the hypothesis supported towards improving the quality of economies as well as the lives of the citizens. However, those countries with higher usage of non-renewable energy sources i.e., fossil fuels, should be focused on policies that will build and improve the renewable energy sectors in ensuring efficient energy sectors. This way, each country will work on its part towards combating climate change, environmental health issues.

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