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HUMAN DEVELOPMENT- RENEWABLE ENERGY-GROWTH NEXUS IN THE TOP 10 ENERGY GLUTTONS

LJUDSKI RAZVOJ, OBNOVLJIVA ENERGIJA I EKONOMSKI RAST U 10 ZEMALJA SA NAJVEĆOM POTROŠNJOM ENERGIJE

Abstract

This paper employs a trivariate panel VAR model to explore the link, if any, between the renewable energy consumption (REN), human development (HDI) and economic growth (GDP) in the period 1990-2015 for the sample of top 10 leading economies in terms of energy consumption. The most important findings of the panel VAR model suggest a positive response of economic growth to the human development. With regard to renewable energy, economic growth is found to respond negatively but only in the short-run. This response is found to decrease exponentially and to reach positive values in the long-run. The findings of this paper emphasize that policy makers need to do necessary efforts to develop strategies that will support the usage of renewable energy since it tends to contribute to key dimensions of human development and to the sustainable economic growth in the long-run.

Keywords: economic growth; human development; panel VAR; renewable energy

JEL Classifications: Q56; O15; F43

Sažetak

U ovom radu je korišten VAR model za ispitivanje veze između obnovljive energije (REN), ljudskog razvoja (HDI) i ekonomskog rasta (BDP) u razdoblju između 1990. i 2015. za uzorak 10 vodećih privreda u pogledu potrošnje energije. Najvažniji nalazi panel VAR modela sugerišu pozitivnu reakciju ekonomskog rasta na ljudski razvoj. Što se tiče obnovljivih izvora energije, ekonomski rast reaguje negativno, ali samo kratkoročno. Utvrđeno je da se ova reakcija eksponencijalno smanjuje i da u dugom roku bilježi pozitivne vrijednosti. Nalazi ovog rada naglašavaju da kreatori politika moraju uložiti potrebne napore na razvoju strategija koje će podržati korištenje obnovljivih izvora energije, jer oni doprinose ključnim dimenzijama ljudskog razvoja i dugoročnom održivom ekonomskom rastu.

Ključne riječi: ekonomski rast; ljudski razvoj; panel VAR; obnovljiva energija

JEL klasifikacije: Q56; O15; F43

1. INTRODUCTION

Many of the countries have recorded a significant economic growth in the last decades. This growth has been strongly connected with the energy consumption. In parallel with the significant increase in the economic activity, the energy consumption has recorded tremendous increase. This is since energy is recognized as one of the main factors of production (Abul et al., 2019). In addition, the role of energy is of great importance in the modern manufacturing, transportation, communication etc. However, the most of the energy consumed is based on the non-renewable resources. Thus, the devices using this kind of energy tend to produce significant amounts of CO2 and contribute to the environmental degradation and climate change (Banos et al., 2011). This has increased a concern among scholars and they have started looking for the alternative.

Non-renewable resources are diminishing day by day. Thus, the environmental concern is not the only concern connected with these energy sources. The depletion of fossil fuels based energy tends to decrease the availability of cheap energy. This tends to significantly increase the production costs and consequently to increase the prices of many goods. The strongly energy-depended economies will thus become less competitive in the global market. Due to these reasons, many of the countries nowadays try to find the alternative to the fossil fuels energy supply. Kazar and Kazar (2014) have thus found the renewable energy to be an effective and low-cost alternative. Moreover, Dincer (2000) advocates the importance of renewable energy in promoting the sustainable development.

Due to the great importance of energy in the growth process, this topic has received much attention among research community. For instance, energy is recognized as an important factor of production by Dogan (2016) and Kahia et al. (2016). In addition to the great role of energy in economic growth, it is also important to emphasize that it tends to significantly influence the social well-being. Thus, energy has a great role in providing the modern hospital facilities, transportation, education etc. Hence, Ouedraogo (2013) suggests that the shortage of energy can result in the poor education services, communication or health services. In addition, it will reduce the chances to struggle against the poverty. Thus, Wang et al. (2018) suggests that energy consumption is an important determinant of the social development. In addition, it is important to emphasize that the population has been grown intensively. With the growth of population, the demand for energy has also been rose. The urbanization took place in the last twenty years. Thus, Niu et al. (2013) outlines the necessity to provide the adequate energy supply in order to have the sustainable development of a modern society.

The literature to date recognizes a significant role of renewable energy in the growth process at the local level. It also tends to significantly contribute the human in the rural areas. Not only developed, but developing countries can use the advantages of renewable energy while satisfying the growth objectives. Consequently, these countries can invest more resources to increase the level of human development (Satrovic, 2017). Wang et al. (2018) also suggest that the countries with the higher level of human development tend to invest more in renewable rather than non-renewable energy in the long-term. Moreover, Abdullah and Morley (2014) have advocated the great role of economic development indicating that it tends to decrease the poverty and release more resources to support the human development.

The fact that renewable energy tends to play an important role in the growth process as well as the human development was the motivation to conduct this study. From the best of our knowledge, this is the first attempt to analyze the link between energy consumption, human development and economic growth in the case of the top 10 energy gluttons. The motivation to select these countries lies in the fact that these top 10 countries spend the most energy on average and consequently produce the most CO2, thus this paper aimed to research whether or not these countries support the development of renewable energy. This is also the main contribution of this paper to the literature to date. The second contribution is the fact that we have used the last available data. The third contribution is the fact that this paper summarizes the important policy implications. The paper will summarize some of the empirical evidence treating the link between the variables of interest. It will also present the employed methodology together with the variables used. Moreover, the results section will display the obtained results and will provide the brief discussion. At the end we provide the concluding remarks.

2. LITERATURE REVIEW

Literature review section summarizes some of the latest empirical evidence on the link between the variables of interest. For instance Kazar and Kazar (2014) have collected the annual panel data in the two periods of interest: 1980-2010 and 2005-2010. The findings suggest the economic development to be an important determinant of the supply of renewable energy in the long-run. However, the short-run suggests a bidirectional relationship between these two variables. These findings are also supported by Apergis and Payne (2010). Moreover, the authors outline the important role of human development while analyzing the renewable energy-growth nexus.

Alabi et al. (2017) have conducted an empirical analysis on the renewable energy-growth nexus in the case of Angola, Algeria and Nigeria. The authors have employed panel data econometrics. The results of this paper suggest a bidirectional link between the variables of interest in the both, short- and the long-run. An important finding suggests the bidirectional relationship between emissions of CO2 and growth. Thus, the authors strongly recommend the need to support the supply of renewable energy since it tends to be cheaper, more efficient and it tends to deal with the modern environmental issues. Most of the papers to date analyze the link of the interest in the case of developed countries. However, the empirical evidence on the matter is lacking in developing countries. In addition, these countries suffer major energy problems such as the shortage of the energy or the poor access (Ackah et al., 2016; Amaewhule, 2002).

Bozkurt and Destek (2015) have compared the link between renewable energy and economic growth in the group of developed and developing countries. The period of interest is between 1980 and 2012. The empirical evidence suggests a positive renewable-energy growth nexus only in the sample of more developed countries. These findings are supported by Bugaje (2006) suggesting that the renewable energy can be beneficial for economic growth but the governments should be aware of the potential problems that can arise from this kind of energy taking into account the fact that it mostly relies on natural conditions e.g. weather.

Soukiazis et al. (2017) have suggested the need to take into account not only the link between economic performance and renewable energy but also the link between renewable energy and well-being of the society in the case of OECD countries. The data are collected in the time span between 2004 and 2015. The findings suggest that both, social well-being and renewable energy are important determinants of the sustainable growth. Barro (2001) suggests that higher productivity and consequently economic growth is strongly connected with the healthier society, thus health conditions are of great importance. Taking into account the fact that renewable energy tends to improve these conditions (due to the lover emission of CO2), Soukiazis et al. (2017) suggest the necessity to take into account the human development approximated using HDI.

Wang et al. (2018) have explored the link between social development, renewable energy and growth in the case of Pakistan. The data are collected in the period between 1990 and 2014. The findings suggest no link between the social development and renewable energy. In addition, the findings imply the negative link between social development and growth. The authors suggest that these findings are of great importance for the policy makers and describe in detail the policy recommendations.

At last, Bulut and Muratoglu (2018) have investigated the case of Turkey. The authors first suggest the necessity to support the development of renewable energy in Turkey taking into account its high dependency on the imported energy. To explore the energy-growth nexus authors have collected the data in the period between 1990 and 2015. The empirical evidence suggests no link between growth and the consumption of renewable energy in the case of Turkey.

3. METHODOLOGY AND VARIABLES

VAR models are broadly used in modern econometrics research. They assume all variables to be endogenous. Abrigo and Love (2016) propose panel VAR models as adequate to deal with individuals that are independent. These models are as opposed to DSGE models and they tend to estimate the dynamic interdependencies while minimizing the restrictions set. By introducing innovations, these models can be transformed from the reduced into structural form and thus allow for the analysis of the impulse-response function. Despite to the criticism, panel VAR models still presents and update of DSGE models and provide their significant improvement.

Abrigo and Love (2016) suggests that panel VAR model can be summarized as following:

$$Y_{it} = Y_{it-1}A_1 + Y_{it-2}A_2 + \cdots + Y_{it-p+1}A_{p-1} + Y_{it-p}A_p + X_{it}B + u_{it} + \varepsilon_{it} \quad (1)$$

where the vector of outcome variables is denoted by Y_{it} with the dimension of $(1\times k)$ endogenous covariates are denoted by X_{it} and the dimension of this vector is $(1\times l)$; the outcome variable effects that is fixed and specific is denoted by and has a dimension of $(1\times k)$. Moreover, the individual errors are denoted by ε_{it}. . Individuals are in the range between 1 and N while time-period ranges between 1 and T_i Shocks are assumed to: $E[e_{it}]=0, E[e'_{it}e_{it}]=\Sigma$ and $[e'_{it}e_{is}]= 0$ and the condition that

There are two possible alternatives to estimate the parameters $A_1, A_2, \ldots, A_{p-1}, A_p, B$.. The first one is to include the fixed effect, while the other one is estimated solely and includes fixed effects by the transformation. However, Nickell (1981) suggests that the lagged dependent variable would provide biased estimates (when it is included in the right-hand). To improve efficiency, Abrigo and Love (2016) suggest a model to be estimated using GMM estimation. The model is actually the system of equations.

This paper attempts to answer the question whether or not renewable energy and human development matter for economic growth. Thus, Eq. 2 formalizes the models to be estimated and interpreted in the empirical section as following:

$$\boldsymbol{GDP_{it}} = \sigma + \sum_{\boldsymbol{i=1}}^{\boldsymbol{k}} \boldsymbol{\beta_i}\, \boldsymbol{GDI_{t-1}} + \sum_{j=1}^{k} \theta_j\, REN_{t-j} + \sum_{m=1}^{k} \varphi_m\, HDI_{t-m} + u_{1t}$$

$$\boldsymbol{REN_{it}} = \alpha + \sum_{i=1}^{k} \beta_i\, GDP_{t-1} + \sum_{\boldsymbol{j=1}}^{\boldsymbol{k}} \boldsymbol{\theta_j}\, \boldsymbol{REN_{t-j}} + \sum_{m=1}^{k} \varphi_m\, HDI_{t-m} + u_{2t}$$

$$\boldsymbol{HDI_{it}} = d + \sum_{i=1}^{k} \beta_i\, GDP_{t-1} + \sum_{j=1}^{k} \theta_j\, REN_{t-j} + \sum_{\boldsymbol{m=1}}^{\boldsymbol{k}} \boldsymbol{\varphi_m}\, \boldsymbol{HDI_{t-m}} + u_{3t}. \ (2)$$

The advantage of panel VAR compared to time-series VAR is that it first enables to deal with the difference among units. Thus it easily deals with both, static and dynamic, interdependencies (Canova and Ciccarelli, 2013). One of the most important features of panel VAR models is their ability to control for the heterogeneity and dynamics in the coefficients. The methodology applied in this paper follows Love and Zicchino (2006).

The panel data at annual level are collected in the period between 1990 and 2015. The time-frame is selected based on the data availability. GDP (GDP per capita (constant 2010 US$)) is the proxy variable of economic growth. REN is the notation for the proxy of renewable energy. To approximate renewable energy this paper suggests renewable energy consumption (% of total final energy consumption). The source of these two variables is The World Bank. Human development is approximated using HDI – Human Development Index. UNDP databases are used to collect the data on HDI. With regard to the stationary test, this paper will employ Im–Pesaran–Shin, Levin–Lin–Chu (LLC) t* test andADF – Fisher test. To calculate the confidence bounds assigned with IRFs, 1000 Monte Carlo simulations are used. In order to choose the optimal number of lags, this paper employs moment and model selection criteria (MMSC) proposed by Andrews and Lu (2001).

4. RESULTS OF THE RESEARCH AND DISCUSSION

The sample of interest includes the top 10 leading countries in terms of energy consumption in the last observed year (2015). Global Energy Statistical Yearbook suggests the countries listed in the Table 1. The leading country is reported to be China. The Yearbook suggests an exponential increase in the energy consumption in China which is in the line with the growth of industrial sector. Besides that, energy consumption rises significantly in other Asian countries as well. For instance, India is ranked third while Japan is ranked fifth and Korea is placed 8th. Both increases are driven by the economic development. The same holds true for most of the European countries; hence Russia is ranked fourth while Germany is ranked sixth among biggest energy gluttons in the world. In terms of Russia, it is important to emphasize that the two-years recession period has ended in the last observed year. The similar explanation can be given for the Brazil that is ranked seventh. Despite to the fact that United States is ranked second, its energy consumption is found to be stable due to the lower electricity consumption as well as energy improvements.

Table 1: Descriptive statistics

	Measur.	Brazil (7)	Canada (9)	China (1)	France (10)	Germany (6)	India (3)	Japan (5)	Korea (8)	Russia (4)	United States (2)	Total
GDP	mean	9546.06	43572.98	2793.58	38049.80	38740.60	961.52	42760.32	16816.85	8608.16	44745.80	24659.57
	sd	1364.60	5273.77	1799.64	3335.21	3978.25	377.91	2557.77	5133.04	2209.00	5217.83	17849.72
	max	11915.40	50303.80	6496.62	41642.30	45412.60	1758.84	47163.50	24870.80	11803.70	51933.40	51933.40
	min	7797.83	35108.50	730.77	32543.90	32337.10	530.90	38074.50	8464.94	5505.63	35803.90	530.90
REN	mean	45.60	21.90	22.90	10.53	6.26	48.44	4.26	1.10	3.60	5.96	17.05
	sd	2.44	.42	8.48	1.49	4.09	7.21	.63	.61	.22	1.60	17.02
	max	49.86	22.70	34.08	13.50	14.21	58.65	6.30	2.84	4.04	8.75	58.65
	min	41.48	21.01	11.70	8.46	1.99	36.02	3.57	.44	3.23	4.09	.44
HDI	mean	68.81	88.13	62.39	85.15	87.85	51.90	86.28	82.87	74.57	89.29	77.72
	sd	4.27	2.24	7.70	3.39	4.37	6.21	2.62	5.37	3.70	1.88	13.01
	max	75.70	92.00	74.30	89.80	93.30	62.70	90.50	89.80	81.30	92.00	93.30
	min	61.10	84.90	50.20	77.90	80.10	42.70	81.60	72.80	70.00	86.00	42.70

Source: Authors

In terms of the basic measures of summary statistics, it is important to emphasize that the highest real GDP per capita is reported for United States on average, second highest is Canada while Japan is ranked third. The data suggest a significant difference among the top 10 energy gluttons in terms of the proxy of economic growth. With regard to the renewable energy consumption, the highest value of renewable energy consumption (% of total final energy consumption) on average is outlined for India, while the second highest is reported for the Brazil. However, it is important to emphasize that minimum values are assigned with some of the top energy gluttons. For instance, the energy obtained from renewable resources represents just 5.96% on average of the total final energy consumption. It is worthwhile noticing that this percentage reaches 22.9% in the case of China and 48.44% in the case of Brazil. Hence, Asian countries can be considered leading in this segment. At last, human development is found to record the highest values in the top energy gluttons. Thus, HDI is reported to reach 89.29% on average in United States (second biggest energy consumer; poor statistics in terms of renewable energy consumption). Second best country in terms of human development is Canada (ninth biggest energy consumer; third best in terms of renewable energy consumption). The least ranked country is India (third biggest energy consumer; the best in terms of renewable energy consumption).

In addition to the measures of descriptive statistics, we have tested for the stationarity properties of the variables. The three tests are utilized with the trend included in the models. Table 2 summarizes the obtained results.

Table 2: Unit-root tests

Trend included in the model	lnGDP		D.lnGDP		lnREN		D.lnREN		lnHDI		D.lnHDI	
Method	Stat.	p-value	Stat.	p-value	Stat.	p-value	Stat.	p-value	Stat.	p-value	Stat.	p-value
Levin–Lin–Chu (LLC) t* test	-2.54	.006	-6.52	.000	-1.59	0.057	-10.68	.000	-2.39	.008	-6.80	.000
Im–Pesaran–Shin test	-1.44	.075	-6.94	.000	-.46	0.323	-11.45	.000	0.43	.666	-6.12	.000
ADF – Fisher inverse chisquare	41.30	.003	80.15	.000	19.11	0.514	111.23	.000	33.53	.030	50.77	.000

Source: Authors

The Table 2 summarizes the results in log levels and the first difference. Levin–Lin–Chu (LLC) t* test and ADF – Fisher inverse chisquare suggest the proxy of economic growth to be stationary for a 1% level of significance. However, Im–Pesaran–Shin (IPS) test suggests that all panels contain unit root (for a 10% level of significance). Thus, there was a need to test for the first difference. All three tests agree that the null on unit root should be rejected, thus the proxy of economic growth is assumed to be stationary at the first difference for a 1% level of significance. The similar conclusion can be drawn for the other two variables suggesting that these two are also stationary at the first difference for a 1% significance level. The necessary precondition of the VAR model (variables to be stationary in the first difference) is thus met. Beforehand, we needed to determine the order of the VAR model. Table 3 summarizes the Andrews and Lu (2001) procedure based on the R square and Hansen's (1982) J statistics. All of the three criteria (MBIC, MAIC and MQIC) agree on the first-order panel VAR.

Table 3: The order of PVAR

Order	CD	J	J p-value	MBIC	MAIC	MQIC
1	.86786	22.19703	.727299	-120.858	-31.803	-67.842
2	.891683	9.744213	.939936	-85.6255	-26.2558	-50.2818
3	.812384	5.902212	.749664	-41.7826	-12.0978	-24.1108

Source: Authors

Thus, GMM estimator is employed to estimate the trivariate panel VAR. Table 4 displays the obtained results.

Table 4: VAR model (trivariate – GMM estimation)

Independent variables	Dependent variables		
	D.lnGDP	D.lnREN	D.lnHDI
D.GDP$_{t-1}$	.317 (.146)**	.287 (.272)	-.006 (.022)
D.lnREN$_{t-1}$	.033 (.024)	.031 (.089)	.004 (.003)
D.lnHDIt-1	2.262 (1.204)*	-6.180 (2.342)*	0.778 (.191)*

Note: ***, **, * significant at 1%, 5% and 10 % respectively.

Source: Authors

The findings of panel VAR model show a significant positive response of economic growth to its lagged value. Moreover, economic growth is found to respond positively to the human development indicating that human development tends to significantly contribute to the real GDP per capita primarily through education. This is due to the fact that in order to develop high-tech goods and industry based on renewable energy, the necessary prerequisite is to have a highly educated workforce. However, renewable energy is found to react negatively to the human development. It is quite understandable in the short-run since it may close some energy intensive industries if these are operated by energy obtained from fossil fuels. Thus, some people tend to be unemployed in the short-run. However, the impact in the long-run is expected to be positive what will be explored using IRFs. To explore the causal link between variables of interest, we have employed Granger causality test. Table 5 displays the obtained results.

Table 5: Results of the Granger causality tests

Equation	Excluded		
	D.lnREN	D.lnHDI	All
D.lnGDP	1.971 (.160)*	3.531 (.060)	4.950 (.084)
	D.lnGDP	D.lnHDI	All
D.lnREN	1.113 (.291)	6.962 (.008)	7.942 (.019)
	D.lnGDP	D.lnREN	All
D.lnHDI	.070 (.792)	2.234 (.135)	2.437 (.296)

Note: * p-value

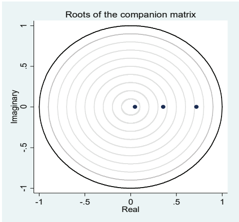
Source: Authors

Table 5shows a unidirectional Granger causal link running from HDI to GDP. Despite to the fact that renewable energy is not found to Granger cause economic growth, the joint link of the renewable energy consumption and human development with GDP is significant for a 10% level of significance suggesting the necessity to include the human development while analyzing the role of renewable energy consumption in economic growth. Moreover, HDI is found to have a unidirectional link with renewable energy while the coefficient with GDP is not found to be significant. Apart from this result, the joint link of HDI and GDP with REN is found to be significant. Lastly, none of the variables is found to have a significant causal link with HDI. The stability of the model is tested calculating eigenvalues. The Table 6 reports all eigenvalues to be lower than one. Additionally, Graph 1 suggests all eigenvalues to lie within the unit circle. Thus the trivariate panel VAR model can be considered stable.

Table 6: Stability of the model

Eigen value		
Real	Imaginary	Modulus
.719	.000	.719
.356	.000	.356
.049	.000	.049

Graph 1: Stability of the model



Source: Authors

To provide more informative results, we are presenting forecast-error variance decomposition (FEVD) and impulse responses function (IRF). Table 7 displays that 88.1% of the variability of GDP is explained by itself. Moreover, 0.4% of the variability of this variable is explained by REN and 11.5% by HDI. With regard to the renewable energy, 9.6% of the variability in the variable is explained by economic growth, 82.1% by itself while HDI explains 8.3% of the variability of renewable energy consumption. Lastly, forecast-error variance decomposition suggests that GDP explained 47.5% of the variability of HDI, renewable energy explains 0.4% while 52.1% is explained by itself.

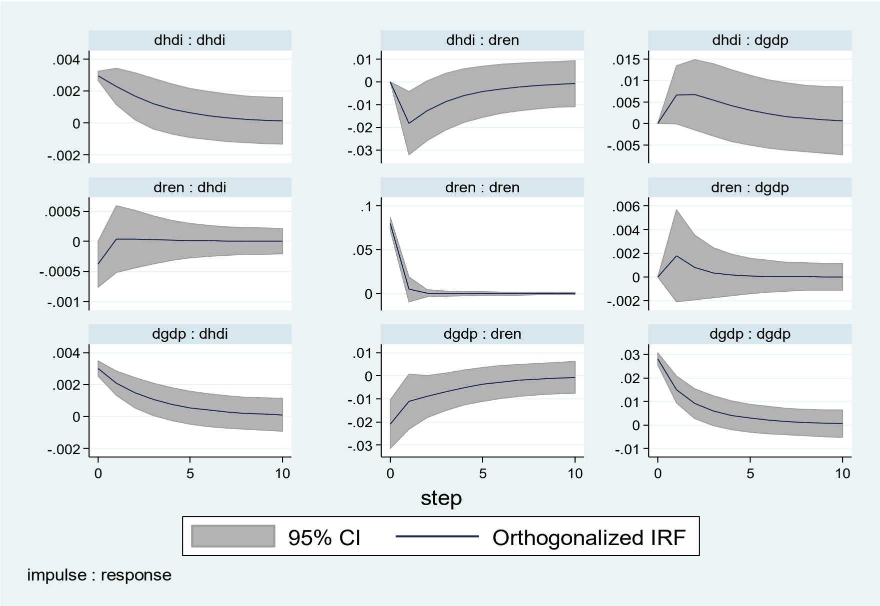
Panel VAR is in general accompained by forecast-error variance decomposition (FEVD) and impulse responses function (IRF) in order to increase the effectiveness of the interpretation of the results. Before estimating and graphing these measures, there is a need to test for the stability of trivariate PVAR model. Table 7 (eigenvalues) and Graph (1) confirm the assumption of the stability of these models. This table clearly indicates that all three macroeconomic variables are very complex and require determinants to be carefully selected.

Table 7: Forecast-error variance decomposition

Response variable	Impulse variable			Response variable	Impulse variable			Response variable	Impulse variable		
D.lnGDP	D.lnGDP	D.lnREN	D.lnHDI	D.lnREN	D.lnGDP	D.lnREN	D.lnHDI	D.lnHDI	D.lnGDP	D.lnREN	D.lnHDI
0	.000	.000	.000	0	.000	.000	.000	0	.000	.000	.000
1	1.000	.000	.000	1	.065	.935	.000	1	.506	.008	.486
2	.955	.003	.042	2	.078	.877	.046	2	.488	.005	.507
3	.922	.003	.075	3	.086	.848	.066	3	.481	.004	.515
4	.902	.003	.095	4	.091	.834	.075	4	.478	.004	.518
5	.891	.003	.106	5	.093	.827	.079	5	.476	.004	.520
6	.885	.003	.111	6	.095	.824	.081	6	.476	.004	.520
7	.882	.003	.115	7	.095	.822	.082	7	.475	.004	.521
8	.881	.003	.116	8	.096	.821	.083	8	.475	.004	.521
9	.880	.003	.117	9	.096	.821	.083	9	.475	.004	.521
10	.880	.003	.117	10	.096	.821	.083	10	.475	.004	.521

Source: Authors

Graph 2: IRF plots



Source: Authors

At last, Graph 2 displays the impulse-response function. HDI is found to respond negatively to REN, but this impact occurs only in the short-run. After the second period, this reaction is still negative but decreases substantially. HDI is found to respond positively to the change in GDP in both, short- and the long-run. However, the stronger reaction is reported in the short-run. With regard to the reaction of renewable energy on HDI, as explained above, this reaction is negative in the short-run. However, in the long-run this negative reaction vanishes. With regard to the response of renewable energy to the GDP, this response is positive, but more intensive in the short-run. Lastly, economic growth is found to react positively to the human development in both, short and long-term. In terms of the reaction of economic growth to renewable energy, it is negative in the short-run but decreases exponentially and reaches positive values after the fifth period of interest.

5. CONCLUSION

This paper provides the empirical evidence on the link between renewable energy, human development and growth in the case of the top 10 energy gluttons. The data are collected in the period between 1990 and 2015. We have employed the panel data methodology including the panel VAR model.

The findings of panel VAR model show that economic growth is found to respond positively to the human development indicating that human development tends to significantly contribute to the real GDP per capita. However, renewable energy is found to react negatively to the human development. It is quite understandable in the short-run since it may close some energy intensive industries if these are operated by energy obtained from fossil fuels. Thus, some people tend to be unemployed in the short-run.

The positive impact of human development is quite expectable taking into account the fact that in order to develop high-tech goods and industry based on renewable energy, the necessary prerequisite is to have a highly educated workforce. Hence, the results of this paper tend to provide an important insight for policy makers implying that these countries need to support the development of renewable energy in order to meet the needs for energy to operate the economic activities, deal with environmental depletion as well as to try to decrease the price of energy and to improve the energy efficiency. The findings to date suggest that renewable energy is in general more efficient and cheaper than traditional one. To use the advantages of renewable energy, educated workforce is of great importance. Thus, there is a need to improve human development. Consequently, by reducing CO2 emissions renewable energy tends to improve the health conditions and hence the productivity of the economy.

This paper suggests that one of the most important preconditions for the development of renewable energy is the policy framework. Moreover, the lack of educated workforce and the technology represents a serious obstacle. Thus, to meet the energy needs over renewable energy, there is a need for the countries of interest to build the necessary institutional capacity. Moreover, there is a need to have a scientific approach and to educate the workforce who will lead the development of renewable energy. Thus, governments should develop the policies that will support the production of renewable energy. Besides that, the investor friendly climate should be created that will enable the easy access for foreign investors tending to support the development of renewable energy. Governments should support the development of institutional capacity to produce the renewable energy and should also subsidize the firms that base their economic activities on renewable energy. As a last recommendation, there is a need to conduct a feasibility study especially in terms of the hydropower energy.

Hence, the recommendations for future research are to take into account the CO2 emissions, oil prices and financial development (Oguz and Huskic, 2019). Besides that, the sample of countries can be extended by analyzing OECD or OPEC countries. As a last recommendation, there is a need to take into account the source of renewable energy while conduction this analysis as well as the investments directed to this sector.

REFERENCES

1. Abdullah, S., and Morley, B. (2014). Environmental taxes and economic growth: evidence from panel causality tests. *Energy Economics*, 42, pp. 27-33.

2. Abul, S.J., Satrovic, E., Muslija, A. (2019). The Link between Energy Consumption and Economic Growth in Gulf Cooperation Council Countries, *International Journal of Energy Economics and Policy*, 9(5), pp. 38-45.

3. Abrigo, M. and Love, I. (2016). Estimation of panel vector autoregression in Stata: a package of programs. Working Paper No. 16-2.University of Hawai.

4. Ackah, I., Alabi, O. and Lartey, A. (2016). Analysing the efficiency of renewable energy consumption among oil-producing African countries, OPEC Energy Review, Wiley Online Library, 40(3), pp. 316-334.

5. Alabi, O., Ackah, I. and Lartey, A. (2017). Re-visiting the renewable energy– economic growth nexus: Empirical evidence from African OPEC countries, *International Journal of Energy Sector Management*, 11(3), pp.387-403.

6. Amaewhule, K. (2002). What are the constraints facing the development and implementation of an energy efficiency policy in Nigeria and how can these be overcome?, Oil, Gas & Energy Law Journal (OGEL), Maris BV.

7. Andrews, D.W.K. and B. Lu (2001).Consistent model and moment selection procedures for GMM estimation with application to dynamic panel data models.*Journal of Econometrics*, 101(1), pp. 123-164.

8. Apergis, N., Payne, J.E. (2010). Renewable energy consumption and economic growth: Evidence from a panel of OECD countries, *Energy Policy*, 38, pp. 656-660.

9. Banos, R., Manzano-Agugliaro, F., Montoya, F.G., Gil, C., Alcayde, A. (2011). Optimization methods applied to renewable and sustainable energy: A review, *Renewable and Sustainable Energy Reviews*, 15(4), pp. 1753-1766.

10. Barro, R. (2001). Human capital: growth, history and policy - A session to honor Stanley Engerman. Human Capital and Growth. *American Economic Review*, 91(2), pp. 12-17.

11. Bozkurt, C. and Destek, M.A. (2015). Renewable energy and sustainable development nexus in selected OECD countries. *International Journal of Energy Economics and Policy*, 5(2), pp. 507-514.

12. Bugaje, P.M. (2006). Renewable energy for sustainable development in Africa: a review. *Renewable and Sustainable Energy Review*, 10, pp. 603-612.

13. Bulut, U., and Muratoglu, G. (2018). Renewable energy in Turkey: Great potential, low but increasing utilization, and an empirical analysis on renewable energy-growth nexus. *Energy Policy*, 123, pp. 240-250. doi:10.1016/j.enpol.2018.08.057

14. Canova, F. and Ciccarelli, M. (2013). Panel vector autoregressive models a survey, ECB Working Paper SerieS NO 1507.

15. Dincer, I. (2000). Renewable energy and sustainable development: a crucial review, *Renewable and Sustainable Energy Reviews*, 4(2), pp. 157-175.

16. Dogan, E. (2016). Analyzing the linkage between renewable and non-renewable energy consumption and economic growth by considering structural break in time-series data.*Renewable Energy*, 99, pp. 1126–1136. doi:10.1016/j.renene.2016.07.078

17. Hansen, L.P. (1982). Large sample properties of generalized method of moments estimators. *Econometrica*, 50(4), pp. 1029-1054.

18. Kahia, M., Ben Aïssa, M. S., and Charfeddine, L. (2016). Impact of renewable and non-renewable energy consumption on economic growth: New evidence from the MENA Net Oil Exporting Countries (NOECs). *Energy*, 116, pp. 102-115. doi:10.1016/j.energy.2016.07.126

19. Kazar, G., and Kazar, A. (2014).The renewable energy production-economic development nexus, *International Journal of Energy Economics and Policy*, 4(2), pp. 312-319.

20. Love, I. and Zicchino, L. (2006). Financial development and dynamic investment behavior: Evidence from panel VAR. *The Quarterly Review of Economics and Finance*, 46(2), pp. 190-210.

21. Nickell, S.J. (1981). Biases in dynamic models with fixed effects. *Econometrica*, 49(6), pp. 1417-1426.

22. Niu, S., Jia, Y., Wang, W., He, R., Hu, L., and Liu, Y. (2013). Electricity consumption and human development level: A comparative analysis based on panel data for 50 countries. *International Journal of Electrical Power & Energy Systems*, 53, pp. 338-347. doi:10.1016/j.ijepes.2013.05.024

23. Oguz, S., and Huskic, M. (2019). On The Relationship between Financial Development and Trade Openness, *Research Journal of Politics, Economics and Management*, 7(1), pp. 23-32.

24. Ouedraogo, N. S. (2013). Energy consumption and human development: Evidence from a panel cointegration and error correction model. *Energy*, 63, pp. 28-41. doi:10.1016/j.energy.2013.09.067

25. Satrovic, E. (2017). Financial development and human capital in Turkey: ARDL approach, *Cappadocia Academic Review*, 1(2), pp. 1-15.

26. Sims, C.A. (1980). Macroeconomics and reality.*Econometrica*, 48(1), pp. 1-48.

27. Soukiazis, E., Proença, S. and Cerqueira, P.A. (2017). The interconnections between Renewable Energy, Economic Development and Environmental Pollution. A simultaneous equation system approach. CeBER Working Papers, No. 10.

28. Wang, Z., Danish, Zhang, B., and Wang, B. (2018). Renewable energy consumption, economic growth and human development index in Pakistan: Evidence form simultaneous equation model. *Journal of Cleaner Production*, 184, pp. 1081-1090. doi:10.1016/j.jclepro.2018.02.260