International Journal of New Political Economy 5(2): 87-114, 2024

Factors Affecting Electricity Generation from Renewables Energies in Iran

Masoomeh Alipourian[1], Ali Hussein Samadi[2]*, Ebrahim Hadian[3],
Ali Akbar Safavi[4], Fatemeh Ostovar[5]

ARTICLE INFO

Article history:

Date of submission: 16-12-2023

Date of revise: 21-05-2024

Date of acceptance: 14-06-2024

JEL Classification:

Q28

Q42

Keywords:

Electricity Generation

Renewable and Non-Renewable Energy

Energy Subsidies

E3 Models

ABSTRACT

Due to the existence of abundant sources of non-renewable energy and due to the structure of electricity generation strongly dependent on fossil fuels, Iran is facing challenges such as air pollution, climate change and energy security. However, due to favorable geographical features, Iran has diverse and available renewable resources that provide suitable alternatives to reduce dependence on fossil fuels. Considering the importance of this issue, in this paper, we have investigated "factors affecting electricity generation from renewable energies (RE) in Iran" during the period of 1990-2020 using the system of simultaneous equations in the framework of E3 models. These factors include: electricity generation from non-renewable energies (NRE), energy subsidies (SUB), capacity of renewable power plants (CRPP), technical cooperation grants (TCG) and foreign direct investment (FDI). The results show that making the electricity market competitive through reducing SUB (and thus increasing the price of fossil fuels) leads to an increase in the share of renewable energies in electricity generation. Besides, the increase of CRPP, the allocation of TCG to renewable technologies and the increase of FDI share in development of renewable technologies have positive effects on the expansion of RE.

1. Department of Economics, Shiraz University, Iran
2. Department of Economics, Shiraz University, Iran
3. Department of Economics, Shiraz University, Iran
4. School of Electrical and Computer Engineering, Shiraz University, Shiraz, Iran
5. School of Electrical and Computer Engineering, Shiraz University, Shiraz, Iran
*** Corresponding Author Email Address**: asamadi@rose.shirazu.ac.ir

DOI: https://doi.org/10.48308/jep.5.2.87

1. Introduction

Energy is an essential tool for economic activities and plays an important role in the sustainable development. But considering the exhaustion of non-renewable energy sources, as well as the negative and destructive environmental effects of using fossil fuels, the economic growth resulting from them cannot lead to sustainable development. Today, energy independence, security of energy supply, energy price shocks, non-renewable characteristics of oil and natural gas as traditional sources of energy and global warming are considered the most fundamental global issues (Sadorsky, 2009). This has caused the emergence of a wide range of solutions to face these issues. One of these solutions is replacing fossil energies with clean and renewable energies and using non-polluting technologies in order to reduce climate change and air pollution. According to the estimates, until 2040, Iran needs to increase its electricity generation capacity by 54 gigawatts with an annual growth of 3 gigawatts in the first years and 1.3 gigawatts in the last years. This increase in capacity should be provided by building new combined cycles and using renewable energies (Parliament Research Center of IRI[1], 2019). While the government has tried to develop renewable energy in electricity generation by using various policy tools, the share of these energy in Iran's energy basket is less than 1%. In other words, regardless of the hydropower plants, nearly 99 % of electricity generation in Iran is using non -renewable energies (Ministry of Energy, 2019).

Some of the reasons that have made NRE provides a significant share of the Iranian electricity market, including: the inability to export and sell oil due to oil sanctions (Dianat et al., 2021), Lower cost of initial investment of fossil power plants compared to renewable power plants (Mousavian et al., 2021), the low price of fuels in the fossil power plants (Shakouri & Aliakbarisani, 2016) due to the payment of subsidies to fossil fuels by the government (Dizaji et al., 2022). Energy subsidies (SUB) cause changes in

1. Islamic Republic of Iran (IRI)

the allocation of economic resources due to their impact on the amount of costs or the level of prices. These subsidies cause the non-optimal consumption of energy, reduce the ability and motivation of investors to invest in infrastructure sectors (including renewable technologies), severely reduce financial resources and the government's budget deficit (Javan & Nasimi, 2006). Based on what was said, in this paper the investigation of the factors affecting RE in Iran (along with the analysis of mutual relations between RE, EC, CO2 and GDP) is targeted in the framework of (E3) models and using the simultaneous equations system. There are many influential factors, but due to the unavailability of data for some of them, or the lack of their application in Iran's economy, in the present study, five influential factors (Electricity Generation from Non-Renewable Energies, Capacity of Renewable Power Plants, Energy Subsidies, Technical Cooperation Grant and Foreign Direct Investment) have been selected.

This paper is organized in five sections. The second section is dedicated to the literature review. In the third section, the methodology and specification of the model are presented. In the fourth section, we have presented the experiential results and discussion. In the fifth section, we will have conclusions and policy implications.

2. Literature Review

Currently, innovative and more sustainable methods to meet energy needs in the world have led to a change in the pattern of dependence on fossil fuels and an increase in the share of renewable energies in the global energy composition. Renewable energies as an approach to transition to sustainable energy on a global scale have been seriously considered and the process of using them in electricity production has accelerated. Researchers have identified several influential factors in the use of this type of energy in electricity production. Some of them have examined the necessary conditions for the transition to renewable energy in electricity production. Some others have measured the effectiveness of the policy tools used in the development of electricity production from renewable energies. Others have investigated factors such as "natural resources and geographical and climatic conditions of the region", "economic situation of the government", "population growth", "electricity market conditions", "political conditions and interest groups". The studies conducted in this regard are classified into the following groups.

2.1. Necessary conditions for transition to renewable energy in electricity generation

Some authors (e.g., Gunningham, 2012, Mousavi Dorche et al., 2016 and Kaswan, 2018) believe that energy transition is only possible through effective energy governance at the national, regional and global levels, changes in the institutional environment governing the country's socio-technical power plant system, and the intervention of government organizations only in cases of market failure. Others (e.g., Marzban et al., 2018) have been categorized key factors into seven main groups (political, economic, social, technological, environmental, legal and industrial) and three important emerging trends in the path of future changes and transformations (including the democratization of energy interactions, the development of technical-social innovations and the cultivation of human, social, and cultural aspects of energy systems).

2.2. Policy instruments for the transition to electricity generation from renewable energies

The studies conducted in this field are presented in the form of three categories of policy instruments (control and regulatory instruments, market-based instruments, and information instruments).

2.2.1. Control and Regulatory instruments

The policy instruments used by government agencies to achieve goals are defined as control and regulatory instruments or coercive instruments.

Keyuraphan et al. (2012), Chaharsooghi et al. (2015), Lee and Seo (2019) considered the Renewable Portfolio Standards (RPS) as one of the most common policies to support renewable electricity, which seeks to create price competition between renewable energy producers. Barimani and Kaabi-nejad (2013) and Aien and Mahdavi (2020) considered the policy of guaranteed renewable electricity purchase tariff as the most practical policy to attract private sector investors in Iran.

Tang (2013) and Kariuki (2018) showed that "government financial support" from investors in the electricity production of renewable energy and "creating suitable infrastructure" for the development of this energy will lead to the growth of renewable production. Najafi et al. (2015) considered the availability of technology, investment, human resources expertise and other resources along with long-term renewable energy policies as effective factors in the development of renewable energy. According to Shokri Kalehsar (2019), the main obstacle to the development of renewable technology in Iran is obtaining the required financial capital, and one of its solutions is to attract foreign investment and transfer the required technology.

Noorollahi et al. (2019) considered the lack of national and local laws, poor management of human resources, inability to transfer technology, and most importantly, the lack of ownership and the process of obtaining a license for geothermal resources as obstacles to the development of the use of this renewable energy in Iran. Pahlavani et al. (2020) considered facilitating the process of obtaining land permits and connecting to renewable power plants as one of the ways to remove obstacles to investment in electricity production from renewable energies in Iran.

2.2.2. Market-Based instruments

In market-based policy instruments, people try to choose the options that have the most benefits for them in order to maximize their utility. According to Shi (2014), the increase in the price of energy carriers increases the share of renewable energy, but the rapid growth of demand for energy decreases the share of renewable energy in the total supply of energy. Abbasi Gudarzi and Maleki (2016) considered the modification of the prices of energy carriers to be the primary condition and a strong driving force in accelerating the penetration of renewable technologies in Iran. Rottgers and Anderson (2018) concluded that the increase in the price of fossil energy causes an increase in the share of renewable energy in electricity production, and the subsidy to fossil energy causes a decrease in the use of renewable energy. Bayomi and Fernandez (2019) by examining the energy subsidy structure in four countries, Iran, Kuwait, Saudi Arabia and the UAE, concluded that the high energy subsidy in these countries compared to the world has caused inefficient production and consumption of energy in these countries. Beck and Martinot (2004) found that investment tax credits, production tax credits and Feed in Tariff (FIT) laws have played the greatest role in the development of renewable energy in European electricity. Zhao, Tang and Wang (2013), Warbroek (2015) and Sarti (2018) concluded that FIT is the most effective policy instruments in promoting renewable capacities in electricity generation. Sharifi et al. (2013), Mousavi Dorche et al. (2016), Argentiero et al. (2018) have paid to the issue of the spread of renewable energy technologies and the commercialization of entrepreneurial ideas in the field of renewable energy, and its positive impact.

2.2.3. Information instruments

Information instruments encourage people to participate in the use of renewable energies by creating culture and increasing public awareness of the advantages of using renewable energies. Information instruments are considered as modern forms of government intervention with the lowest degree of coercion. Afsharzade et al. (2016) emphasize the importance of "social acceptance" in the development of the use of renewable energies. Shi (2014) concluded that the factors influencing people's decision to "participate in the use of renewable energy" are influenced by the level of household income and their views on the environment. Ghorban-nejad et al.

(2018) and Mohammadi and Sabouri (2015) have emphasized the importance of raising the level of awareness of farmers in Iran in the use of renewable energy technology.

2.3. Other factors

The third group of studies examines the effects of factors such as: "natural resources and geographical and climatic conditions of the region", "economic situation of the government", "population growth", "electricity market conditions" and "political conditions and interest groups". According to Delmas and Montes-Sancho (2011) and Park (2013), the presence of renewable potential resources is one of the effective factors in the successful implementation of RE development policies. Sapat (2004) and Park (2013), found that rich government has the ability to invest more in environmentally friendly projects, and the better the economic status of the government, the more RE will be. High population growth on one hand, can increase RE, on the other hand, may increase NRE due to its lower cost (Park, 2013). Carley (2009) concluded that interest groups in fossil fuel industries, by putting pressure on politicians, hinder the support of statesmen and legislators for the establishment of laws for the development of renewable energy and their implementation. This has negative effects on the development of the renewable electricity market. Delmas and Montes-Sancho, (2013) believe that the greater the number of participants in environmental groups, the more policies related to the development of renewable energy technologies will be adopted. Carley (2009) found that the high wholesale price of natural gas causes the tendency of electricity producers to replace renewable energies. Salamon (2002) concluded that the efficiency of private companies in RE is higher than that of public companies.

Some researchers believe that by using the components of transition governance, the path of technological transition to RE can be accelerated. According to Some other researchers, among the regulatory instruments, the guaranteed purchase of renewable electricity has been stated as the most effective instrument to invest in RE. Some authors believe that keeping the price of fossil fuels low through subsidies allocated to this type of energy has hindered the competitiveness of renewable energy in the market. Therefore, they suggest reducing SUB and increasing the price of energy carriers and allocating the resulting income to RE. Some scholars, in relation to information and awareness instruments, have emphasized the role of social acceptance and increasing public willingness to use renewable energy. Most of the studies have only investigated the relationship between energy, CO2 emissions and GDP, while some others have investigated the relationship between other variables related to these variables (such as foreign direct investment, renewable and non-renewable energies, energy subsidies, etc.). In this paper, while examining the factors affecting RE, we also examine the interrelationships between production and consumption of renewable and non-renewable electricity, GDP and CO2 emissions, in the framework of E3 models in Iran.

The contribution of this paper is that by separating RE and NRE, while examining the effect of NRE on RE, the effect of other related factors such as SUB, CRPP, TCG and FDI has also been measured. At the same time, using the simultaneous modeling (in the framework of E3 models), we have analyzed the mutual relationship between RE, EC, CO2 emission and GDP.

3. Model Specification and Methodology

The main reason for paying attention to the mutual relationship between CO2 emissions, energy production and consumption, and GDP is that almost two-thirds of the world's energy comes from burning fossil fuels, and the continuation of economic growth has led to more greenhouse gas emissions, especially CO2. Therefore, there is a positive relationship between GDP and CO2 emissions globally (Ritchie and Roser, 2020). The relationship between EC, CO2 emissions, and GDP varies from country to country and depending on the methodology used. This relationship can be examined in three categories: the relationship between EC and GDP), the relationship between

CO_2 and GDP; the relationship between EC, GDP and CO2 emissions. The relationship between EC and GDP has been investigated in the form of four hypotheses (growth, conservation, feedback and neutrality) (Soytas, et al., (2007), Apergis and Payne (2010), Tugcu, et al., (2012)). The relationship between environmental pollution and economic growth has been investigated using the environmental Kuznets curve (EKC). The third category is the hybrid approach and examines the dynamic relationship between the Energy sector, Economic growth and Environmental pollution (E3 models). From an economic point of view, E3 models are augmented models of economic growth considering energy and environmental factors. The capital factor in neoclassical growth models also includes environmental investments. The reduction of greenhouse gas emissions in this augmented model is similar to the discussion of investment in the main models. In fact, by considering greenhouse gases as negative natural capital, a decrease in their emissions can be considered as lowering the amount of negative natural capital (Asali, 2012).

In this paper, the analysis of the effects and feedbacks between economy, energy and environment (E3) along with the investigation of factors affecting RE in Iran, has been formulated using a system of simultaneous equations. Most of the existing literature generally assumes that economic growth leads to changes in CO2 emissions. But in some studies, the opposite relationship has been observed. Energy consumption is also often a key factor in economic growth and in carbon emissions. Therefore, investigating the mutual relations between these variables in a system of simultaneous equations becomes important. Also, a wide range of studies have used several variables to investigate the factors affecting RE. In Iran, due to the abundance of fossil resources (oil and gas), the availability of infrastructure for their production and exploitation, and their low price in electricity generation due to the subsidy paid to them by the government, the possibility of making the electricity market competitive in favor of RE is facing problems. Some of these problems are: the high initial cost and as a result the high risk of investing in RE, the lack of access to advanced technologies in the field of RE due to economic sanctions and the unwillingness of foreign investors to Investment in Iran and the small share of RE in the research and development budget. Therefore, in this research, the following five key factors have been selected.

- NRE as a complement and competitor of RE in Iran's energy portfolio. NRE has a share of about 85% of Iran's electricity generation and has the greatest impact on RE.
- SUB, which are the main factor in keeping the price of fossil fuels low and making the electricity market uncompetitive in Iran.
- FDI due to the impact of the spillover of renewable technologies and the financing of investment projects on RE.
- TCG, which provides a research and development platform for RE.
- CRPP as the main platform for RE development and capacity of renewable power plants.

NRE, CRPP, and TCG variables are subcategory of regulatory and control instruments, and SUB is a subcategory of market-oriented instruments. FDI depends on the foreign policy of the government.

Based on the explanations provided, the system of simultaneous equations in this paper includes four behavioral equations (1-4) that describe the interrelationships between EC, RE, CO2 and GDP as follow. These equations are specified based on the following studies and are not found in any study. For Eq. 1, See, e.g., Shengfeng, et al. (2012), Ezenwa, et al. (2021). For Eq. 2, See, e.g., Apergis and Payne (2010), Apergis and Payne (2012), Pao and Fu (2013), Shahbaz et al. (2015), Dizaji et al. (2022). For Eq. 3, See, e.g., Coondoo and Dinda (2002), Shahbaz et al. (2012), Shengfeng et al. (2012), Ezenwa et al. (2021). For Eq. 4, See, e.g., Ayres and Nair (1984), Coondoo and Dinda (2002), Stern and Cleveland (2004), Ang (2008), Shengfeng et al. (2012), Pao & Fu (2013), Atems & Hotaling (2018).

$$\text{Log (EC)} = \alpha_{0}+ \alpha_1\log(RE)+ \alpha_2\log(NRE)+ \alpha_3\log(GDP)+ \alpha_4\log(CO_2) + \alpha_5\log(CRPP_{t-1})+\varepsilon t \quad (1)$$

$$\text{Log (RE)} = \beta_{0}+ \beta_1\log(NRE)+ \beta_2\log(GDP)+ \beta_3\log(CO_2) + \beta_4\log(SUB_{t-1}) + \beta_5\log(EC)+\mu t \quad (2)$$

$$\text{Log } (CO_2) = \gamma_{0}+ \gamma_1\log(RE)+ \gamma_2\log(NRE)+ \gamma_3\log(GDP) + \gamma_4\log(TCG_{t-1}) + \gamma_5\log(EC)+\varphi t \quad (3)$$

$$\text{Log (GDP)} = \delta_0+ \delta_1\log(RE)+ \delta_2\log(NRE) + \delta_3\log(CO_2) + \delta_4\log(FDI_{t-1}) + \delta_5\log(EC)+\omega t \quad (4)$$

Where, EC is Electricity Consumption per capita (in kilowatt hours), RE is electricity generation from Renewable Energy (in kilowatt hours), CO_2 is Carbon dioxide emissions (in metric tons), GDP is Gross Domestic Product per capita at constant prices, NRE is electricity generation from Non-Renewable Energy (in kilowatt hours), CRPP is the Capacity of Renewable Power Plants, SUB is Energy Subsidies, TCG is Technical Cooperation Grants, and FDI is Foreign Direct Investment. Log in the beginning of the variables also refers to the natural logarithm of the variables.

The reason for using the linear logarithm specification is that the simple linear specification does not provide consistent results (Omri, 2013). In this model, since the effect of policies appears with a lag, the four variables CRPP, SUB, TCG and FDI are included in the model with one lag. Equations (1-4) design a system that describes the relationship between macroeconomic variables, factors affecting RE and pollution reduction goals. It is expected that: the expansion of CRPP will increase the consumption of renewable electricity and as a result reduces environmental pollution (Equation 1); reducing SUB and NRE will help to develop the use of renewable energies and thus transition to sustainable energy (Equation 2); Allocation of TCG to activities that work towards the development of renewable technologies and as a result reducing environmental pollution has affected the development of RE (Equation 3); and increasing FDI (which leads to the development of new clean and renewable energy technologies and thus reducing pollution) and reducing electricity generation costs (especially from non-renewable energies) in the transition to RE be effective (Equation 4).

4. Empirical Results

Data and pre-tests

The data used in this paper is in the form of annual time series and in the period of 1990-2020. These data have been collected from World Bank (2021)., the statistical bulletin of the International Energy Agency (2021) and Ministry of Energy of IRI (2020). The first step of pre-tests is to show that the specified Equations (1-4) form a system of simultaneous equations. Based on this, the tests of Simultaneity Bias, Diagonality and specification problem tests have been used. The results of these tests showed that Equations (1-4) are specified system of simultaneous equations and they can be estimated with the 3SLS method[1].

Estimation Results and Discussion

The results of estimating Equations (1-4) are given in Table 1.

Table1. Results of the Estimation: 3SLS Technique (1990-2020)

Variable	Coefficients of Eq. (1) (Dependent variable EC)	Coefficients of Eq. (2) (Dependent variable RE)	Coefficients of Eq. (3) (Dependent variable CO_2)	Coefficients of Eq. (4) (Dependent variable GDP)
Intercept	-6.5465 (-4.59) [0.000]***	98.6905 (5.3343) [0.000]***	-18.0089 (-12.0306) [0.000]***	22.9864 (11.2317) [0.000]***
LOG(EC)		10.1791 (10.5422) [0.000]***	-1.6013 (-6.2723) [0.000]***	1.5339 (4.2752) [0.000]***
LOG(RE)	0.0703 (7.7204) [0.000]***		0.1145 (5.0905) [0.000]***	-0.1425 (-3.3442) [0.001]***

1.These results and model validation are not reported here due to lack of space and are available from the authors.

Variable	Coefficients of Eq. (1) (Dependent variable EC)	Coefficients of Eq. (2) (Dependent variable RE)	Coefficients of Eq. (3) (Dependent variable CO_2)	Coefficients of Eq. (4) (Dependent variable GDP)
LOG(GDP)	0.2293 (3.3778) [0.001]***	-3.5561 (-3.9908) [0.000]***	0.6360 (6.1343) [0.000]***	
LOG(CO_2)	-0.5398 (-7.7123) [0.000]***	5.4750 (5.4076) [0.000]***		0.9907 (4.5410) [0.000]***
LOG(NRE)	1.0490 (33.9906) [0.000]***	-10.8610 (-9.8053) [0.000]***	1.7676 (7.6842) [0.000]***	-1.6784 (-4.4588) [0.000]***
$(LOGCRPP)_{t-1}$	0.0404 (3.1943) [0.001]***			
$(LOGSUB)_{t-1}$		-0.1002 (-2.7187) [0.007]***		
$(LOGTCG)_{t-1}$			0.0631 (1.8213) [0.071]*	
$(LOGFDI)_{t-1}$				0.0268 (2.3449) [0.021]**
R-squared	0.9985	0.7880	0.9835	0.9144
Adjusted R-squared	0.9982	0.7439	0.9800	0.8966
S.E. of regression	0.0212	0.2420	0.0362	0.0496
Durbin-Watson stat	2.1640	2.1102	1.8504	1.9711
Mean dependent var	25.6113	23.0479	1.7984	18.0722
S.D. dependent var	0.5123	0.4782	0.2569	0.1544
Sum squared resid.	0.0108	1.4057	0.0315	0.0592

Notes: numbers in parentheses are t -statistic and numbers in brackets are p-values.

***, **, * indicate that coefficients are statistically significant at the 1%, 5% and 10% significance level, respectively.

Source: research findings

The results (Table 1) show that the estimation of equations does not face problems such as autocorrelation; the coefficients of all variables are significant at 5% level except TCG (which is significant at 10% level); the values of (R^2) also indicate a good model fit. Since the purpose of this paper is to investigate the factors affecting RE in the framework of the E3 models, the coefficients obtained from the estimation of the model (Table 1) have been analyzed by examining the effect of NRE, CRPP, SUB, TCG and FDI on RE. Also, we have looked at the mutual influence of EC, RE, CO_2 and GDP on each other.

Electricity generation from non-renewable energies in Iran is about 85% and regardless of hydropower plants, it is about 99% (Ministry of Energy, 2020). The results (Table 1) show the high share of NRE in meeting the demand for consumer electricity (EC) in Iran. 1% increase in NRE leads to an increase in EC by 1.05% and 1% increase in RE leads to 0.07% increase in EC (Equation 1). The negative effect of NRE on RE in Equation 2 indicates that 1% increase in NRE causes 10.86% decrease in RE. It is possible to increase the demand for electricity produced from renewable energies through the development of the capacity of renewable power plants (CRPP). The construction of new power plants based on renewable energies and the use of savings to invest in research and development for renewable energy technologies will increase the consumption of renewable electricity (Moshiri and Lektenbommer, 2015). Table 1 shows that 1% increase in CRPP leads to 0.04% increase in EC in the next period, and 1% increase in EC leads to 10.18% increase in RE.

According to Table 1, 1% increase in NRE leads to 1.77% increase in CO_2 emission. The findings (Table 1) show that RE also has a positive effect on CO_2 emissions and its 1% increase causes 0.11% CO_2 emissions. The reason for the positive effect of RE on CO_2 can be due to the low share of this type of energy in energy consumption, the lack of research and development expenses in this sector, the significant drop in the price of natural gas, and the inadequacy of suitable electricity storage technologies related to renewable energies (Apergis and payne., 2010). Nguyen & Kakinaka (2019) also show that for low-income countries, renewable energy consumption has a positive and negative relationship with carbon emissions and production, respectively. While for high-income countries, the relationship between renewable energy consumption and carbon emissions and production is negative and positive, respectively.

EC has a negative effect on CO2 emissions, and a 1% increase in EC causes a 1.6% decrease in CO2. The negative relationship between EC and CO2 emissions is due to the fact that environmental considerations, the necessity of reducing carbon dioxide emissions and diversifying the energy portfolio, have expanded the use of renewable energies in electricity generation. Therefore, the increase in electricity consumption has a lower pollution effect than the consumption of other energy carriers (oil, gas and coal).

As mentioned, one of the reasons for the high share of fossil fuels in electricity generation in Iran is subsidies. The findings (Table 1) show that a 1% increase in SUB (and as a result, a decrease in the price of fossil fuels) causes 0.10% decrease in RE in the next period.

Another factor influencing the transition to electricity generation from renewable energy is TCG[1]. The findings (Table 1) show that TCG has a positive effect on CO2 in the next period. The positive effect of TCG on CO2 in the next period due to the fact that about 85% of the electricity produced in Iran is from fossil sources. Therefore, it is natural that the contribution of NRE to TCG is more than RE. According to Table 1, 1% increase in TCG leads to 0.06% increase in CO2, and 1% increase in CO2 leads to 5.47% increase in RE. The positive effect of CO2 on RE indicates the attention of politicians to maintain the quality of the environment and reduce climate change.

CO2 emission has a positive effect on GDP. The positive effect of CO2 emissions on GDP has been confirmed in Arori et al. (2012), Zhang and

1. TCG is free financial assistance to technical cooperation to fund technical and managerial skills or technology to build national public capacity, without referring to specific investment projects, or to enhance the capacity of special investment projects (WDI, 2022).

Yuan (2013), Mesegan (2015), Ahmad and Du (2017). According to Table 1, 1% increase in CO2 causes 0.99% increase in GDP. GDP also has a positive effect on CO2emissions (Apergis & Ozturk, 2015, Abid, 2017, Dizaji & Ousia, 2017) and 1% increase in GDP causes 0.64% increase in CO2.

According to the findings of Runge (1994), Helpman (1998), Yanqing and Mingsheng (2012), FDI has a positive effect on GDP in this paper such that 0.01 increase in FDI leads to .027% increase in GDP in the next period.

In developing countries, FDI has a positive effect on CO2. The reason for this conclusion based on the pollution shelter hypothesis (which explains the relationship between CO2emissions and FDI) can be stated as environmental regulations usually do not exist in developing countries. For this reason, investors are more inclined towards these countries to avoid the environmental laws in their countries. Therefore, foreign investors usually benefit from relatively weak environmental laws in developing countries through FDI (Omri et al.,2014). The result of this is the increase in environmental pollution (Bakirtas and Cetin,2017; Yiadom et al., 2023). The effective utilization of renewable energy is highly dependent on the dissemination of technologies used in renewable energy production (Tsoutsos & Stamboulis 2005). In most studies in the field of technology spillover (e.g., Bayoumi et al.,1999, Keller, 2004, Cheung & Lin, 2004, Ping and Qingchang, 2008), international trade and FDI as the most important factors of technology transfer between different countries have been mentioned. FDI through technology spillover has an impact on increasing the share of renewable energy from total energy in both developing and developed countries (Mousavi et al., 2017).

There is disagreement about the effect of renewable energy on economic growth. Some scholars (e.g., Sadorsky (2009), Ocal and Aslan, (2013), Inglesi-Lotz, (2016), Sadeghi et al, (2017), Adams et al. (2018), Zafar et al. (2018)), believe that different types of renewable energy will lead to economic growth. Others (e.g., Menegaki (2011), Kulionis (2013), Tahamipour et al, (2016), Maji (2015)) believe that there is a negative relationship between renewable energy and economic growth. Some (e.g., Ohlan, 2016) concluded that the long-term elasticity of economic growth towards renewable energy is not statistically significant. The findings (Table 1) show that 1% increase in RE causes 0.14% decrease in GDP. GDP also has a negative effect on RE, and 1% increase in GDP leads to 3.6% decrease in RE. The reason is that despite the large resources of oil and gas and the availability of their infrastructure in Iran, the development of renewable power plants (due to the high cost of investing in them) is not affordable (Pahlavani et al., 2020).

There is also disagreement about the relationship between non-renewable energy and economic growth. Some (e.g., Ito, 2017) believe that non-renewable energy has a negative effect on economic growth and some (e.g., Adams et al. 2018, Zafar et al. 2018) believe that non-renewable energy has a positive and long-term effect on growth. Atems & Hotaling, (2018) found the positive effect of RE and NRE on economic growth. According to Table 1, due to the strong dependence of electricity generation in Iran on fossil fuels and the dependence of fossil fuels on SUB (which constitute 15% of GDP), NRE has a negative effect on GDP. As in the study of Yanqing and Mingsheng (2012) and Apergis & Payne (2016), electricity consumption has a positive effect on GDP. GDP also has a positive effect on EC (Asadzadeh and Jalili (2015), Neuhaus, (2016), Anija et al., (2017). Table 1 shows that 1% increase in electricity consumption causes 1.53% increase in GDP, and 1% increase in GDP causes 0.23% increase in electricity consumption.

5. Conclusion and policy implications

In Iran, keeping the price of fossil fuels low compared to global prices, through the payment of energy subsidies, as well as the problems in exporting and selling oil due to oil sanctions, the electricity generation from non-renewable energies has intensified. These cases have caused renewable power plants to have lower profitability, competitiveness and growth compared to fossil power plants, and NRE forms a large share of Iran's electricity market. The rate of electricity generation from non-renewable sources in Iran is close to 85% and regardless of hydropower plants, it is close to 99% (Ministry of Energy, 2019). Although in recent years, there has been a tendency towards the use of renewable energy in electricity generation and the government has been trying to develop the RE by using different policy instruments, but the contribution of this type of energy is less than 1% in Iran's energy portfolio. Meanwhile, Iran has abundant natural resources for setting up renewable power plants (especially solar and wind energy).

Therefore, understanding the necessity of addressing this issue, we have aimed to identify the factors affecting in the development of RE using E3 model. The five factors affecting the transition to RE (that we have investigated in this paper) are: NRE, CRPP, SUB, TCG and FDI. The results show that the very low price of "NRE" (through allocating energy subsidies to them) reduces the share of renewable energies in electricity generation. "CRPP" increases RE and consequently the consumption of renewable electricity. "FDI" through the import of renewable technologies to the country can increase RE. Allocation of "TCG" to investments that develop renewable technologies, affect the development of RE.

Another finding of this paper is that the high ratio of SUB to GDP (about 15%) put a lot of financial pressure on governments and reduce the power of economic growth and cause disruptions in the allocation of resources and the investment process. Fossil fuel subsidies cause the cost of using fossil fuels and its price to decrease and by creating a substitution relationship, the consumption of renewable energy decreases (Dizaji et al., 2022). This issue is one of the reasons for low energy efficiency and lack of motivation to invest in electricity generation from renewable energy in Iran. Therefore, policymakers are advised to reduce energy subsidies and make the electricity market competitive considering the existing renewable energy capacities in Iran. Policymakers by using effective financial and cultural incentives to support the private sector investors in investment in expanding CRPP and allocation of TCG to activities that work towards the development of renewable technologies, can provide the basis for the growth and development of RE. If these policies are successful and stable in the face of the existing resistance and pressures from the dominant regime activists (fossil power plants), this change of direction will lead to new companies entering the field wind and solar energies should continue to compete and be able to create vast changes in the transition to RE.

Funding

This study received no financial support from any organization.

Authors' contributions

All authors had contribution in preparing this paper.

Conflicts of interest

The authors declare no conflict of interest

References

Abbasi Gudarzi, A. and Maleki, A. (2016). Policymaking of the Islamic Republic of Iran in the optimal use of renewable energy sources. *Quarterly Journal of Strategic Studies of Public Policy, 23, 159-174* (in Persian).

Abid, M. (2017). Does economic, financial and institutional developments matter for environmental quality? A comparative analysis of EU and MEA countries. Journal of environmental management, 188, 183-194.

Adams, S., Klobodu, E. K. M. & Apio, A. (2018). "Renewable and Non-Renewable Energy, Regime Type and Economic Growth". *Renewable Energy*, *25*, 755-767.

Afsharzade, N., Papzan, A., Ashjaee, M., Delangizan, S., Van Passel, S., & Azadi, H. (2016). Renewable Energy Development in Rural Areas of Iran. *Renewable and Sustainable Energy Reviews*, *65, 743–755.*

Ahmad, N.; Du, L. (2017). Effects of energy production and CO2 emissions on economic growth in Iran: ARDL approach. Energy, 123, 521–537.

Aien, M. and Mahdavi, O. (2020). On the Way of Policy Making to Reduce the Reliance of Fossil Fuels: Case Study of Iran, *Sustainability, 12, 10606; doi:10.3390/su122410606.*

Ang JB. (2008). Economic development, pollutant emissions and energy consumption in Malaysia. *Policy Model; 30:271–8.*

Aneja, R., Banday , U. J., Hasnat, T., & Kocoglu, M. (2017). Renewable and Non-renewable Energy Consumption and Economic Growth: Empirical Evidence from Panel Error Correction Model. *Jindal Journal of Business Research, 6(1), 76-85.*

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

Apergis, N., Payne, J.E. (2012). Renewable and non-renewable energy consumption– growth nexus: evidence from a panel error correction model. *Energy Econ 34.733–738.*

Apergis, N. and Ozturk, I. (2015). Testing environmental Kuznets curve hypothesis in Asian countries. Ecological Indicators, No. 52, pp. 16-22.

Apergis, N. & Payne, J. E. (2016). "Renewable and Non-Renewable Energy Consumption-Growth Nexus: Evidence from a Panel Error Correction Model". Energy Economics, 36(2), 715–725.

Argentiero, A., Bollino, C.A., Micheli, S. Zopounidis, C. (2018). Renewable energy sources policies in a Bayesian DSGE model. Renewable Energy 120, 60-68.

Arouri, A., &Youssef, B., &Mhenni, H. (2012). Energy consumption, Economic Growth and CO2 Emission Middle East and North African Countries, *Energy Policy, 45: 126-135.*

Asadzadeh, A. and Jalili, Z. (2015). The effect of economic growth on renewable energy consumption in developed countries: Evidence from panel cointegration and the CUP-FM estimator. *Quarterly of Energy Economics Studies, 11 (47), 161-180* (in Persian).

Asali, M. (2012). Analysis based on modeling and measurement prediction of mutual effects of energy, *economy and environment, the world of economics, No. 2892* (in Persian).

Atems, B. & Hotaling, C. (2018). The effect of renewable and nonrenewable electricity generation on economic growth. *Energy Policy 112, 111–118.*

Ayres, R.U. and Nair, I. (1984). "Thermodynamics and economics", *Physics Today, 37, 62-71.*

Bakirtas, I. and Cetin, M. A. (2017). Revisiting the environmental Kuznets curve and pollution haven hypotheses: MIKTA sample, *Environmental Science and Pollution Research*, 24, 18273–18283

Barimani, M. and Kaabi-nejad, A. (2013). Examining the final price and guaranteed purchase tariff of renewable electricity in Iran. *Scientific and specialized quarterly of renewable and new energies, 2, 3-9* (in Persian).

Bayoumi, T., Coe, D. T & Helpman, E.(1999). "*R&D Spillovers and Global Growth*," *Journal of International Economics*, 47(2); 399-428.

Bayomi, N. and Fernandez, J.E. (2019). Towards Sustainable Energy Trends in the Middle East: A Study of Four Major Emitters, *Energies 12 (9), 1615, 1-20.*

Beck, Fred, and Eric Martinot. (2004). "Renewable energy policies and barriers". *Encyclopedia of energy 5, no. 7, 365-383.*

Carley, S. (2009). State renewable energy electricity policies: An empirical evaluation of effectiveness. *Energy Policy, 37, 3071–3081.*

Chaharsooghi, S.K., Rezaei, M. and Alipour, M. (2015). Iran's Energy Scenarios on a 20-Year Vision, International *Journal of Environmental Science and Technology 12 (11), 3701–18.*

Cheung, K. Y. and Lin, P. (2004), "Spillover effects of FDI on innovation in China: Evidence from the provincial data", *China Economic Review*, 15(4); 25-44.

Coondoo D, Dinda S. (2002). Causality between income and emission: a country group-specific econometric analysis. Ecological Economics, 40 (3), 351–367

Delmas, M., & Montes-Sancho, M. R. (2011). US states policies for renewable energy: Context and effectiveness. Energy Policy, 39(5), 2273–2288.

Dianat F, Khodakarami V, Hosseini S H, Shakouri Ganjavi H. (2021). Systemic Modeling of Renewable Electricity Generation Expansion Planning in Competition with Conventional Electricity. Quarterly Journal of Energy Policy and Planning Research; 7 (1) :7-50 (in Persian).

Dizaji, S. F., & Ousia, N. A. S. (2017). The Effects of Economic, Financial and Political Developments on Iran's CO2 Emissions. *Iranian Economic Review*, *21*(4*), 925-940.*

Dizaji, S. F., Arefian, M.R. and Asari Arani, A. (2022). Investigating the role of carbon tax and fossil fuel subsidies on development Renewable energy in selected OEC countries. *Quantitative Economics Quarterly (Former Economic Reviews),19 (4), 79-109* (in Persian).

Ezenwa, N., Nwatu, V. and Gershon, O. (2021). Renewable Energy Consumption Shocks on CO2 Emissions and Economic Growth of Nigeria. International Conference on Energy and Sustainable Environment, IOP Conf. Series: Earth and Environmental Science **665** (2021) 012013.

Ghorban-nejad, M., Chobchian, Sh. and Farhadian, H. (2018). Analysis of obstacles to the development of renewable energy technology from the perspective of farmers. *Rural Research Quarterly, 2, 311-323.*

Gunningham, N. (2012). Confronting the Challenge of Energy Governance. *Transnational Environmental Law, 1, 119-135, doi:10.1017/S2047102511000124.*

Helpman, E. (1998). Explaining the Structure of Foreign Trade: Where do We Stand. *Review of World Economics, 134: 573-589.*

Inglesi-Lotz, R. (2016). "The Impact of Renewable Energy Consumption to Economic Growth: A Panel Data Application". *Energy Economics*, *53*, 58-63.

International Energy Agency (IEA). (2021). World energy outlook. Available at: http://www.iea.org/publications/ free publications/ publication/ MTRMR. Pdf.

Ito, K. (2017). “CO2 Emissions, Renewable and Non-Renewable Energy Consumption, and Economic Growth: Evidence from Panel Data for Developing Countries”. *International Economics, 151, 1-6.*

Javan, A., & Nasimi, H. (2006). Optimal Methods for Reviewing and Modifying Energy Subsidies. *Journal of Energy Economics Studies*, (6), 99-64. https://www.noormags.ir/view/en/articlepage/5858/97) (in Persian).

Kariuki, D. (2018). Barriers to Renewable Energy Technologies Development. *Doi.Org/10.1515/Energy today2018-2302*

Kaswan, A. (2018). Energy, Governance, and Market Mechanisms, University of Miami, *Law Review, 72, 476-580.*

Keller, W. (2004), “*International technology diffusion*”, *Economic Literature*, 42(3); 752-782.

Keyuraphan, S., Thanaraka, P. Ketjoy, N., Rakwichian, W. (2012). Subsidy schemes of renewable energy policy for electricity generation in Thailand. *Procedia Engineering, 32, 440 – 448.*

Kulionis, V. (2013). “The Relationship between Renewable Energy Consumption CO2 Emissions and Economic Growth in Denmark, *Energy policy*, 24(8), *145-252.*

Lee, y. & Seo, I. (2019). Sustainability of a Policy Instrument: Rethinking the Renewable Portfolio Standard in South Korea, Sustainability, 11, 3082.

Maji, I. K. (2015). “Does Clean Energy Contribute to Economic Growth? Evidence from Nigeria”. *Energy* Reports, 1, 145–150.

Marzban, A., Mohammadi, M., Pourezzat, A.A. and Qadri, S.F. (2018). The future of governance in the field of non-profit facilities: key factors and emerging trends (case study: distribution of electric energy). *Strategic Public Policy Studies Quarterly, 8(27)* (in Persian).

Menegaki, A. N. (2011). “Growth and Renewable Energy in Europe: A Random Effect Model with Evidence for Neutrality Hypothesis”. Energy Economics, 33(2), 257-263.

Mesegan, E. P. (2015). Economic growth and Carbon Emission in Nigeria. *Research Gate, 1- 16.*

Ministry of Energy, Deputy of Electricity and Energy Affairs. (2020). Ministry of Energy, Office of Planning and Macroeconomics of Electricity and Energy, *A review of 31 years of Iran's energy statistics (1367-1397)* (in Persian).

Mohammadi, M. and Sabouri, M. (2015). Analysis of the role of increasing the price of energy carriers in the adoption of renewable energy by broiler chicken breeders in Garmsar city. *Journal of Economic Research and Agricultural Development of Iran, 4, 913-927* (in Persian).

Moshiri, Saeed (Ed.); Lechtenböhmer, Stefan (Ed.) (2015): Sustainable energy strategy for Iran, Wuppertal Spezial, No. 51, ISBN 978-3-929944-98-3, Wuppertal Institute for Climate, Environment and Energy. Wuppertal, http://nbn-resolving.de/urn:nbn:de:bsz:wup4-opus-61757.

Mousavian, M., Shakouri, H., Mashayekhi, A.-N., & Kazemi, A. (2019). "Does the short-term boost of renewable energies guarantee their stable long-term growth? Assessment of the dynamics of feed-in tariff policy", Renewable energy, Vol. 159, pp. 1252–1268.

Mousavi Dorche, S., Ganeirad, M., Karimian, H. and Shahmoradi, b. (2016). Identifying the path of technological transition of renewable energies (wind and solar energies) in Iran based on multi-level analysis approach. *Scientific-Research Journal of Innovation Management, 4, 98-63* (in Persian).

Mousavi, M.H., Shah-Abadi, A. and Shaygan Mehr, S. (2017). The effect of technology spillover from foreign direct investment channel and import of goods on the share of renewable energy production in total energy, Technology Development Management Quarterly, 5(1), 99-122 (in Persian).

Najafi, G.; Ghobadian, B.; Mamat, B.; Yusafi, T.; Azmi, W.H. (2015). Solar energy in Iran: Current state and outlook. *Renew. Sustain. Energy Rev. 49, 931–942. DOI: 10.1016/j.rser.2015.04.056*

Neuhaus, L. (2016). "Examining the renewable energy consumption: economic growth nexus in sub-Saharan African countries", *Honors Program Theses, University of Northern Iowa.*

Nguyen, K. H., & Kakinaka, M. (2019). Renewable energy consumption, carbon emissions, and development stages: Some evidence from panel cointegration analysis. *Renewable Energy*, *132*, 1049-1057.

Noorollahi, Y.; Shabbir, M.S.; Siddiqi, A.F.; Ilyashenko, L.K.; Ahmadi, E. (2019). Review of two decades geothermal energy development in Iran, benefits, challenges, and future policy. *Geothermics, 77, 257–266.*

Ocal O, Aslan A. (2013). Renewable energy consumption-economic growth nexus in Turkey. *Renew Sustain Energy Rev; 28:494–9.*

Ohlan, R. (2016). "Renewable and Non-Renewable Energy Consumption and Economic Growth in India". *Energy Sources*, 11(11), 1050-1054.

Omri A. (2013). CO2 emissions, energy consumption and economic growth nexus in MENA countries: evidence from simultaneous equations models. *Energy Econ; 40:657–64.*

Omri, A., Nguyen, D. K., & Rault, C. (2014). Causal interactions between CO2 emissions, FDI, and economic growth: Evidence from dynamic simultaneous-equation models. *Economic Modelling*, *42*, 382–389.

Pahlavani, S., Jahangiri, M., Alidadi Shamsabadi, A. and Baharizadeh, A. (2020). Assessing the Current Status of Renewable Energies and Their Limitations in Iran, *Int. Journal of Renewable Energy Development 9 (1), 97-105.*

Pao HT, Fu HC. (2013). Renewable energy, non-renewable energy and economic growth in Brazil. *Renew Sustain Energy Rev; 25:381–92.*

Park, Sunjoo, (2013). "The Influence of State-Level Renewable Energy Policy Instruments on Electricity Generation in the United States: A Cross-Sectional Time Series Analysis". *ETD Archive. 231. Submitted in partial fulfillment of requirement for the degree Doctor of Philosophy in Urban Studies and Public Affairs Cleveland State University August, 2013.*

Parliament Research Center of Islamic Republic of Iran (2019). Prospects of Iran's electricity and natural gas situation in 2040, Vice President of Infrastructure Research and Production Affairs, *Office: Energy, Industry and Mining Studies, subject code: 310, serial number: 16404* (in Persian).

Ping, L. and Qingchang, Z. H. (2008), The Effects of technological spillover through FDI and import trade on China's innovation, school of economy of Shandong University of technology, www.seiofbluemountain.com/search/detail.php?id=3948.

Ritchie, H., & Roser, M. (2020). *Energy Mix*. Our World in Data. https://our world in data.org/electricity-mix.

Röttgers, D. and Anderson, B. (OECD). (2018). Power Struggle: Decarbonizing the Electricity Sector - Effects of Climate Policies, Non-Climate Policies, and Political Economy Factors on Decarbonization", *Environment Working Paper, 139*.

Runge, CF. (1994). Free Trade, Protected Environment: Balancing Trade Liberalization with Environmental Interests. *Council on Foreign Relations Books*.

Sadeghi, K., Sojudi, S., & Ahmadzadeh Deljavan, F. (2017). Renewable Energy, Economic Growth and Quality of the Environment in Iran (1980 – 2012). *Journal of Energy Planning and Policy Research*, 3(6), 171-202 (in Persian).

Sadorsky, P. (2009). "Renewable Energy Consumption and Income in Emerging Economies". *Energy policy, 37(10), 4021-4028.*

Salamon, L. M. (2002). The new governance and the tools of public action: An introduction. In L. M. Salamon (Ed.), The tools of government: A guide to the new governance. New York: Oxford University Press.

Sapat, A. (2004). Devolution and innovation: The adoption of state environmental policy innovations by administrative agencies. *Public Administration Review, 64(2), 141–151.*

Sarti, B. (2018). Policies for the Deployment of Renewable Energies: An Overview. *Social Impact Research Experience (SIRE). 62.* https://repository.upenn.edu/sire/62.

Sharifi, A. Kayani, G. Rahman Khoshakhlaq, R. and Bagheri, M. M. (2013). Evaluating the substitution of renewable energies instead of fossil fuels in Iran: an optimal control approach. *Economic Modeling Research Quarterly, 11, 123-140* (in Persian).

Shahbaz, M., Loganathan, N., Zeshan, M., Zaman, Kh. (2015). Does renewable energy consumption add in economic growth? An application of auto-regressive distributed lag model in Pakistan. Renewable and Sustainable Energy Reviews. 44 (April), pp. 576-585.

Shahbaz M, Feridun M. (2012). Electricity consumption and economic growth empirical evidence from Pakistan. *Qual Quant: Int J Methodol; 46:1583–99.*

Shakouri G, H., & Aliakbarisani, S. (2016). "At what valuation of sustainability can we abandon fossil fuels? A comprehensive multistage decision support model for electricity planning", Energy, Elsevier, 107, 60–77.

Shengfeng, X., Sheng, X., Tianxing, Z., & Xuelli, Z. (2012). The Relationship between Electricity Consumption and Economic Growth in China. *International Conference on Applied Physics and Industrial Engineering, 24*, 56-62.

Shi, L.(2014), Econometric Analyses of Renewable Energy Promotion. *Doctoral Thesis* Swedish *University of Agricultural Sciences Umeå*

Shokri Kalehsar, O. (2019). Iran's Transition to Renewable Energy: Challenges and Opportunities, *Middle East Policy 26 (2), 62–71*.

Soytas U, Sari R, Ewing BT. (2007). Energy consumption, income, and carbon emissions in the United States. *Ecol Econ; 62:482–9.*

Stern, D.I. and Cleveland, C. J. (2004), "Energy and Economic Growth", *Encyclopedia of Energy. 1 (2), 35-51.*

Tahamipour, M., Abedi, S., Karimi Baba Ahmadi, R., and Ebrahimi Zadeh, M. (2016). Investigating the effect of renewable energies on the real economic growth of Iran per capita. *Iran's energy economy research journal, 5 (19), 53-77* (in Persian).

Tang, A. (2013). Leveraging Policy for Renewable Energy Development in Industrialized Countries and Emerging Markets. Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in the Graduate School of Arts and Sciences ,*Columbia University.*

Tsoutsos, T. D. and Stamboulis, Y.A. (2005). The sustainable diffusion of renewable energy technologies as an expel of a focused-innovation policy, *Technovation*, 25(7); 753-761. http://dx.doi.org/10.1016/j.technovation.2003.12.003.

Tugcu CT, Ozturk I, Aslan A. (2012). Renewable and non-renewable energy consumption and economic growth relationship revisited: evidence from G7 countries. *Energy Econ; 34:1942–50.*

Warbroek, B. (2015). Effectiveness of policy instruments in stimulating renewable energy production in the European Union. *Bachelor Thesis/ 14-5-2013. European Studies/European Public Administration.*

World Bank. (2021). World Development Indicators (WDI). Available online: https://databank. worldbank.org

Yanqing, X. & X. Mingsheng. (2012). A 3E Model on Energy Consumption, Environment Pollution and Economic Growth-An Empirical Research Based on Panel Data, *Energy Procedia, 16: 211-218.*

Yiadom, E.B., Mensah, L. and Bokpin, G.A. (2023), "Environmental risk and foreign direct investment: the role of financial deepening, access and efficiency", *Sustainability Accounting, Management and Policy Journal*, 14(2), 369-395. https://doi.org/10.1108/SAMPJ-12-2021-0552.

Zafar, M. W., Shahbaz, M., Hou, F. & Sinha, A. (2018). “From Nonrenewable to Renewable Energy and Its Impact on Economic Growth: The role of Research & Development Expenditures in Asia-Pacific Economic Cooperation Countries”. *Journal of Cleaner Production, 36(3), 31–38.*

Zhang, B-S. & X-l. Yuan. (2013). Pollutant Emissions, Energy Consumption and Economic Development in China: Evidence from Dynamic Panel Data, Oxford Development Studies (ODS). www.ceauk.org.uk

Zhao, Y., Tang, K. K., Wang, L. L. (2013). Do renewable electricity policies promote renewable electricity generation? Evidence from panel data. *Energy Policy 62, 887–897.*