Investigating Impact of Environmental Tax Policy on Behavior of Investors in Renewable Energies Using a Dynamic Panel Data Approach

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ABSTRACT

Expanding use of renewable energies (RE) around the world is a critical mission to achieve global environmental policies. The largest share of global energy mix relates to deployable and carbon-intensive fossil fuels, so it is necessary to create proper incentives for investors to invest in RE in order to move toward a low carbon economy. In this regard, one of the implemented policies is imposing tax on using deployable energies, which includes tax on both energy consumption and motor vehicle transportation. This paper investigates the impact of environmental tax policy on investors' behavior in 13 leading selected developed and developing countries during 2004 to 2016. Based on economic theory, investment, particularly in capital-intensive energy industries, has a long gestation period. To capture this feature and evaluate the dynamic relations of investments in RE, a partial adjustment dynamic model is applied and estimated using generalized method of moments (GMM). The results show that imposing tax on fossil fuel energy consumption and transportation systems, in particular those which use fossil fuels, has a significant negative and positive impact on investing in RE, respectively. Moreover, empirical results demonstrate that there is a significant negative relation between the interest rate (IR) and investments in renewable energies (IRE).

1. Introduction

In order for the world's governments to limit the rise of global temperatures to less than 2 °C, to stem the climate damage that is already starting to occur, to shift to a low-carbon economy, and to seize the economic opportunities of clean energy and other climate-related activities, trillions of dollars of investment are required over the coming decades (UNEP FI, 2010). Environmental challenges are increasing the pressure on governments to find ways to reduce environmental damage while minimizing harm to economic growth. Governments have a range of tools at their disposal, including regulations, information programs, innovation policies, environmental subsidies, and taxes. Taxes in particular are a key part of this toolkit. Environmental taxes have many important advantages such as environmental effectiveness, economic efficiency, the ability to raise public revenue, and transparency. Furthermore, environmental taxes have been successfully used to address a wide range of issues, including waste disposal, water pollution, and air emissions. Regardless of the policy area, the design of environmental taxes and political economy considerations in their implementation are crucial

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determinants of their overall success. Thus, not only can taxes directly address the failure of markets to take environmental impacts into account by incorporating these impacts into prices, but also environmental pricing through taxation leaves consumers and businesses to flexibly determine how best to reduce their environmental “footprint” (Braathen et al., 2010). Without government intervention, there is no market incentive for firms and households to take into account environmental damage since its impact is spread across many people, and it has little or no direct cost to the polluter. Therefore, the protection of the environment generally requires collective action, usually led by the government.

More than 80% of global energy supply relies on delectable fossil fuels, which create significant energy security challenges with resources being unevenly distributed across world regions. Wüstenhagen, et al., (2012) mention that increased investment in renewable energy technologies, in combination with energy efficiency, can help to meet future energy demand. To reach the proposed framework of renewable energies (RE), cooperation between public and private investors needs to be strengthened. The trend of investments in renewable energies (IRE) sector in 13 selected developed and developing coungtries[1] during 2004-2016 is depicted in Figure 1.

As shown in Figure 1, investing in RE is volatile in the most of the selected countries, and it is reasonable to pay more attention to the behavior of investors in RE market. Bloomberg publishes yearly report on clean energy investment trends and releases the IRE of some world countries. This study selects 13 developing and developed countries which are leader in IRE, where, based on Louw (2017), the selected countries would have the most volume of investments in RE across the world. In other words, the countries are leading nations in expanding their renewable energy sector in the world. More importantly, data on IRE are more easily available for the chosen countries than others. The financial crisis reversed the upward trend in economic aggregates observed during 2002-2008. Energy and transport tax revenue together with total environmental tax revenue had already fallen in 2008, while GDP, total revenue from taxes and contributions, and pollution and resource taxes still grew, albeit very slightly in that year, and only fell sharply in 2009. Looking closer at the three types of environmental taxes, namely energy taxes, transport taxes, and pollution/resource taxes, there are slight differences in their pattern. Transport tax revenue increased at a faster pace than the other types of taxes, recording an overall rise of 43.4% between 2002 and 2017. Over the same period, energy taxes rose by 38.7% and pollution and resource taxes by 34.5%. While in 2016, the growth of all economic aggregates slowed down slightly, they regained speed in 2017. The only exception observed was revenue from pollution and resource taxes, which remained rather stable in 2015 and 2016 and then started to fall in 2017 (Environmental tax statistics, 2017).

The main focus of this paper is to investigate the effectiveness and efficiency of implementing tax policies, as one of the main influential factors, on investors’ behavior in RE energy market considering a partial adjustment dynamic panel data model

In fact, the main question is that whether imposing

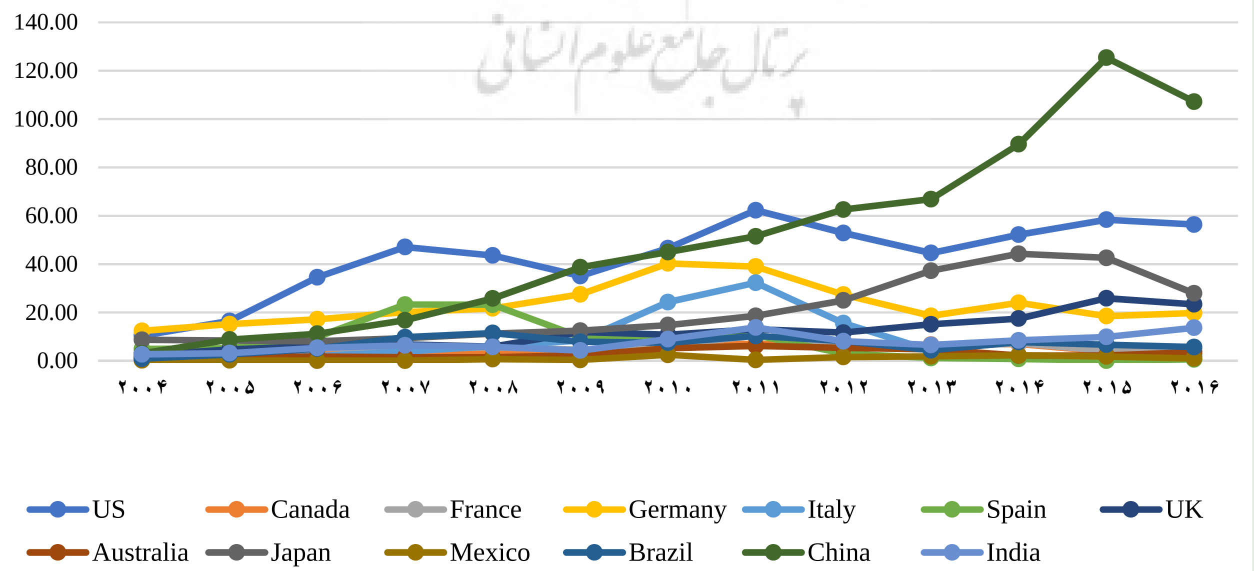

Figure 1: Trend of investments in renewable energies (IRE) of 13 selected developed and developing countries during 2004-2016 (Louw, 2017)

[1]The selected Countries including United States, Mexico, Canada, Brazil, France, Germany, Italy, Spain, United Kingdom, Australia, china, India, and Japan.

tax on fossil fuels encourages investors to move forwards and invest in RE sector. Is imposing tax policy effective? It is assumed that imposing tax on fossil fuel consumption induces investor to perform more activities in RE sector in accordance with climate change policies. Other than this factor, this research work also analyzes the influence of other factors impacting on investors' behavior in RE market, including interest rate, fossil fuel price, and population growth. In other words, the most behavioral factors influencing investments decision in the renewable energy market of the selected countries are considered in this paper.

The remainder of the paper is structured as follows. The next section reviews the relevant literature and the theoretical foundations of the research. Section 3 describes the data and the research model variables, and section 4 presents the research methodology used for the study. Section 5 illustrates the empirical results and discussions. Finally, section 6 highlights the main conclusions and policy recommendations especially for energy policy makers.

2. Literature Review and Theoretical Background

In 1920, British economist Arthur C. Pigou wrote the textbook titled "the economics of welfare." In this book, Pigou argues that industrialists seek their own marginal private interest (Pigou, 1920). Quite often the marginal social interest diverges from the marginal private interest, but the industrialist has no incentive to internalize the cost of the marginal social cost. To tackle over-production, Pigou recommends taxing offending market participants to cover the social cost. The producer would then have to pay for the externality created by his/her production. This problem can impact on the quantity of the produced goods and services and lead the economy back to equilibrium (Pigou, 1920). In this context, a growing number of literatures have analyzed the effect of taxation incentives on spurring renewable energy extension (Barradale, 2010; Bird et al., 2005). In addition, Barradale mentioned the missing commitment of policy as a main deficiency of taxes in order to direct dependency on the public budget (Barradale, 2010). Therefore, scholars tried to illustrate the effects of a number of various policy instruments on the contribution of renewables to the total energy supply (Bird et al., 2005). They showed that aggregated measures such as fiscal and financial incentives as well as measures that seek to define strategies and outline specific programs to promote these RE sources have a positive significant impact. Policies on RE growth had no significant positive influence on controlling a range of political elements such as energy security, Kyoto protocol ratification, and socio-economic factors (e.g. prices of fossil fuels, welfare, etc.) (Marques et al., 2012); however, fiscal and financial incentives (i.e. taxes) had a negative contribution to these factors (Aguirre et al., 2014).

The idea of political internalization of externalities brings together the elements (Coasian, 2015; Pigouvian, 2012) approaches to environmental policy. The issue of environmental policy arises due to production externality. It is assumed that firms in each industry use an input (raw materials, clean water, etc.) that has an external effect on the well-being of consumers (smoke, toxic wastewater, etc.). Furthermore, it is assumed that the government has access to two environmental policy instruments. Production tax-cum-subsidies can be used to affect activity in various sectors, and through that presumably the use of the externality generating inputs. Input tax-cum-subsidies, which in our specification are equivalent to pollution tax-cum-subsidies, can be aimed directly at the source of the externality, thereby presumably giving firms an incentive to use a cleaner production technology (Baumol et al., 1989).

Renewable energy investment is a type of environmentally/socially responsible investment specifically relating to investments in companies focusing on renewable energy resources like wind, solar, biofuels, hydropower, and tidal power as well as on the technology and systems relating to these sources. Renewable energy investment is a sub-category of environmental investment, which in turn is a sub-category of socially responsible investment (SRI). Growing concern for the environment and the well-evidenced existence of climate change and its devastating consequences combined with advancements in technology has seen the demand for a rise in alternative energy resources. As such, renewable energy investment is no longer considered a purely philanthropic endeavor but is now considered a profitable avenue for renewable energy investors looking for strong financial returns on capital invested as well as for supporting environmentally conscious companies. These companies and community organizations would seek seed enterprise investment scheme (SEIS), enterprise investment scheme (EIS), or venture capital trust scheme (VCT) investment (tax-advantaged venture capital schemes); community organizations would also pursue social investment tax relief (SITR) investment, where a substantial part of the activities of the company or community organization is, or will be, eligible for a government subsidy for the energy generation from renewable sources. Individuals and some fund managers who invest in the companies or community organizations may also be affected (Wilson, 2015).

Herein, we refer to some studies related to the aim of this paper among a number of available empirical studies. Polzin et al., 2015 examined the impact of public policy measures on RE investments in electricity-generating capacity made by institutional investors across organization for economic co-operation and development (OECD) countries. Using a panel regression over a time period from 2000 to 2011, they investigated the effect of different policy measures in the selected OECD countries to recommend an effective policy mix which could resist failures in the market for clean energy. The results of this study call for technology-specific policies which consider actual market conditions and technology maturity.

Zhang et al. 2016 proposed a real options model for evaluating RE investment considering uncertain factors such as CO2 price, non-renewable energy cost, investment cost, and the market price of electricity. Their results showed that the current investment environment in China may not be able to attract immediate investment, while the development of carbon market helps to advance the optimal investment time. Tietjen et al., 2016 compared the investment risks of different technologies in markets with increasing shares of RE. The results confirmed that capital intensive REs face the highest stand-alone risks since their profits are most affected by the power price risk. However, the results further indicated that the stand-alone risks of variable REs decrease with their share in the market because of a negative correlation between output and price risk. Some researchers also analyzed the impact of clean-development mechanism and carbon emission on energy investment (Strand et al.. 2014; Hieronymi et al., 2015; Mo et al., 2015; Jones et al., 2016; Cadarso et al., 2014; Cucchiella et al., 2016).

In one of the most recent studies, Aflaki and Netessine, 2017 analyzed incentives to invest in the capacity to generate renewable electricity, and they modeled the trade-off between renewable (e.g. wind) and nonrenewable (e.g. natural gas) technologies. They proved that the intermittency of renewable technologies drives the effectiveness of carbon pricing mechanisms, which suggests that charging more for emissions could unexpectedly discourage investment in renewables. In short, they showed that, compared to carbon taxes alone, actions to reduce the intermittency of renewable sources may further affect promoting investment in renewable generation capacity (Aflaki and Netessine, 2017).

This paper covers the recent developments of RE deployment and investments (until 2016). In this study, we intend to contribute to the existing academic literature by exploring and investigating the effectiveness of environmental tax policies on investors' investment behavior in RE sector, including all kinds of renewable energies (wind, solar, biomass, geothermal, etc.). In contrast to the previous studies, this study separates tax policies in two parts, namely tax on energy (fossil fuels) consumption (TEC) and tax on motor vehicles in transportation systems, and aims to investigate the effects of these tax policies on investors' behavior in RE sector. In other words, the effectiveness of tax policies on expanding renewable energy is examined in two dimensions in the leading developing and developed countries.

3. Data and Research Variables

This paper constructs an empirical model of investments in renewable energies using a panel data set of 13 selected developed and developing countries during 2004 to 2016. The selected countries are a combination of developing and developed nations, including the United States, Mexico, Canada, Brazil, France, Germany, Italy, Spain, the United Kingdom, Australia, China, India, and Japan. Table 1 summarizes research variables used in this study. As shown, investment in renewable energy (IRE) is the dependent variable and the others are independent variables. All the monetary variables are used in real values.

Also, Table 2 tabulates the summary statistics of the described variables.

4. Methodology

Dynamic panel data models contain one or more lagged dependent variables, allowing for the modeling of a partial adjustment mechanism (Baum, 2013). Similar to any longitudinal analysis, this paper assumes that the dependent variable (IRE) is affected by its own past values immediately and with a time delay. This approach is applied to the model of this paper through a lagged dependent variable structure named dynamic panel data. This approach helps to account for the time-dependent influence of policy measures on investors' behavior in the RE sector (Angrist et al., 2008; Wooldridge, 2009). Hence, this paper investigates the impacts of environmental policies on investment in RE considering the dynamic and lagged nature of investment decision in the RE sector. Accordingly, based on the work of (Polzin et al., 2015), the research model can be expressed by Equation 1:

$$IRE_{i,t}=\beta_0+\beta_1 IREi.t\text{-}1+\beta_2 IRE_{i,t-2}+\beta_3 IRE_{i,t-3}+\beta_4 TEC_{i,t}+\beta LTM_{i,t}+\beta_6 FFC_{i,t}+\beta_7 POP_{i,t}+\beta_8 FFP_{i,t}+\beta_9 IR_{i,t}+\varepsilon_{i,t} \quad (1)$$

where, IRE refers to the amount of investment in the RE sector, and TEC represents tax on energy consumption; LTM indicates logarithm of tax on motor vehicles transportation, and FFC is an aggregated amount of fossil fuel (oil, natural gas, and coal) consumption measured in ton per day; POP also stands for the population growth, and FFP is the weighted average of fossil fuel (oil, natural gas, and coal) prices calculated in US dollars per ton; IR is interest rate; it subscript stands for country i in year t, and s_{it} denotes the error term.

There are many ways in the literature to estimate dynamic panel data models. The first way is instrumental variables (IV) method to correct the bias of an estimator and the second method is generalized method of moments (GMM) estimation technique. This research work uses balanced panel data to estimate the research model. To this end, we have examined a number of estimators, including fixed effects (FE), random effects (RE), and GMM estimators. After evaluating several estimation methods, we used GMM to estimate a partial-

Table 1- Description of research model variables[2]

Variable	Description	Measurement Unit	Source of Data
IRE	Investment in renewable energy (dependent variable)	Billion dollars (constant 2004 US$)	(Louw ,2018) -Bloomberg New Energy Finance
TEC	Tax on energy consumption	Million dollars (constant 2004 US$)	(Eurostat, 2018)
LTM	Logarithm of tax on motor vehicles transportation	Million dollars (constant 2004 US$)	(Eurostat, 2018)
POP	Population growth	%	World Bank
FFP	Weighted average of fossil fuel prices	US dollar per ton (constant 2004 US$)	Authors calculation based on BP Statistical Review of World Energy 2017 (BP Statistical Review, 2018)
FFC	Aggregate amount of fossil fuels consumption	Million ton per day (constant 2004 US$)	Authors calculation based on BP Statistical Review of World Energy (BP Statistical Review, 2018)
IR	Interest rate of each country	%	(Federal Reserve Bank of St. Louis, 1914)

Table 2 - Descriptive statistic of the estimated variables

Variable	Observations	Mean	Standard Deviation	Min	Max
IRE	169	14.85325	19.65211	0.1	125.4
TEC	169	32642.03	25185.41	-19660.54	78690.53
TM[3]	169	9.198462	0.8767765	7.33	11.04
FFP	169	321.4219	139.2549	69.44	685.32
FFC	169	734.1957	1132.196	105.9	4606.49
IR	169	4.32142	5.157661	0.1	26.27
POP	169	$2.84\times10^{+8}$	$4.35\times10^{+8}$	$2.01\times10^{+7}$	$1.38\times10^{+9}$

[2] We have examined logarithmic and non-logarithmic form of all the variables in Table 1. After estimating and testing several combinations of the variables, the coefficient estimated for tax on motor vehicles would give a significant result in the logarithmic form, while all the other variables would have the most significant estimated coefficients in the non-logarithmic form.
[3] Tax on motor vehicles (TM)

adjustment dynamic panel data model and examine the factors impacting on renewable energy investment, including energy and environmental taxes. The GMM estimation method helps to explore a dynamic relation of investment function in the RE sector.

5. Empirical Results and Discussion

Before estimating the main model and discussing the empirical results, first, we perform Pesaran's cross section dependence (CD) test (Pesaran, 2004) to determine the type of appropriate panel unit root (stationary) test for the research variables (Omri, 2015). Second, the study carries out panel unit root test to find the order of the integration of the model variables. Then, we utilize the two-step Arellano-Bond (differenced GMM) method to estimate the research model and discuss the given results.

5.1. Cross Section Dependence Test

In panel data model analysis, it is required to test error terms for cross-section dependence when N is relatively large with respect to T. Thus, this paper applies Pesaran's CD test (2004). The result of Pesaran's CD test of the estimated model is presented in Table 3.

Table 3- Pesaran's cross section dependence (CD) test of

Test	Test statistics	Probability	Result
Pesaran's CD	0.431	0.6663	Cross section independence

Source: Authors' findings

According to the results listed in Table 3, we fail to reject the null hypothesis, and the error terms of the estimated model have cross-section independency. This means that we can use Levin, Lin, and Chu (LLC) and Im, Pesaran, and Shin (IPS) tests for performing panel unit root tests on the model variables.

5.2. Panel Unit Root and Cointegration Test Results

Since there is no cross-section dependence in the panel data model, for improving reliability and validity of the results, this paper utilizes Levin, Lin, and Chu (LLC, 2002) t* and Im, Pesaran, and Shin (IPS, 2003) W-test methods for stationary tests (Levin et al., 2002; Im et al., 2003). The results of LLC and IPS unit root tests for the model variables are tabulated in Table 4.

As presented in Table 4, the null hypothesis of unit root is almost rejected for all the variables at the 5% or 10% significance levels. This means that all the series are stationary, revealing that all the variables, except for IRE and IR which are stationary in the first difference using IPS unit root test, are integrated of zero order, I (0). Based on the given results of the panel unit root tests, since variables are stationary in both LLC and IPS unit

Table 4 - The results of panel unit root tests for the variables of estimated model.

Unit Root Test	Variable	Test Statistics	Prob (P-value)	Result
LLC	IRE	-5.1297	0.0000***	Stationary, I (0), Level
	TEC	-3.2331	0.0006***	Stationary, I (0), Level
	LTM	-3.9285	0.0000***	Stationary, I (0), Level
	FFC	-2.7180	0.0033***	Stationary, I (0), Level
	POP	-3.4407	0.0003***	Stationary, I (0), Level
	FFP	-1.8591	0.0315**	Stationary, I (0), Level
	IR	-5.0473	0.0000***	Stationary, I (0), Level
IPS	IRE	-1.3093	0.0952*	Stationary, I (0), First difference
	TEC	-2.7668	0.0028***	Stationary, I (0), with trend
	LTM	-2.1962	0.0140**	Stationary, I (0), with trend
	FFC	-1.3358	0.0908*	Stationary, I (0), with trend
	POP	-1.5750	0.0576*	Stationary, I (0), Level
	FFP	-1.6974	0.0448**	Stationary, I (0), Level
	IR	-1.3815	0.0836*	Stationary, I (0), First difference

***, **, and * denote the rejection of the null hypothesis at the 1%, 5%, 10% levels of significance respectively.
Source: Authors' findings

root tests, there is no need to implement panel cointegration test.

5.3. Estimation Results and Discussion

This study estimates the dynamic panel data model (1) using two-step Arellano-bond estimator based on GMM proposed by (Arellano and Bond, 1991). Equation 1 includes the lagged dependent variables of investment in the RE sector, which are endogenous considering country fixed effects, so we can take into account endogeneity using GMM-type instruments for the lagged dependent variable of investment in RE sector. The estimation results of Equation 1 are listed in Table 5. Also, the test statistics and the P-values of serial correlation tests, AR (1), AR (2), and Sargan test are reported in Table 5 (Sargan et al., 1958; Sargan et al., 1983).

The estimations include three lags of the dependent variable, and the test statistics of autocorrelation and the validity of the instruments are satisfactory. The estimation coefficients of all the variables except tax on energy consumption (TEC) in the estimated model have the expected signs. The null hypothesis about the test for first-order autocorrelation, AR (1), is autocorrelation, but the null hypothesis about the test for second-order autocorrelation, AR (2), is no autocorrelation. The test statistics of AR (1) and AR (2) are satisfactory, which is crucial for the validity of the instruments. The null hypothesis about the AR (1) test is rejected, but the null hypothesis about AR (2) test is not rejected. Moreover, the test statistic of the Hansen test for over identifying restrictions (the validity of the instruments) is satisfactory; the null hypothesis is not rejected, so the Hansen test is robust.

As can be seen in Table 5, the amount of investment in the RE sector (IRE) has a positive relation with its first and third order lagged value but a negative relation

Table 5 - Estimation results of dynamic panel data model of investment in renewable energy sector in selected developed and developing countries during 2004-2016

Difference in Dynamic Panel Data Estimation: Two-Step Results					
IRE	Coefficient	Standard Error	Z	P > |Z|	95% Confidence Interval
IRE (-1)	0.56923***	0.21917	2.60	0.009	0.139659 0.998820
IRE (-2)	-1.48453***	0.47970	-3.09	0.002	-2.424736 -0.544337
IRE (-3)	0.04795	0.23346	0.21	0.837	-0.409634 0.505550
FFC	0.03977*	0.02194	1.81	0.070	-0.003239 0.082798
TEC	-0.00067**	0.00030	-2.22	0.026	-0.001269 -0.000080
LTM	83.41202**	38.39504	2.17	0.030	8.159127 158.6649
POP	5.49032	4.70527	1.17	0.243	-3.731853 14.7125
FFP	-0.00681	0.00629	-1.08	0.279	-0.019148 0.005524
IR	-17.6061*	9.51862	-1.85	0.064	-36.26228 1.050042
Cons	-685.3912**	316.2118	-2.17	0.030	-1305.155 -65.62747
Number of observations	117				
Number of groups	13				
Number of instruments	70				
Arellano-bond test for AR (1)	1.7972 (Z)		0.0722 (Prob)		
Arellano-bond test for AR (2)	0.7995 (Z)		0.4239 (Prob)		
Sargan test of overidentifying restrictions	0.7874 chi2(60)		1.0000 (Prob)		

a*,**,and*** indicate statistical significance at 10%, 5%, and 1% levels respectively.
Source: Authors' findings

with its second order lagged value for the selected countries during 2004-2016. In other words, decision to invest in the RE sector deals with delays from one to three years because of specific characteristics of energy sector such as reliance on non-renewable energies, capital intensiveness of investments in the RE sector, long gestation period, and other economic and technical factors affecting investment decisions in energy market. Furthermore, the estimated coefficients of the first and second order lagged value of IRE are significant at the 1% significance level, but IRE does not have a significant relation with its third order lagged value. Accordingly, we have estimated that, other things being equal, a 1 billion $ increase in IRE in the current year would on average lead to 0.56 billion $ rise in investment in RE in next year; consequently, IRE decreases significantly more than 1 billion $ two years from now in the selected nations. In other words, the fluctuations of fossil fuel prices, the limitation of resources, and increasing concerns on climate change have made investors have variable behaviors in the RE sector in the selected countries over time.

As depicted in Figure 1, this estimated result also complies with real investment behavior of investors in the selected countries during 2004 to 2016. Another effective variable is the aggregate amount of fossil fuels (oil, natural gas, and coal) consumption (FFC), where the estimated coefficient of FFC shows an important positive impact on IRE at the 10% significance level. Actually, it is estimated that, on average, a 1 million ton rise in FFC per day increases IRE by about 40 million $ in the selected countries from 2004 to 2016. This result is accompanied by empirical facts in sample data because consuming more fossil fuels increases greenhouse gas (GHG) emissions and causes environmental problems. To deal with this issue, policy makers align policies for transition towards a low carbon economy, which makes investment in RE more desirable for investors. Hence, increasing FFC leads to rising IRE in the selected countries.

Imposing tax on energy consumption (TEC) has a significant and negative effect on IRE at the 5% significance level. This unexpected outcome rejects the research hypothesis that tax on energy consumption would increase incentives to raise investments in the RE sector. This impact establishes some implications that some environmental policies like carbon tax or tax on fossil energies consumption do not lead to predetermined results. In other words, some researches have reported that actions to reduce the intermittency of renewable sources may be more effective than carbon taxes alone on promoting investment in renewable generation capacity (Aflaki et al., 2017). The results show that TEC, simultaneously, increases the cost structure of the RE generation and reduces the profitability of investments. In addition, this result may prove that market liberalization, expanding RE, and giving subsidies to investors (or consumers) are more effective than tax on energy consumption policy. The intermittency of renewable technologies drives the effectiveness of carbon pricing mechanisms, which suggests that charging more for emissions could unexpectedly discourage investment in renewables as stated by (Aflaki and Netessine, 2017). Thus, the result indicates that although tax on fossil energy consumption may lead to reducing GHG emissions, this policy might not be an appropriate approach to encouraging and promoting investment in RE.

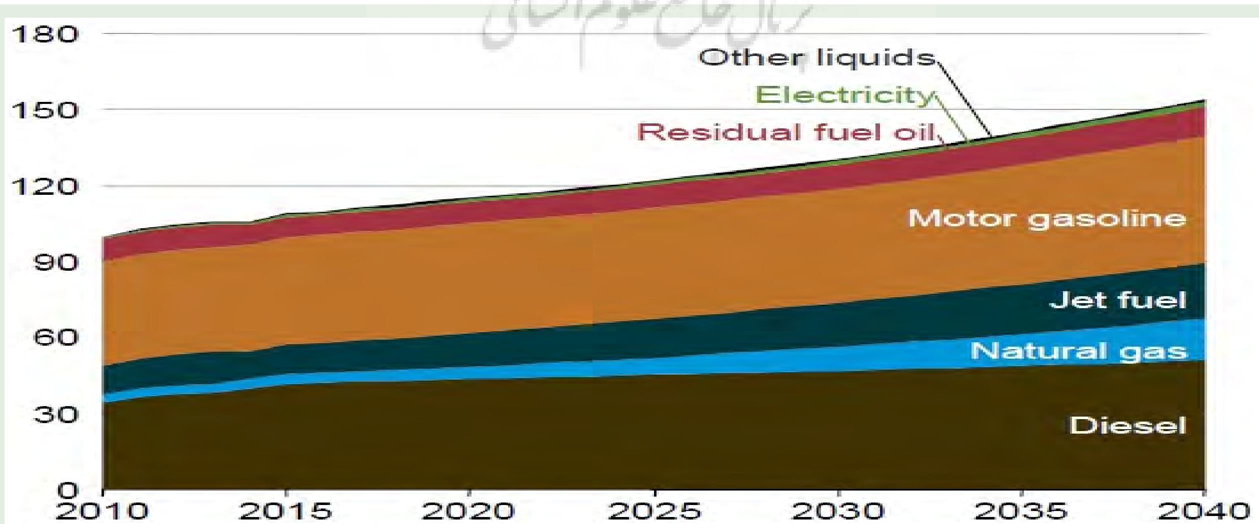

Figure 2: Energy consumption share by fuel type in world transportation sector from 2010 to 2040 (quadrillion Btu) (U.S. Energy Information Administration, 2016)

Furthermore, the estimation results show that tax on motor vehicle transportation (LTM) has a significant positive impact on IRE at the 5% significance level; it is also estimated that, on average, a 1% rise in tax on motor vehicle transportation approximately results in an 834 million $ increase in investment in the renewable energy sector in the selected countries over the studied period, indicating a large share of fossil fuel consumption in transportation sector in the given sample data. In fact, petroleum and other liquid fuels are the dominant energy source in the transportation sector worldwide, including the selected countries although their share in total transportation energy use is expected to decline from 96% in 2012 to 88% in 2040 (Energy Information Administration (EIA)'s Energy Outlook 2016). Figure 2 illustrates the share of different fuel consumption in transportation sector all over the world from 2010 to 2040.

According to Energy Information Administration (EIA) Energy Outlook 2016, transportation sector generates a substantial share of the GHG emission in the world and off course in the selected countries. Therefore, in contrast to TEC, tax on motor vehicle transportation, which uses fossil (liquid) fuels, should expect desirable implications due to its considerable impacts on the environment. Thus, those countries that use fossil fuels in their transportation systems could apply this policy to reducing GHG emission from motor vehicles.

In addition, population growth (POP) has a positive, but statistically insignificant, impact on IRE. This result indicates that after several meetings on climate change such as Kyoto protocol (1997) and Paris agreement (2015) and the increasing concerns about climate change, most of countries, including the selected 13 countries, have enhanced their endeavors and designed educational programs to encourage people to use and invest in RE. In other words, it shows that the new born population is being encouraged to use and invest in RE more than fossil fuels, but the success rate has been low due to economic growth and environmental conflicts, lack of resources, barriers to renewable energy technologies, low price of fossil fuels, political issues, etc. Moreover, the weighted average of fossil fuel prices (FFP) has a negative and statistically insignificant effect on IRE, stating that increasing fossil fuel prices has led to a decrease in investments in the RE sector over time in the studied nations . This relation, mostly, is due to the increasing marginal profit of fossil fuel energies with a price rise compared to renewable energies. In other words, this result shows that high price fossil fuel energies would make investment in the fossil fuel sector more profitable than the RE sector, in the selected countries with abundant oil over the study period, at least in short term

Finally, the last effective variable is interest rate (IR) which has a negative important effect on IRE variable at the 10% significance level. As given in Table 5, it is estimated that, on average, a 1% increase in interest rate results in a 176 million $ drop in investment in the renewable energy sector in the selected countries over the study period. The result is supported by economic theory.

In response to the main research question, the empirical results show that imposing tax on fossil fuels and energy has two separate and diverse impacts on the RE sector. First, tax on energy consumption (TEC) has, unexpectedly, a significant negative but negligible impact on IRE. The results demonstrate that tax on energy consumption may increase the production cost of the renewable energy generation leading to a decline in the investment profitability. Additionally, this result may prove that market liberalization, expanding RE, and giving subsidies to investors (or consumers) could be more effective than tax on energy consumption policy. Secondly, tax on motor vehicle transportation has a positive and substantial significant effect on IRE. This considerable impact is due to the large share of fossil fuel consumption and GHG emissions in transportation systems, across the world, including the selected countries. Moreover, the results indicate that imposing tax on motor vehicles is a more viable and effective policy tool than imposing tax on energy consumption (fossil fuels) to influence investors' behavior in the RE sector. In other words, imposing tax on energy consumption merely discourages investment in RE (IRE), but tax on motor vehicles encourages IRE. These conclusions are consistent with renewable energy policy realities in the selected countries.

Based on KPMG international 2017 report (KPMG International, 2014), the most leading countries have focused on investments and operating subsidy[4] schemes (called investment subsidies) instead of merely concentrating on tax penalties for energy consumers. Investment subsidies are unique to operating subsidies, which encourage the production of renewable energy. Investment subsidies provide financial assistance through grants, low-interest loans, education, or tax incentives such as R&D tax concession in the RE sectors

[4]These subsidy schemes include feed-in-tariffs (FIT), premiums, quota obligations, renewable portfolio standard (RPS), tradable renewable energy certificates (RECs), etc.

to encourage the investment in a particular renewable energy industry (KPMG International, 2014).

6. Conclusion and Policy Implications

This paper contributes to the stream of academic and institutional literature by investigating and exploring, merely, the efficiency of two types of tax policies on doing business or investments in renewable energy sector. Climate change and sustainability issues continue to gain headlines, and the likelihood of costs being imposed on carbon dioxide emissions in the developed countries has profoundly changed the economic outlook of RE sources. Making the shift from fossil fuels to renewable energy is leading global governments, businesses, and consumers alike to examining all the aspects of their environmental footprint and creating strategies to become environmentally responsible and thrive in today's economic climate (KPMG International, 2014).

Many agreements and protocols like Kyoto protocol in 1997 and COP 21 and Paris agreement in 2015 have been signed by most of the world countries to lower the implications of fossil fuel consumption based on United Nations Framework Convention on Climate Change (UNFCCC) policies. To reach global agreements' goals and keep the global temperature rise to less than 2 °C, developing RE is essential and policies should be implemented in this regard. Imposing tax on carbon-intensive tools or fossil fuel consumption is one of the proposed solutions to reduce environmental pollutions in the world. To this end, this paper investigates the effectiveness of imposing taxes on energy consumption and motor vehicle transportation to encourage investments in the RE sector during 2004-2016 for 13 developing and developed countries. Other factors like the price of fossil energies and interest rate are included in the research model to evaluate the investors' behavior in the RE sector. Based on the empirical results, we conclude that tax on fossil fuel consumption do not enforce investors to do businesses in the RE sector; however, imposing tax on transportation systems, which use fossil fuels, is effective and encourage investors to move their capital towards technologies producing lower carbon or greenhouse gas (GHG) emissions.

In accordance with economic theories, investing in the RE sector deals with some time delays, one and two years. Investment volume in RE is volatile, and many organizations in the world, like UNFCC, try to make doing business in RE attractive for global investors. Investors evaluate different risks, factors, business indicators, and policies to make decision about investing in the RE sector. Based on the empirical results in Table 6, investing in RE usually increases in the first year in the sample countries, but investors move their profits and capital to other businesses in next year and may then decide to invest their profits from other sectors in the RE sector. Hence, investing in the RE sector grows in a nonlinear path, and investors reduce their portfolio risks by diversifying assets value. The main purpose of the current paper is investigating the effectiveness of tax policies in encouraging investors to take part in the RE sector. Imposing tax on fossil fuel energies is implemented to protect the world environment from the negative outcomes of consuming fossil fuels. As mentioned, tax on fossil fuel energies is separated in two parts: tax on energy consumption and tax on transportation systems. Despite the research assumption, tax on the consumption of fossil fuel energies does not encourage investors to move their capital towards the RE sector of the selected countries. Therefore, it is proposed that giving subsidies to investors or consumers in the RE sector can be more effective than imposing tax on fossil fuel consumption and/or production. Based on the results, unlike tax on energy consumption, tax on motor vehicle transportation is effective in inducing investors to make investment in the RE sector. Tax policies cause innovations, investments, and agreements to apply modern, cost-effective, and efficient technologies to transportation systems. Due to the considerable share of transportation system in polluting the environment, rigorous regulations are employed in this sector to encourage people to use modern transportation systems and persuade investors to do business in this sector for accessing more air quality. Consequently, tax policies in the developed and developing countries can be efficient and effective along with the subsidy payments.

Considering substitutability of RE and fossil fuel energies and a negative relation of fossil fuel prices (FFP) with expanding RE, policy makers in global energy market should try to keep FFP in a reasonable range to attract investors to RE sustainable development plans. The interest rate of banking system is the other behavioral effective risk factor for global investors which is analyzed in the behavioral economic of investments in RE market. We recommend that an optimal interest rate should be pursued by all the countries in the sample to encourage moving accumulated capital towards the RE sector projects.

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Declaration of Conflicting Interest

The author(s) declare that there is no conflict of interest.

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