Supporting Renewable Energy: Incentive Mechanisms

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This thesis is based on panel data analyses by using one way fixed effects method in order to examine the factors that are effective on the development of renewable energy through putting a special emphasis on the role of incentive mechanisms. Two main groups of countries are employed throughout the empirical work one of which includes OECD countries and the other focuses on 40 countries and five different models are formed underneath these groups that have the natural logarithm of renewable energy share in the total primary energy supply of a country as dependent variable. The results indicate that gross domestic product per capita and market deployment policies affect the development of renewable energy positively while CO2 emissions, energy import dependency, total natural resources rents, and share of fossil and nuclear sources in electricity production have significant and negative effects on it. Our findings support that the market deployment policies are more effective in the European Union which emphasize the importance of creating political continuity and stability for renewable energy development. The results also reveal that having a large geographical area makes the implementation of renewable energy technologies and policies harder throughout the country. This study adds to the existing literature not only by widening the scope of inspected countries but also by introducing three new explanatory variables with significant results.

Keywords: Renewable Energy, Market Deployment Policies, Market Based Energy Policies, Research and Innovation Policies, Panel Data Analysis

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Supporting Renewable Energy: The Role of Incentive Mechanisms

1. Introduction

Energy security has arisen as an important issue and has been kept on governments' agendas since 1970s. Energy crises and ongoing instability in the Middle East convinced the policymakers to consider renewable energy as an alternative solution that presents a wide range of benefits such as energy security, reduction of GHG emissions which is followed by prevention of biodiversity loss, increase in employment facilities with job creation and rural development. Additionally with the emergence of international efforts like "Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy" and Kyoto Protocol, interest in renewable energy (RE) resources rose. Furthermore, the Fukushima nuclear disaster in 2011 decreased the trust in nuclear energy and reinforced the importance of RE resources by increasing public awareness.

On the other hand, due to a variety of technical and financial challenges, renewable resources cannot enter the market as easily as their fossil fuel alternatives. To neutralize the market environment which is currently to the detriment of renewable resources, governments have established renewable energy targets and have been implementing many support policies. As of early 2014, 138 countries, more than two thirds of which are developing countries have implemented RE support policies while 144 countries had renewable energy targets (REN21, 2014).

Major aim of this study is to examine the main drivers of RE and to reveal the role and effectiveness of government incentives in supporting renewable energy development. The empirical study focuses on two groups of countries. Initially OECD countries are investigated. However, empirical model is also extended to include 6 developing countries in addition to OECD. For these country groups, five different panel data analyses are conducted for the period 2000-2009 using various explanatory variables.

The literature in this area mainly focuses on developed countries, very few studies are done for emerging markets (e.g. Schmid 2012 and Aguirre and Ibikunle 2014) Present study examines Brazil, China, India, Indonesia, Russian Federation, South Africa together with the

OECD countries[1]. Additionally, the effect of natural resources (such as oil, natural gas, coal, minerals, and forest) on RE is investigated which is a novelty of this study. Moreover, two new variables one investigating the effectiveness of RE policies only in the European Union and the other examining the effect of the geographical area of a country on its RE share, are introduced.

The remainder of this paper is organized as follows: Section 2 briefly categorizes the policies implemented by different countries. In Section 3, previous empirical studies on drivers towards renewables are reviewed. Section 4 gives information about the data, methodology and models used throughout the estimations while Section 5 presents and discusses the empirical results. Conclusions appear in the final section.

2. Incentive Mechanisms in Promoting RE

Policy instruments (incentive mechanisms) that are currently used around the world can be classified based on the direction of the support: demand side and supply side. Figure 1 illustrates how incentive mechanisms could be categorized.

[1] Aguirre and Ibikunle (2014) is the only other study that focuses on BRICS.

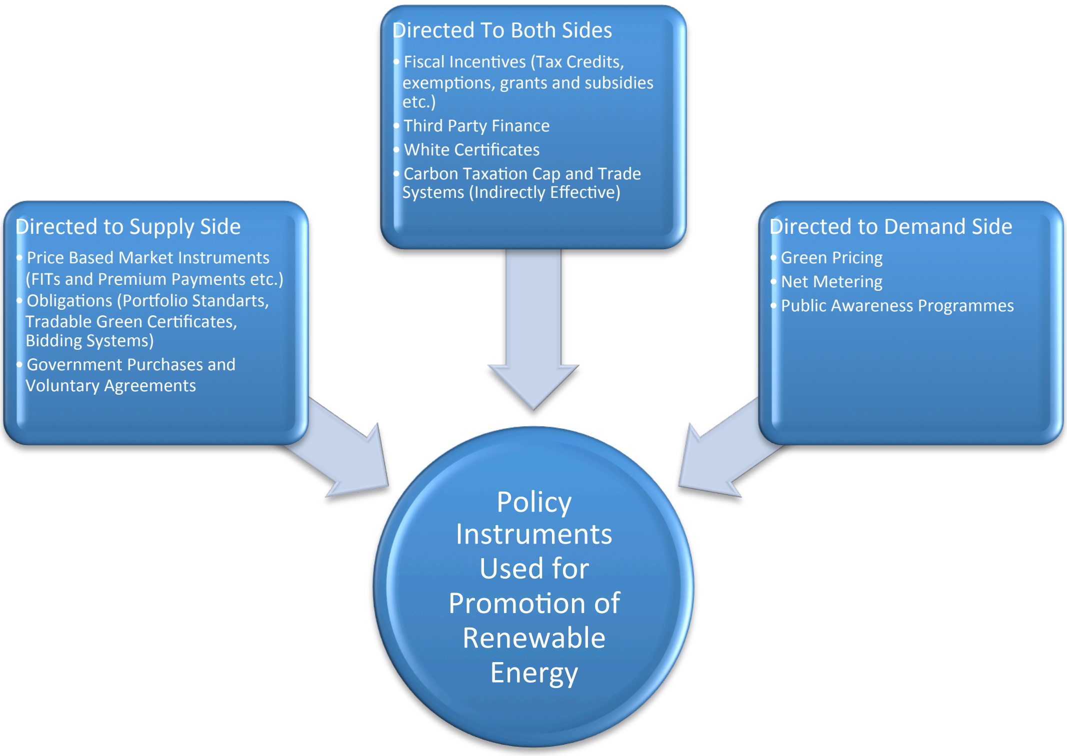

Figure 1 Classification of promotion policies for renewable energy

Source: Authors

Instruments directed to supply side constitute the most widely used promotion policies for RE with price based market instruments and obligations. They are generally used for assuring acquisitions for RE producers and making them continue for further productions. Among these incentives, price based market instruments such as guaranteed price systems, feed-in tariffs (FIT), premium payments and preferential rates are the most popular ones implemented by countries. According to Renewables Global Status Report 2014 at least 98 countries have adopted premium payments or FIT among 144 countries that have renewable power policy. Obligations or renewable portfolio standards which are facilitated with tendering systems and tradable green certificates (TGC) (or renewable energy certificates (REC)) are other common policies that are widely used by countries at national or local level, which were implemented in 79 countries in 2014 (REN21, 2014).

Demand side as being the complementary part of RE deployment is supported by different instruments such as green pricing, net metering and public awareness programs. These mechanisms pave the way for consumers to participate actively in RE promotion through enabling them to choose and track the type of energy they use, to install their own small renewable systems. These types of policies also raise public awereness regarding the importance of RE use since the public mainly shoulders the costs of the promotion policies.

There are policy instruments that are directed to both demand and supply sides, which are generally subsidiary implementations of main promotion policies of RE. A mix of regulatory policies, pricing and also trading of environmental externalities such as cap and trade system or carbon tax, public financing mechanisms or fiscal incentives are adopted for supporting RE technologies at various maturation or costing stages. These combinations reinforce other adopted policies especially supply side policies and reduce the possible deficiencies that would be experienced in the production or distribution of RE through the agency of not only conditioning the environment with instruments like urban planning, reinforcement and upgrading of the grid connections, but also lowering the risks and high costs of RE production or RE use via tax measures, capital grants and third party finance. [2]

In the empirical model all available mechanisms will be covered and we will not strictly adhere to this classification due to overlapping in categories.

3. Literature Survey on Determinants of Renewable Energy

Although the majority of the literature on RE incentives is based on normative and descriptive analysis, the empirical studies are becoming increasingly popular in recent years. This section analyzes the studies that search for the determinants of renewable energy by including RE policies in their empirical models.

Menz and Vachon (2006) and Adelaja and Hailu (2008) are among the initial studies that use econometric models to explain the drivers of RE by using OLS and cross-sectional analysis respectively. Eearly studies usually focuse on the U.S. data due to lack of comprehensive data, as the data became available, panel data analyses has become the method generally used in the studies.

[2] For detailed and compiled information about policies and the countries implementing them, please visit: http://library.metu.edu.tr/search~S8?/cIII.EC+.13-19/ciii.ec+.13+19/-3,-1,0,E/l856~b1808307&FF=ciii.ec+.13+19&1,1,,1,0

As the U.S. and Europe constitute the biggest strongholds in the fight against climate change and the first places that implement incentives for RE technologies, the studies generally concentrate on them. Menz and Vachon (2006), Adelaja and Hailu (2008), Kneifel (2008), Carley (2009), Yin and Powers (2010), Shrimali and Kneifel (2011) focus on state level policies in the U.S., particularly Renewable Portfolio Standards (RPS) implementation. Marques et al. (2010, 2011); Biresselioğlu and Karaibrahimoğlu (2012), Del Río and Tarancón (2012) and Jenner et al. (2013) conduct their surveys on a group of European countries. On the other hand, there are efforts to understand the drivers of RE by examining a wide array of countries that Johnstone et.al. (2010), Gan and Smith (2011) and Popp et.al. (2011) establish their works on OECD countries. Dong (2012) carries this effort forward that he employs a panel data analysis on 53 different countries that account for over 99.5% of the total wind capacity of the world. Schmid (2012) brings a new breath by focusing on 9 Indian states. It is worth to express that developing countries are rarely examined that Aguirre and Ibikunle (2014) have the single study that scrutinizes BRICS (Brazil, Russia, India, China and South Africa) together with the EU and OECD countries.

The dependent variables are generally chosen as measures of total RE capacity or generation. For example the share of renewable sources in electricity generation or per capita renewable energy supply are used while some of the studies are centered upon specific technologies. Menz and Vachon (2006), Adelaja and Hailu (2008), and Dong (2012) select wind energy capacity or generation as dependent variables while Gan and Smith (2011), Shrimali and Kneifel (2011), and Jenner et al. (2013) try to understand the factors of development of not only total renewable energy but also specific resources such as bioenergy, solar PV, onshore wind and geothermal. As distinct from those, Johnstone et al. (2010) look for the drivers of the number of patent applications in each of the technological areas of RE in order to test the effects of policies on innovation. Similarly Popp et al. (2011) consider net renewable investments as indicator for development of RE and include patents in their model to measure their effects on investments.

The explanatory variables are generally common throughout the studies. Technical potential of resources, CO_2 emissions, income, energy or electricity consumption, share of traditional sources in energy supply, natural resource endowments or land areas, electricity and fossil fuel prices, energy import dependency are most commonly used independent variables. On the other hand, due to the difference of dependent variables and scope of countries, it is also possible and natural to attain different variables particularly policy variables as well.

The policy variables in studies which are focused on the U.S. states consist of RPS implementations, fuel generation disclosure requirements (FGDR); mandatory green power option; public benefit funds or clean energy funds and renewable energy credits (REC). In addition to those, League of Conservation Voters (LCV) scores[3] - that are seemed to be an expositional symptom of susceptibility to environmental issues in a state- are employed in the models. The articles which mirror the RE in the European Union and OECD utilize feed-in tariffs, RECs, investment incentives, tax measures, guaranteed price, voluntary programs, R&D expenditures and renewable obligations (RO) as policy variables. Differently, Marques et al. (2010, 2011), Biresselioğlu and Karaibrahimoğlu (2012) look for the effects of EU Directive 2001/77/EC and membership to the EU; while Johnstone et al. (2010), Popp et al. (2011) and Aguirre and Ibikunle (2014) investigate the consequences of ratification of Kyoto Protocol. Schmid (2012) employs The Electricity Act 2003 and The Tariff Policy 2006 of India together with the FITs and ROs as policy variables.

Most of the studies use policyindicators as binary variables however, some of the researchers create more complex and realistic indicators for them. For instance, Adelaja and Hailu (2008) and Yin and Powers (2010) take different RPS stringency factors –such as number of years remained to reach the target, the number of years since the adaptation of RPS, mandatory proportion of renewables, etc.- into account in their models. Johnstone et al. (2010) use national public sector expenditures on different types of RE for R&D expenditures. For FITs they take the price levels guaranteed to each technology and for RECs they employ the percentage of electricity that must be generated by renewables in their models. Gan and Smith (2011) classify policies in conformity with IEA (2004) as market deployment policies, market based policies and research and innovation policies. They use the number of these policies as the policy variable for each country in their analysis. Jenner et al. (2013) generate

[3] "The League of Conservation Voters (LCV) annually publishes the National Environmental Scorecard, which rates all congressional votes on conservational issues by each representative. For example, if there are ten total votes in a year on environmental issues and a congress person voted in favor of conservation six times, his or her LCV rating would be 60." (Kneifel, 2008)

an indicator for FIT strength that captures variability in tariff size, contract duration, digression rate and electricity price. Aguirre and Ibikunle (2014) use seven policy-type variables which correspond to year-on-year changes of the accumulated number of policies such as direct investments, feed-in tariffs, voluntary instruments, etc. by year.

When we look at the common findings of the empirical studies; income, energy consumption, energy prices, technical potential of RE resources has positive association with RE development while share of traditional resources has negative correlation. The policy variables usually play important roles in the deployment of RE, however their effect may change according to the type of technology. Johstone et al. (2010) argue that FITs are positively effective only on solar technology while RO affects wind technologies. Carley (2009) finds that RPS implementations have a small and negative association with RE electricity share, but large positive impacts on total renewable energy generation and tax policies decrease RE share.

4. Methodology, Data and the Models

4.1. Methodology

The main objective of this study is to explore the drivers of renewable energy by putting an emphasis on the effects of government policies. In this direction, two sets of panels are employed throughout the empirical work; one group includes 34 OECD countries and the other focuses on 40 countries[4] and five different models are formed underneath these groups. It is well known that Ordinary Least Squares (OLS) does not only ignore the structure of the data and remain is not appropriate for cross sectional time series data analysis but also will not produce unbiased and consistent estimates in the presence of serial correlation and heteroscedasticity For this reason panel data analysis will be used in the empirical analysis.

While using the panel data analysis, choosing the best method among pooled OLS, fixed effects method (FEM) and random effects method (REM) is the most important step to

[4] These are: 34 OECD countries; Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States and 6 developing countries; Brazil, China, India, Indonesia, Russian Federation, South Africa.

proceed. In this direction, we performed a series of F Tests, Breusch Pagan LM Tests, Hausman's Specification Tests and Schaffer and Stillman (2010)'s overidentification tests for all of our models and concluded that fixed effects method is the most appropriate one for our analyses. We also checked the direction of individual heterogeneity to determine whether it exists in only cross sections (one-way) or both cross sections and time periods (two-way) by conducting a joint F test. Finally we failed to reject the null and concluded that there will be no need for considering time-year effect which guides us to one-way fixed effects method as the best estimation method[5].

The template model throughout the empirical study will be

$$Y_{it} = \beta_{0it} + \beta_1 X_{it} + \beta_2 P_{it} + u_{it}$$

where -in country i at time t- Y is the outcome variable, X and P are the vectors of independent variables i.e. non-policy and policy variables respectively. The intercept term β_{0it} stands for the individual heterogeneity and constant term.

4.2. Data

Since data availability is one of the important factors that constraint the empirical studies, the period of the study is chosen toencompass ten years between 2000 and 2009 resulting in strongly balanced panels. The cross section units of our panel data models are countries which consist of OECD countries for the first panel and 40 countries in the second one.

Similar to Carley (2009), Marques et al. (2010) and (2011), we use the natural logarithm of the RE share in total primary energy supply (LNRES) of the country as the dependent variable in all of our models. It is worth to mention that renewable energy supply includes the primary energy equivalent of hydro (excluding pumped storage), geothermal, solar, wind, tide and wave as well as the energy derived from solid biofuels, biogasoline, biodiesels, other liquid biofuels, biogases, and the renewable fraction of municipal waste.

The explanatory variables are also chosen in accordance with the literature. The list of explanatory variables are as follows:

[5] For detailed test results, please visit: http://library.metu.edu.tr/search~S8?/cIII.EC+.13-19/ciii.ec+.13+19/-3,-1,0,E/l856~b1808307&FF=ciii.ec+.13+19&1,1,,1,0

Carbon dioxide emissions per capita (CO2pc): Being one of the most important ones of anthropogenic greenhouse gases, CO2 emissions are frequently used as the independent variable in the literature (e.g. Marques et al. 2010 and 2011, Gan and Smith 2011, Dong 2012 Aguirre and Ibikunle 2014). As higher levels of CO2 emissions can be a signal of either evoked environmental concerns or the alienation to those issues along with the commitment to carbon intense traditional sources, the expected sign of CO2pc is not definite.

Income-Gross domestic product per capita (GDPpc): The effect of wealth and income is seen as one of the most important factors for deployment of RE in the literature (e.g. Carley 2009, Marques et al. 2010 and 2011, Gan and Smith 2011, Popp et al. 2011, Shrimali and Kniefel 2011, Biresselioğlu and Karaibrahimoğlu 2012, Dong 2012, Jenner et al. 2013, Aguirre and Ibikunle 2014). The expected sign of GDPpc is not definite because higher levels of income could provide an opportunity for overcoming the regulatory costs which are caused by promotion of renewables, in that respect the sign of this variable could be positive. At the same time higher income per capita could also be the signal of higher energy consumption supplied through traditional fossil sources, indicating a negative sign

Consumer Price Index-Energy (CPI): Electricity, gas and other fuels of individual consumption, fuel and lubricants for personal transport equipment are considered in this price calculation and the base year is taken as 2005. Prices are included in the literature in alternative ways (e.g. Kneifel 2008, Carley 2009, Johnstone et al. 2010, Marques et al. 2010 and 2011, Yin and Powers 2010, Gan and Smith 2011, Popp et al. 2011, Shrimali and Kniefel 2011, Aguirre and Ibikunle 2014). Expected sign of this variable is positive because an increase in the prices of fossil fuel based energy will increase the preference of renewable resources due to substitution effect. Regrettably CPI data are not available for Brazil, China, India, Indonesia, Russian Federation, and South Africa; therefore we conduct the analyses of 40 countries (extended model) without the CPI variable.

Import Dependency of Energy (IMPDEP): In the literature import dependency is considered as an indicator of energy security. (e.g. Marques et al. 2010 and 2011, Yin and Powers 2010, Popp et al. 2011, Dong 2012, Jenner et al. 2013, Aguirre and Ibikunle 2014) It can be argued that the higher the energy imports higher will be the need and search for new and secure energy sources such as renewables. Thus the expected sign of this variable is positive.

Electricity production from oil, gas and coal (fossil) sources (FSHARE): The electricity generated by using oil (crude oil and petroleum products), natural gas (natural gas liquids excluded), coal (all coal and brown coal, hard coal and lignite-brown coal), derived fuels (including patent fuel, coke oven coke, gas coke, coke oven gas, and blast furnace gas), and peat is included in this variable and it is found as a percentage of total electricity production. The contribution of fossil sources to total energy supply or GDP is commonly used in the literature (e.g. Carley 2009, Popp et al. 2011, Marques et al. 2010 and 2011, Shrimali and Kniefel 2011, Jenner et al. 2013, Aguirre and Ibikunle 2014). As an indicator of the power of lobbying efforts and fossil based consumption patterns, FSHARE is expected to have a negative association with RE share.

Electricity production from nuclear sources (NSHARE): The share of electricity produced by nuclear power plants in the total electricity production constitutes this variable.(e.g. Kneifel 2008, Marques et al. 2010 and 2011, Popp et al. 2011, Biresselioğlu and Karaibrahimoğlu 2012, Del Río and Tarancón 2012, Jenner et al. 2013, Aguirre and Ibikunle 2014). Although the expected sign of NSHARE is negative, a positive association with RE share is also possible since the use of nuclear sources could be an indicator of the quest for alternative energy resources which might trigger the deployment of RE as well.

Total natural resources rents (TNR): It consist of the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents is new to the literature. We consider this variable as a proxy for natural resources endowments. Since the higher levels of total natural resources rents in a country show self-sufficiency in energy there will be a lack of quest for alternative sources, thus the expected sign of this variable is negative.

The non-policy variables are listed in Table 1 with their descriptive statistics and data sources.Table 1 Non-Policy Variables, Descriptive Statistics and Data Source[6]

Variable	Definition	Mean	Std.Dev.	Min	Max	Data Source
LNRES	The natural logarithm of RE share in a country's total primary energy supply	2,133	1,101	-0,916	4,404	OECD Factbooks
CO2pc	Carbon dioxide emissions per capita	8,714	4,488	1,136	24,824	The World Bank
GDPpc	Gross domestic product per capita	25175,64	19409,47	455,443	112028,5	OECD Stat.Extracts
CPI	Consumer Price Index of Energy	0,982253	0,175771	0,252	1,521	OECD Stat.Extracts

[6] Descriptive statistics are produced from the data of 40 countries except fort he CPI.

IMPDEP	Net energy imports are estimated as a percentage of energy use	0,121	1,299	-8,424	0,9808	The World Bank
FSHARE	Electricity production from oil, gas and coal (fossil) sources	0,586	0,307	0,00011	0,9995	The World Bank
NSHARE	Electricity production from nuclear sources	0,152	0,199	0	0,79	The World Bank
TNR	Total natural resources rents	0,034	0,063	0	0,4306	The World Bank

Policy Variables (POLD, POLE, POLR): Following IEA (2004) and Gan and Smith (2011), we classified all of the renewable energy policies into three categories which can be briefly described as:

1- Research and Innovation Policies (POLR): Policies that support the development of new and improved technologies.

2- Market Deployment Policies (POLD): Policies that support the market introduction of new technologies, try to improve their technical performance and cost-competitiveness, and encourage the development of the industry.

3- Market-Based Energy Policies (POLE): Policies that provide a competitive market framework by internalizing the externalities in terms of energy security, environmental protection and economic efficiency.

The data for policies were taken from IEA Policies and Measures Database. Policy variables are constructed by determining the type of policies and duration of the policy for the study period in which 1121 policies were scrutinized. Research and development policies and expenditures are regarded as research and innovation policies (POLR); policies that internalize externalities such as energy and carbon taxation, carbon trading schemes, net metering are regarded as market-based energy policies (POLE); and remaining policies such as feed-in tariff, quota obligations, tradable certificates, tax credits and exemptions, capital grants and subsidies are all regarded as market deployment policies (POLD). As a result of this categorization we concluded that there are 935 types of market deployment policies (POLD), 149 research and innovation policies (POLR) and 37 market-based energy policies (POLE). Among these policies 741 of them are still in force in 2013. On the other hand, for the remaining 380 policies we went into detail and specifically determined the ending dates for each country. Approximately for 20 policies, the definite end dates could not be achieved and the last date that information[7] was available has been assumed as the deadline for them. However, it is worth noting that all of the 1121 policies will not be employed in our analyses; i.e. since we establish our model over the period 2000-2009, only 1099 of these policies will be considered during the regressions.

Figure 2 shows the total number of policies in 2009. Considering all types of policies, 646 policies have been implemented among 40 countries and the maximum number of policies belongs to the United States (with 83 policies) which is followed by Australia (with 40 policies) and France (with 34 policies). On the other hand, Iceland ranks last because of having only one policy[8]. The United States preserves the first place with reference to POLD and POLR, but Norway comes first for POLE.

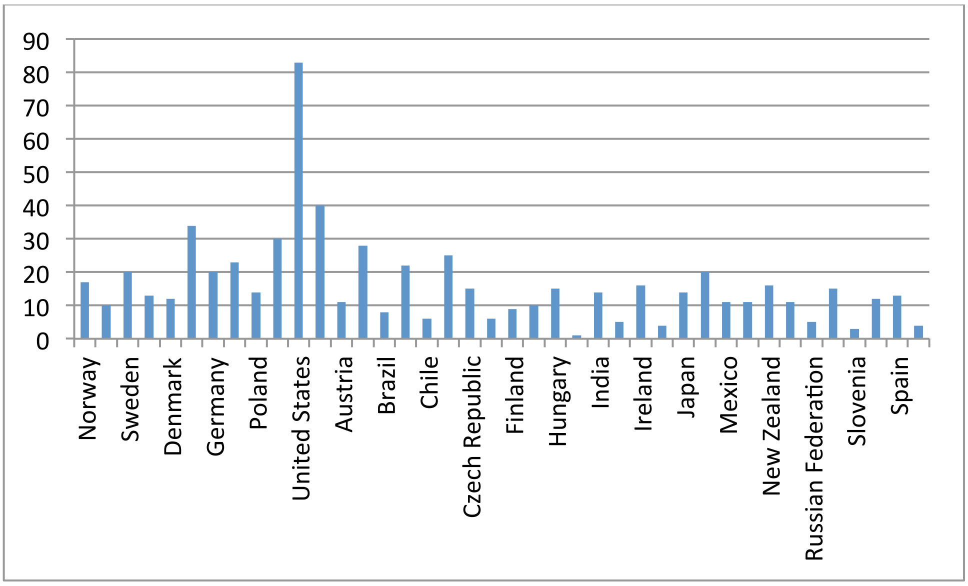

Figure 2 Total number of RE policies for different countries (POLD+POLE+POLR)

[7] These information are taken from articles, reports, newspapers, announcements, etc. which are achieved via Internet.

[8] However this is not a failure for Iceland since 82% of its primary energy supply was met by renewable resources in 2009. Also in 2011, 65 % of primary energy was met by geothermal energy while hydropower accounted for 20% of it (The Independent Icelandic Energy Portal, 2013).

Additionally, it is worth to mention that the political interest to renewable energy has been increasing for recent years. For the 40 countries that are subject to this research, the number of all types of RE policies in 2000 was 268 while it reaches to 731 in 2012. Figure 3 shows the abovementioned trend for each type of policy between 2000 and 2012.

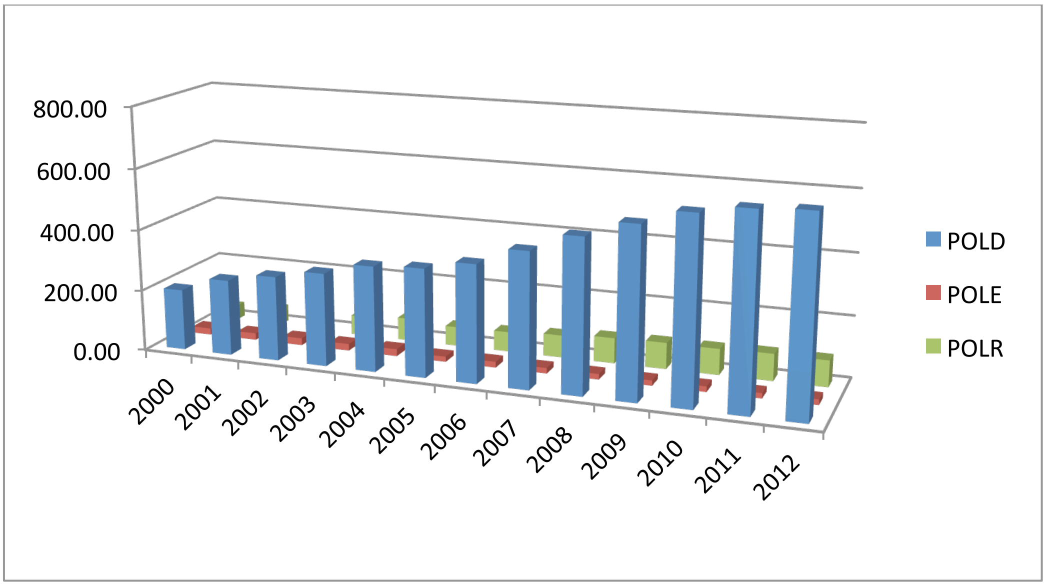

Figure 3 Total number of POLD, POLE and POLR for all 40 countries(2000-2012)

EU Membership (EUPOLICY): Similar to Marques et al. (2010, 2011), and Biresselioğlu and Karaibrahimoğlu (2012) we check whether being a member of the European Union (EU) affects renewable energy share in the country or not. On the other hand, we introduced a new policy variable to measure the effectiveness of policies in the European Union not the effect of membership itself. Our EUPOLICY variable is obtained by multiplying POLD which is the most widely used policy type among all of the countries by a dummy variable which takes the value of 1 when the country is a member of the EU and, 0 otherwise:

EUPOLICY = EUDUMMY * POLD

EUPOLICY variable enables us to measure the effect of POLD in only EU member countries and thus provides an opportunity to see whether they are more or less effective in the EU. Implementing policies is not the only necessity for deployment of renewable energy; the determination of policy makers and other shareholders, economic and political stability, and the institutional environment are just as important as carrying out incentive based RE policies. Since EU is one of the regions that have stringent policies that promote RE by using various tools and limit the emissions by imposing mandatory targets, the expected value of EUPOLICY is positive. Our data include 22 EU member countries.

Number of Policies per square km of land area (POLAREA)**:** Geographical area is used as a proxy for production potential of renewables in the literature (e.g. Marques et al. 2010 and 2011, Gan and Smith 2011). Although it is acceptable to specify RE potentials with geographical area under the influence of data limitations for finding out the real RE technical potentials of a large scope of countries, using this method is open to discussion since larger area does not always mean larger potential of renewable resources. In addition to that, geographical area is time-invariant while technical production potential of renewables may change in time by means of technological developments. Last but not least, large area does not necessarily promote the deployment of RE all the time because the wideness of the area might make it tougher to implement RE technologies and policies throughout the country. For instance, promulgating a RE policy in China would not be as easy as it is in Iceland or Luxembourg. As the area gets larger, more pecuniary resources would be needed. Additionally, larger countries will face higher switching costs when they intend to replace traditional energy resources with renewables. In light of these we calculated a new variable POLAREA by dividing the total number of most widely used policy type POLD[9] by the country's total area and attain the number of policies per square km of land area. This variable is scaled by 100 as it produces very small coefficients due to large values of the AREA variable:

$$POLAREA = (POLD/AREA) \times 100$$

4.3. Empirical Models

In the empirical analysis we present results of five models: two are estimated for OECD and three are for the extended data base including the emerging markets (EM). For the OECD data TNR and IMPDEP are highly correlated therefore we conduct two different analyses covering TNR and IMPDEP seperately . On the other hand, EM, high correlation does not

[9] We tried other versions of POLAREA and EUPOLICY by using POLS instead of POLD..Due to space considerations we will only present the best fitted models here which are the ones with POLD (POLS = POLD+POLE+POLR). Abovementioned estimation results can be obtained from: http://library.metu.edu.tr/search~S8?/cIII.EC+.13-19/ciii.ec+.13+19/-3,-1,0,E/l856~b1808307&FF=ciii.ec+.13+19&1,1,,1,0

exist therefore we include both variables simultaneously in models EM(1), EM(2) and EM(3). Unfortunately, because of the unavailability of the data of CPI for Brazil, China, India, Indonesia, Russian Federation, and South Africa, EM models do not include the CPI variable. The variables used in these models are summarized in Table 2.

Table 2 **Summary of the explanatory variables used in various models**

Model	Non-Policy Exp.Var.	Policy Exp.Var.
OECD (1)	CO_2pc, GDPpc, CPI, IMPDEP, FSHARE, NSHARE	POLD POLE POLR
OECD (2)	CO_2pc, GDPpc, CPI, TNR, FSHARE, NSHARE	
EM (1)	CO_2pc, GDPpc, IMPDEP, TNR, FSHARE, NSHARE	
EM (2)	CO_2pc, GDPpc, IMPDEP, TNR, FSHARE, NSHARE	EUPOLICY
EM (3)	CO_2pc, GDPpc, IMPDEP, TNR, FSHARE, NSHARE	POLAREA

5. Estimation Results and Discussion

In the empirical analysis initially Pesaran CD test for cross sectional dependence, modified Walt test for homoscedasticity, Fisher type Maddala and Wu test (which is an Augmented Dickey Fuller test) for non-stationarity are performed. Results of these tests show that our models have cross sectional dependence and heteroscedasticity problems. To overcome this complication, following Hoechle (2007), we compute our regressions with Driscoll-Kraay (D-K) standard errors. Hoechle (2007) states that the finite sample properties of panel correction standard errors model (PCSE) are rather poor for micro panels and as the T/N get smaller PCSE will be less reliable. So he estimates fixed effects regressions with D-K standard errors and shows that they are well calibrated in the presence of cross-sectional dependence. He also indicates that D-K's covariance matrix estimator produces robust standard errors which are also consistent in the presence of heteroscedasticity. Hence, we conduct our regressions by using D-K standard errors and present the estimation results of all models in Table 3 .

Table 3 Regression Results with Driscoll-Kraay standard errors[10]

Variable	OECD (1)	OECD (2)	EM (1)	EM (2)	EM (3)
CO2pc	-0,073028*** (0,015548)	-0,0742*** 0,016026	-0,0921*** (0,0162)	-0,081*** (0,0105)	-0,09068*** (0,0151)
GDPpc	0,000012*** (0,00000075)	0,000011*** (0,000001)	0,0000*** (0,0000)	0,00001*** (0,0000)	0,00001*** (0,0000)
CPI	0,07702910 (0,05985)	0,121606 (0,0589)	-	-	-
IMPDEP	-0,204167*** (0,034607)	-	-0,1864*** (0,0302)	-0,2215*** (0,0322)	-0,19974*** (0,0257)
TNR	-	-1,5548*** (0,1425)	-0,7363*** (0,1435)	-0,5165*** (0,1349)	-0,58204*** (0,1538)
FSHARE	-1,127036** (0,426073)	-1,0823** (0,4672)	-1,0168** (0,4446)	-0,743* (0,3583)	-1,18835*** (0,2754)
NSHARE	-3,101771*** (0,333737)	-2,9598*** (0,3411)	-3,0505*** (0,3606)	-2,8936*** (0,1762)	-3,20205*** (0,2621)
POLD	0,008528*** (0,001725)	0,00876*** (0,0018)	0,0063*** (0,0009)	-	-
POLE	0,01082800 (0,014263)	0,00434 (0,0145)	0,0111 (0,0153)	-	-
POLR	-0,026597*** (0,00736)	-0,0256*** (0,007)	-0,0231*** (0,007)	-	-
EUPOLICY	-	-	-	0,0221*** (0,0038)	-
POLAREA	-	-	-	-	3,56531* (1,8228)
cons	-1,161225*** (0,320675)	-1,2182*** (0,3275)	-0,9201** (0,329)	-1,239*** (0,2172)	-0,84933*** (0,2650)
R^2_a	0,9844	0,9843	0,9865	0,9888	0,9867
Legend: * p<0.1; ** p<0.05; *** p<0.01 Numbers in parentheses are standard errors.					

For OECD(1) and OECD(2) models, results show that CPI is insignificant, i.e. energy prices does not have an impact on RE share. This can be attributed to several reasons: Firstly, the increase in prices of energy do not reach sufficient level that would trigger the use of RE and contribute to competitiveness of it. Moreover, because of the high initial capital costs of RE, the substitution effect cannot run the competitive mechanism that would make the decision makers choose RE resources. This result is compatible with the findings of Marques et al. (2010, 2011) and Aguirre and Ibikunle (2014).

[10] We take the adjusted R^2 of fixed effects method results because the Driscoll-Kraay (D-K) regression does not produce correct R^2 since the intercept term is suppressed in within estimation used in D-K.

Our results show that POLE does not seem to have an effect on RE share as well. This situation is probably stemmed from the fact that there are very few market based energy policies i.e. only 200 of 4139 policies in OECD countries belong to POLE in the data. Also there are a lot of countries that do not internalize the externalities and have no POLE, but have significant amounts of RE share such as Canada, Chile, Iceland and Portugal. Hence we can confidently say that the implementation of this policy has not gained acceptance among countries and reached a significant level that would affect the RE share. Moreover, according to the results of EM (1), the insignificance of POLE is preserved when the emerging markets are included.

All of the regression results indicate that CO2pc is significant at 99% level and negatively effective the RE share. The negative sign of CO2pc in the estimation results show that higher emissions in the countries do not encourage RE. This result indicate the alienation toward environmental issues overall, along with the commitment to carbon intense traditional sources. Furthermore, we see that the negative effect of CO2pc has increased in EM (1) which is probably because of the fact that emerging markets are heavily dependent on carbon based energy resources in their industrialization processes and do not generally meet their energy need from RE resources. These results related with CO2pc are contradicting with those of Popp et al. (2011), Dong (2012), Sadorsky (2009a), Menyah and Rufael (2010), Salim and Rafiq (2012), Aguirre and Ibikunle (2014); they are verified in all of our models and compatible with previous findings of Marques et al. (2010, 2011), and Marques and Fuinhas (2011).

GDPpc has significant and positive association with RE share in all of the models. Although the magnitude of this effect is not large; its significance is notably high at 99% level. So we can conclude that high levels of per capita income could increase the environmental awareness and provide opportunity for overcoming the regulatory costs which are caused by promotion of renewables. Although our income effect finding is consistent with the most of the previous literature; Marques and Fuinhas (2011), Shrimali and Kniefel (2011), Dong (2012), Aguirre and Ibikunle (2014) find GDP or GDP per capita insignificant for promotion of RE, and Biresselioğlu and Karaibrahimoğlu (2012) conclude that it has negative effects on RE.

All of the regression results that include IMPDEP show that it is significant at 99% level and have negative association with RE share which is an unexpected situation. As mentioned before, import dependency is a proxy for energy security and is expected to stimulate search and use of RE. On the other hand, from the results we can conclude that instead of being a proxy for energy security IMPDEP shows the commitment to traditional energy sources and has not reached the level that would increase the environmental and energy security concerns, yet. Although the literature generally admits import dependency as a need and motivator for search of alternative local energy resources; our findings are robust and valid for all of our regressions. Marques et al. (2011) who conduct a quantile regression analysis go along with our findings by concluding that energy import dependency has negative effects on deployment of RE in countries with high levels of RE.

TNR is also found to be significant at 99% level and when the results of OECD (1) and (2) are compared, it seems to have a higher impact on RE than the IMPDEP has. The direction of its effect is in accordance with our expectations that TNR has negative association with RE share since the higher levels of total natural resources rents in a country show self-sufficiency and a lack of quest for alternative sources.

Despite the change in significance levels of FSHARE, all of the estimation results reveal that FSHARE and NSHARE have significant and negative associations with RE share as expected. These results can be an indicator of the lobbying for fossil fuels.. Moreover, they also imply the existence of a substitution effect in the case of nuclear energy. Nuclear energy requires large financial resources and subsidies because of its high costs, and it competes with RE in this respect. According to World Energy Outlook 2010, $312 billion subsidies were allocated to fossil fuels in 2009 while the cost of support given to renewable energy was only $57 billion which is compatible with our results. The abovementioned negative association is line with the findings of Marques et al. (2010, 2011) and Aguirre and Ibikunle (2014).

Market deployment policies (POLD) which are the most widely used policies, are significant at a level of 99% and have positive association with RE share for the first three regressions. Since they support the market introduction of new technologies and accelerate the development of the industry, they can be seen as one of the main drivers of RE by affecting it positively. Also there is decline in the positive effect of POLD in EM (1), but it should not be omitted that the significant and positive effect of POLD on RE is still definite.

On the other hand, research and development policies (POLR) are significant at 99% level but they seem to affect RE share negatively which is an unexpected result. This finding can be attributed to two facts: Firstly, research and innovation policies are not widely implied policies that in the OECD countries; only 633 of 4139 policies are research and innovation policies. This number increases to 651 when we add 6 developing countries in EM (1). So we can infer that POLR have not achieved the adequate level that can be seen in the supply of renewable energy. Also they are aimed at supporting new and improved technologies and are not devoted to high volumes of production and commercialization. So, although POLR is seemed to be negatively effective on LNRES, the effects of these policies will show up in the long run and using a dynamic model will better capture this affect. As the resources that are allocated to POLR could easily be used for POLD, research and innovation policies seem to affect RE supply share negatively at first glance.

Our regression results show that EUPOLICY is statistically significant at 99% level and is positively effective on RE share. In addition to that, while the coefficient of POLD is 0.0063 for our base model EM (1), it increases to 0.0221 for EU countries as expected. Market deployment policies (POLD), which are the most widely used and result-oriented policies for RE, are almost four times more effective in the EU member countries. This can be seen as a manifestation for the importance of the role of not only policies, but also institutions, economic and political stability, and international cooperation.

The regression results of EM (3) shows that POLAREA is statistically significant and at 90% level and has positive association with RE share. If the number of renewable energy policies (market deployment policies) per sq. km of land area increases, the contribution of renewable energy resources to total primary energy supply of the country increases considerably. Hence, it can be inferred that for comparably smaller countries in terms of land area, policies have higher impacts on RE share and a large country has to extend more support on policies in order to reach high levels of RE supply.

6. Conclusion

This paper examines the factors that are effective on the development of renewable energy through putting a special emphasis on RE policies and utilizing a fixed-effects regression model with Driscoll-Kraay standard errors. It adds to the existing literature not only an updated study but also a wider scope by studying a set of 40 countries which include OECD countries and 6 developing countries between 2000 and 2009. Thus, the important changes experienced after 2006 such as "oil price boom and bust; increase of social and political pressure for fast developments in clean energy; financial crisis, which requires adequate government measures to stimulate the economy" (Marques et al. 2010) are covered bythe study. Although the classification of the policies as market deployment policies, market based policies, and research and innovation policies is inspired by Gan and Smith (2011), determining the type and implementation period of policies necessitates a different and detailed process because of the discrepancies between the research periods and scopes.

In addition, this study contributes to the current literature by introducing two new explanatory variables: EUPOLICY and POLAREA. Different from the previous studies which use EU membership or EU Directives as a dummy variable, EUPOLICY that measures the effectiveness of RE market deployment policies (POLD) in the European Union is generated. This variable tries to emphasize the importance of the determination of policy makers and other shareholders, economic and political stability, and the institutional environment by specifying whether the policies are more effective in the EU or not.

POLAREA measures the number of policies per sq km of land area and represents a different approach to the geographical area variable which is taken as a proxy for production potential of renewables and assumed to have positive association with RE development in various previous studies (e.g. Marques et al. 2010 and 2011, Gan and Smith 2011, Del Río and Tarancón 2012). Larger area does not necessarily promote the deployment of renewable energy; wider geographical areas may increase costs of switching from fuel based energy use to RE technologies and make it harder to implement RE policies.In this respect it is a negative factor in this study.

Two groups of countries are employed in the analysis; one of which investigates the development of RE in OECD countries and the other focuses on 40 countries which are obtained by adding 6 developing countries to OECD. Using these country groups, five empirical models are estimated with various explanatory variables for the period 2000-2009.

Our findings robustly suggest that environmental concerns do not stimulate the more RE. In all of our models as the CO_2 emissions increase, the use of RE resources decreases. Putting it differently, the more intense the economic activity and pollution are; the lower the inclination to invest in RE and the higher alienation to environmental issues.

The results of regressions show that income positively effects RE use supporting the income effect theory. Countries with larger GDP per capita have higher demand, and more production, which means that there is an increasing need for energy. This increase leads countries to search for alternative energy sources and thus larger GDP per capita raises the use of RE sources. Also, it is worth to mention that high income countries seem to attach more importance to environmental concerns and deployment of RE since they can allocate resources to RE technologies,promote more policies and also could cope with the high capital costs.

Furthermore, one of the crucial results of this study is the negative impact of the share of fossil and nuclear sources in electricity production which is in line with the findings of previous literature. As the contribution of traditional fossil sources and nuclear sources to the energy generation increases, the development of RE slows down which can also be seen as the lobbying effect. As the policy makers who want to take important steps towards economic growth are generally more concerned with short term results of their policies, they maintain the path dependence by choosing the energy sources with lowest costs. Also nuclear energy may require similar financial funds and subsidies as the RE do, which will result in an obvious substitution effect to the detriment of RE.

An unexpected empirical finding of this study is that larger energy imports motivate less RE use. The strong commitment to traditional fossil sources along with high energy import dependency levels seem to discourage the deployment of renewable energy and necessitate more intense efforts to deploy the use of RE resources.

Total natural resources rents which is used as an explanatory variable for the first time by this paper, have negative effects on deployment of RE according to our empirical results. Higher levels of total natural resources rents in a country show self-sufficiency and a lack of quest for alternative sources. So as these rents increase, the deployment of renewable energy decelerates.

From the results of the model with OECD countries, we find that energy prices (Consumer Price Index of Energy) are insignificant for the promotion of RE use. The failure of substitution effect may stem from high initial capital costs of RE that the increase in prices of energy do not reach sufficient levels that would trigger the use of RE and contribute to competitiveness of it. Thus, we conclude that an increase in energy prices offers profit for the owners of traditional fossil sources while it does not encourage switching to RE resources.

Moreover, our results provide evidence on positive effect of market deployment policies in promotion of renewable energy. Market deployment policies are most widely used policies among 40 countries we examine and they support the market by introducing new technologies and accelerate the development of the industry. So they can be seen as one of the main drivers of renewable energy that commercialize the RE technologies and catalyze the use of RE. On the other hand, our findings show that research and development policies affect RE use negatively which is a counter initiative finding. Research and innovation policies are implemented to support new technologies which do not immediately give rise to high volumes of production. For this reason, these policies act as a substitute for market deployment policies and seem to have negative effects on the current RE use. Fruits of these types of policies will have an impact in the long-run. Therefore, consequences of research and innovation policies should be examined in a dynamic analysis, so that commercialization of RE technologies in the long run can be captured.

Our empirical findings suggest that market based enerfy policies have insignificant effects on RE. Although market based energy policies provide a competitive market framework by internalizing the externalities; they are the least used policies (only 200 out of 4423 policies are market based energy policies). Considering the fact that the implementation of this policy has not gained acceptance among countries, we can conclude that they have not reached a significant level that would affect RE share.

Our empirical results of the OECD model and extended model do not show considerable differences. This means that emerging market economies do not change the characteristics of the drivers of renewable energy and produce a difference in terms of the impact of policies. However, the results for EU countries are different.According to our empirical findings, market deployment policies in the EU are four times more effective than other countries. The European Union is one of the leading authorities that prioritize climate change, take international precautions and obliges its members to reduce greenhouse gases. Thus, the members of the European Union have stable environments in terms of RE policies i.e. the RE investors may face with a consistent policy support which is necessary for sustaining investments. We can conclude that implementation of RE policies on its own is not sufficient to trigger RE use; creating political continuity and stability is also crucial for the deployment of RE.

Another important result of this study is that the number of renewable energy policies (market deployment policies) per sq. km of land area affects RE use positively. In other words, policies have higher impacts on RE share in smaller countries in terms of land area. A larger country has to expend more energy on policies in order to reach high levels of RE supply. Therefore, our initial claim is verified with our findings: Having a large geographical area makes the implementation of technologies and policies harder throughout the country and it should not be taken as a proxy for production potential of renewables as very commonly done in the literature.

Based on the findings of this study, it can be stated that income and market deployment policies are the main drivers of renewable energy development. Also creating a stable political environment for RE investors and constituting international environmental cooperation are of vital importance for extending the use of RE resources. Additionally, our results indicate that in the countries with large land areas and rich natural resources it is more challenging to develop RE policies in order to obtain satisfactory results. Policy makers should be aware of the fact that they will have to struggle with lobbying effect of traditional fossil fuels and nuclear resources, habits and commitments coming from high levels of CO_2 emissions and import dependency if they desire to build up an environment friendly and sustainable energy system.

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