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Investments in Renewable Energy Sources in OPEC Members: a Dynamic Panel Approach

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Abstract

In this paper we analyze the key factors promoting the investments in renewable energy sources in a panel dataset of Petroleum Exporting Countries (OPEC) members. To address these issues, a dynamic panel analysis of renewable investments in the sample of OPEC with distinct economic and social structures, in the years between 1980 and 2009, is proposed. Results confirm that key factors promoting investments in renewable energy sources are similar to other studies which include more developed countries. However, lack of grants and/or incentives to promote the installations of new renewable power plants is a limit for the future and sustainable development of these countries.

1 Introduction

Renewable Energy Sources (RES) are becoming increasingly important in the energy mix of countries, because of their ability to limit the environmental impact of energy production and counter the gradual appreciation of the raw materials used in the process of traditional generation based on gas and / or oil power plants.

The centrality represented by investments in renewable sources is confirmed by the attention by the international scientific community in recent years. Sadorsky (2009) studied the relationship between renewable energy sources (wind, solar and geothermal power, wood and wastes) and economic growth in a panel framework of 18 emerging economies for the period 1994-2003 and found that increases in real GDP had a positive and statistically significant effect on renewable energy consumption per capita. Wolde-Rufael (2012) analyzes the causal nexus between

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nuclear consumption and GDP. Yuksel (2010) and Baris and Kucukali (2012) analyze RES deployment in Turkey and find that, thanks to the potential for renewable use, Turkey is working towards a clean and sustainable energy development. Menz and Vachon (2006) and Carley (2009) study the renewable investments in the USA, the former with a regression into countries and the latter using a panel regression. Marques et al. (2010) analyze the drivers promoting renewable energy in European countries and finds that lobbies of traditional energy source and CO_2 emission restrain renewable deployment. Evidently, the need for economic growth suggests an investment that supports, but does not replace, the before installed capacity. Romano and Scandurra (forthcoming-a) investigate the drivers of investments in Renewable sources in panel of OECD countries and including some development countries and the divergences in countries that produce electricity using or not using nuclear power plants while the same authors (forthcoming-b), in a forthcoming paper, explore the drivers promoting the investments in renewable energy sources and the divergences on the basis of development stage of the countries employing a large sample of 60 countries split into 3 different sub-samples, following the classification proposed by World Bank (low income and lower middle income; upper middle income; high income). Gan and Smith (2011) identify key factors that may have driven the differences in the shares of renewable energy in total primary energy supply among OECD countries for renewable energy in general and bioenergy in particular. Masini and Menichetti (2012) propose and test a conceptual model in order to analyze factors affecting the investor decisions and the relationship between the investments in RES and the portfolio performances.

The need to meet the demand for energy and environmental sensitivity leads policy makers to plan further investments in generation plants based on renewable sources. However, despite the exponential growth in the production of energy from renewable sources in recent years, yet most of the energy demand is met through the use of fossil fuels (IEA, 2012).

Currently there is great interest in development of RES due to the prospect of the all available of reserves of fossil fuel getting depleted and the environment pollution caused by burning of fossil fuel. However there are some disadvantages of using renewable energy. These are described below.

- Availability of fuel obtained from plants that can be used as economical energy practically is limited. Though lot of research and development activities is going on around to world to develop plants that could provide suitable fuels economically and in sufficient quantities.
- The total potential of renewable energy sources as wind power and tidal power is limited and/or intermittent.
- The current capital cost for equipment to convert renewable energy such as solar, wind and tide is very high.

- Plant for generating power from wind, and tides can be located only in places where suitable conditions of tide or wind exist.
- The plant for generating energy from sun light, wind and solar energy have to be spread around large areas.
- Solar power is dependent on availability of sunlight. Thus the availability of power fluctuates from zero to maximum every day.
- There have been some allegations that large scale use of wind power can interfere pattern of wind flow and disturb the set weather pattern. Use of hydro power is already known change the pattern of silting in rivers.

With this in mind, we analyze the drivers of investment in renewable energy sources in Petroleum Exporting Countries (OPEC). OPEC is a permanent, intergovernmental Organization, created on 1960 by Iran, Iraq, Kuwait, Saudi Arabia and Venezuela. The organization now has 12 members having since been joined by Algeria, Angola, Ecuador, Libya, Nigeria, Qatar and the United Arab Emirates. The objective is to co-ordinate and unifies petroleum policies among Member Countries in order to secure fair and stable prices for petroleum producers; an efficient, economic and regular supply of petroleum consuming nations; and a fair return on capital to those investing industry.

In this paper we analyze the determinants of investments in renewable sources (hydroelectric and other renewable sources) and the divergences in the composition of the energy mix of countries. In practice, we test the impact of key factors in renewables, highlighting the progressive adaptation to the changing energy needs. This paper addresses these issues by means of a dynamic panel analysis of the renewable investment in a sample of OPEC countries with distinct economic and social structures as well as different levels of economic development. The data are the annual time series from 1980 to 2009.

In the model proposed we include the main policy, environmental, socio – economic and generation factors. We use a dynamic specification of the equation that takes into account past investments in renewable energy sources. A widely used methodology for dynamic panel modeling applies Generalized Method of Moments (GMM) estimators proposed by Arellano and Bond (1991). In particular, we try to understand if RES significantly contribute to climate change and if OPEC characterized by a large availability of fossil fuel invests in RES.

The organization of the paper is as follows: Section 2 describes data; Section 3 we briefly explain the method proposed. Section 4 reports the model, the empirical results and discusses the policy implications. Section 5 concludes.

2 Data

The data used in this paper are from U.S. Energy Information Administration (EIA) and International Energy Agency (IEA) databases.
Following the literature (e.g. Carley, 2009; Marques and Fuinhas, 2011), the explanatory variables try to capture main socioeconomic, political and environmental factors from which investment decisions originate.
For the environmental factors we consider the per capita Carbon Dioxide Emissions (CO_2) from the Consumption of Energy. CO_2 emission is one of the main factors of the greenhouse gas (GHG) effects and it could be considered as a proxy of environmental degradation and not the only responsible. The expected results are estimates with a significant positive effect. The presence of a negative effect emphasizes the persistence of an economy tied to fossil fuels, which are still unable to replace the traditional energy sources. The last class of factors (Socioeconomic) includes per capita GDP, per capita Consumption of Energy and a proxy for the energy security of supply. The GDP is directly related to energy consumption (Sadorsky, 2009). The per capita Consumption of Electricity is considered a proxy for economic development of the country (e.g. Toklu, 2011) but it also represents the evolution of energy demand. The need to meet the energy demand can lead to the creation of new power plants based on RES, increasing investment. However, if the increasing demand is met through traditional power plants based on fossil fuel, then the effect on investment will be negative. A similar argument applies to energy security, approximated by the degree of dependence on foreign supplies of electricity. The need to increase their share of production (reducing the energy bill) and to reduce dependence could increase investment in RES. Considering the main production of the countries, we include also the annual oil extraction. The expected result is an estimate with a significant positive effect. The increasing in oil extraction can suggest to countries to increase the investment in RES.
Various forms of incentives are currently adopted and many of those directly affected by the wealth of countries, of which we have detailed information[3]. However, there is a lack of information about the availability of grant to promote the renewable in the OPEC countries. In particular, seems that these countries, at the best of our knowledge, do not provide any incentives for renewable investments. For this reason we do not include a policy variable. In order to reduce variability, GDP, EI, electricity consumption, oil supply and CO_2 are expressed through natural logarithm.
The analysis of data on generation sources (see Table 1) in the dataset considered (OPEC) highlight different patterns in the countries:

- Some countries do not have generation based on RES (Kuwait; Libya; Qatar, Saudi Arabia).
- Angola, Ecuador and Venezuela, generate most of their electricity from RES.

[3] For example, the European Commission with the Directive 2001/77/EC aim to promote the electricity produced from renewable energy sources.

- Iran and Nigeria generate an appreciable share of electricity from RES.

The United Arab Emirates have a small share of generation from RES, since 2009, when the first solar power plants were put into operation.
In the entire sample we observe, however, that the generation from RES is obtained almost entirely from hydroelectric plants.
Given the great availability of fossil fuels for the production of electrical energy, these countries have little considered the possibility of generation sources based on renewable.
Considering the generation share from RES in the countries included in our dataset, we reduce its sectional dimension, analyzing only countries that generate electricity from RES. In addition, Iraq has not been included due to missing data in the GDP series. The countries we have included in the final sample are: Algeria, Angola, Ecuador, Iran, Nigeria and Venezuela.

Table 1: Mean Electricity generation by sources and countries (1980 – 2009).

Countries	Share of total renewable power generation (%)	Share of renewable – not based on hydroelectric power plants (%)	Share of thermal power generation (%)
Algeria	1.88	0	98.22
Angola	65.60	0	34.40
Ecuador	64.70	0.54	35.30
Iran	11.86	0.01	88.14
Iraq	5.00	0	95.00
Kuwait	0	0	1
Libya	0	0	1
Nigeria	34.56	0	65.44
Qatar	0	0	1
Saudi Arabia	0	0	1
United Arab Emirates	0.99	0.01	99.00
Venezuela	64.39	0	35.61

Different ways to evaluate the development of RES are proposed in literature. Bird et al. (2005) measure the total amount of renewable energy produced while Marques et al. (2010) use the contribution of renewable to energy supply. Following Romano and Scandurra (forthcoming-a) we explain the investment in RES (ShRen) as the ratio between Renewable Generation and Total Net Electricity Generation. The share of Renewable Electricity Net Generation can be considered a proxy of investments in RES.

3 Method

Dynamic panel data (DPD) models contain one or more lagged dependent variables, allowing for the modeling of a partial adjustment mechanism, i.e.:

$$y_{i,t} = \delta y_{i,t-1} + \mathbf{x}'_{\mathbf{it}}\beta + u_{i,t} \qquad (3.1)$$

where for country *i* (*i=1,…,N*) at time *t* (*t=1,…,T*), δ is a scalar, $y_{i,t}$ is the outcome variable, $y_{i,t-1}$ is the lagged dependent variable, $\mathbf{x}'_{\mathbf{it}}$ is the vector of independent variables while the error term

$$u_{i,t} = \alpha_i + \tau_{i,t} \qquad (3.2)$$

follows a one - way error component model where α_i denote a country – specific effect, $\tau_{i,t}$ denotes a observation – specific effect and $\alpha_i \sim IID(0, \sigma^2_\alpha)$ and $\tau_{i,t} \sim IID(0, \sigma^2_\tau)$.

The dynamic panel data regression described in (3.1) and (3.2) is characterized by two sources of persistence over time: autocorrelation due to the presence of a lagged dependent variable among the regressors and individual effects characterizing the heterogeneity among the individuals.

Several econometric problems may arise from estimating the parameters in eq. (3.1) (cf. Hsiao, 2003): *i*) the variables in x_{it} are assumed to be endogenous; *ii*) time-invariant country characteristics (fixed effects) may be correlated with the explanatory variables; *iii*) the presence of the lagged dependent variable $y_{i,t-1}$ gives rise to autocorrelation. With these assumptions, the estimations with fixed effects (OLS) or random effects (GLS) would not be appropriate since the obtained estimates would be biased.

Since $y_{i,t}$ is a function of α_i, it immediately follows that $y_{i,t-1}$ is also a function of α_i. Therefore, $y_{i,t-1}$, a right-hand regressor in (3.1), is correlated with the error term. This renders the OLS estimator biased and inconsistent even if $\tau_{i,t}$ are not serially correlated.

One way to solve this problem is to estimate a dynamic panel data model based on the Generalized Method of Moments (GMM) estimator proposed by Arellano and Bond (1991). The GMM procedure is more efficient than the Anderson and Hsiao (1982) estimator, while Ahn and Schmidt (1995) derived additional nonlinear moment restrictions not exploited by the Arellano and Bond (1991) GMM estimator. Arellano and Bond argue that the Anderson–Hsiao estimator, while consistent, fails to take all of the potential orthogonality conditions into account. A key aspect of the method proposed by Arellano and Bond is the assumption that the necessary instruments are ‘internal’: that is, based on lagged values of the instrumented variable(s) (Baltagi, 2005). The estimators allow the inclusion of external instruments as well. For instance, let us consider a simple autoregressive model with no regressors:

$$y_{i,t} = \delta y_{i,t-1} + u_{i,t} \tag{3.3}$$

where $u_{i,t} = \alpha_i + \tau_{i,t}$ with $\alpha_i \sim IID(0, \sigma^2_\alpha)$ and $\tau_{i,t} \sim IID(0, \sigma^2_\tau)$, independent of each other and among themselves.
In order to get a consistent estimate of δ as $N \rightarrow \infty$ with T fixed, we first difference (3.3) to eliminate the individual effects

$$\begin{aligned} \Delta y_{i,t} &= y_{i,t} - y_{i,t-1} = \delta(y_{i,t-1} - y_{i,t-2}) + (\tau_{i,t} - \tau_{i,t-1}) = \\ &= \delta \Delta y_{i,t-1} + \Delta\tau_{i,t} \qquad t = 3, \ldots, T \end{aligned} \tag{3.4}$$

and note that $(\tau_{i,t} - \tau_{i,t-1})$ is MA(1) with unit root.
Equation (3.4) is equivalent to a system of simultaneous equations with (T-2) equations with N observations, or:

$$\begin{cases} \Delta y_{i3} = \delta \Delta y_{i2} + \Delta\tau_{i3} & instruments: y_{i1} \\ \Delta y_{i4} = \delta \Delta y_{i3} + \Delta\tau_{i4} & instruments: y_{i1}; y_{i2} \\ \quad \vdots & \\ \Delta y_{i,T} = \delta \Delta y_{,iT-1} + \Delta\tau_{i,T} & instruments: y_{i1}; y_{i2}; \ldots; y_{i,T-2} \end{cases}$$

where the instruments are uncorrelated with the error terms.
The variance\covariance of the error term can be expressed in the following matrix:

$$V = E(\Delta\tau_i \Delta\tau_i') = \sigma_\tau^2 \begin{bmatrix} 2 & -1 & 0 & \ldots & 0 & 0 & 0 \\ -1 & 2 & -1 & \ldots & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & \ldots & -1 & 2 & -1 \\ 0 & 0 & 0 & \ldots & 0 & -1 & 2 \end{bmatrix}$$

is *(T-2)×(T-2)*, since $(\tau_{i,t} - \tau_{i,t-1})$ is MA(1) with unit root. Define the $(T-2) \times C$ matrix,

$$Z_i = \begin{bmatrix} y_{i1} & 0 & 0 & 0 & 0 & 0 & \dots & 0 & 0 & \cdots & 0 \\ 0 & y_{i1} & y_{i2} & 0 & 0 & 0 & \dots & 0 & 0 & \cdots & 0 \\ 0 & 0 & 0 & y_{i1} & y_{i2} & y_{i3} & \dots & 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & 0 & 0 & 0 & \dots & y_{i1} & y_{i2} & \dots & y_{iT-2} \end{bmatrix},$$

where $C = \sum_{j=1}^{T-2} j$ and lines contain the instruments.

Then, the $N(T-2) \times C$ matrix of instruments is $Z = [Z_1', \dots, Z_N']'$ and the moment equations described above are given by $E(Z_i \Delta\tau_{i3}) = 0$. Premultiplying the differenced equation (3.4) in vector form by Z', one gets

$$Z'\Delta y = Z'(\Delta y_{-1})\delta + Z'\Delta\tau \tag{3.5}$$

Performing GLS on (3.5) one gets the Arellano and Bond (1991) preliminary one-step consistent estimator:

$$\widehat{\delta_1} = [(\Delta y_{-1})'Z(Z'(I_n \otimes V)Z)^{-1}Z'(\Delta y_{-1})]^{-1}[(\Delta y_{-1})'Z(Z'(I_n \otimes V)Z)^{-1}Z'(\Delta y)] \tag{3.6}$$

One can gets the two-step Arellano and Bond (1991) GMM estimator by replacing the matrix of the second population moments with that of the corresponding second sample moments. For a more detailed discussion see e.g. Baltagi (2005).

4 Model and discussion

In this paper we employ a panel dataset including 6 OPEC countries from 1980 to 2009[4]. There are three main issues that can be solved using a panel dataset. In fact, a panel dataset allows us to have more degrees of freedom than with time-series or cross-sectional data, and to control for omitted variable bias and reduce the problem of multi-collinearity, hence improving the accuracy of parameter estimates (Hsiao, 2003), having more informative data. Furthermore, annual data avoids the seasonality problems. Since static regression models can suffer from a number of problems, including structural instability and spurious regression, we employ a

[4] Arellano and Bond's (1991) GMM estimator is consistent for large N (number of countries) with T fixed. In our empirical research, Initially, the current sample was broader and included all of the OPEC members. Considering that some of them do not have sources of generation based on renewable energy, or SHRen = 0 in he analysed years, we employ a subset of countries. The sectional component of the error remains in the variables and must thus refer to the wholeness of the sample. Furthermore, we tries to use only the most recent instruments (but also simple OLS estimation) but without sensible variations in the significance.

dynamic analysis that allows for slow adjustment. The dynamic model captures the "persistence effect" on investment in RES[5]. The assumed model is as follows:

$$\begin{aligned} ShRen_{i,t} &= c + (1+\gamma)ShRen_{i,t-1} + \sum_{k=0}^{K}\varphi_{1k}\Delta lnGDP_{i,t-k} \\ &\quad + \sum_{k=0}^{K}\varphi_{2k}\, lnOil_{i,t-k} + \sum_{k=0}^{K}\varphi_{3k}\, lnCO_{2;i,t-k} \\ &\quad + \sum_{k=0}^{K}\varphi_{4k}\, lnEI_{i,t-k} + \sum_{k=0}^{K}\varphi_{5k}\, lnConsumption_{i,t-k} + u_{i,t}, \end{aligned} \tag{4.1}$$

where for country i ($i = 1,\dots, N=6$) at time t ($t = 1,\dots, T=30$), $ShRen_{i,t}$ are the renewable investments, $\Delta \ln GDP_{i,t}$ is the first differences of natural logarithm of GDP per capita (growth of GDP per capita), $\ln EI_{i,t}$ is the natural logarithm of Energy intensity, $\ln Consumption_{i,t}$ is the natural logarithm of per capita electricity consumption, $\ln Oil_{i,t}$ is the natural logarithm of oil supply while u_{it} is the error component. We include also the natural logarithm of per capita carbon dioxide emission $lnCO_{2;i,t}$. It is considered predetermined, or:

$$E(u_{i,s}|CO_{2;i,t}) \neq 0 \text{ where } s < t.$$

In fact, variation in carbon dioxide emissions are uncorrelated with past (and potentially current) investments, but will be correlated with future investments. Here, $lnCO_2$ is predetermined but not strictly exogenous.

The consistency of the estimation depends on whether lagged values of the endogenous and exogenous variables are valid instruments in our regression[6]. Also, this methodology assumes that there is no second-order autocorrelation in the errors, therefore a test for the previous hypotheses is needed.

In this model we take into account the full electricity generation mix. In fact, the remaining part, not included in the model, is all ascribable to fossil fuel. We employ the robust one-step GMM estimator.

The consistency of the estimations is assessed applying a set of tests (Table 2). The Wald test fails to accept the null hypothesis that all the coefficients except the constant are zero. In order to obtain consistent GMM estimates the assumption of no serial correlation in the residual in levels is essential. The presence of first order autocorrelation in the difference residuals does not imply the estimates are inconsistent, but the presence of second order autocorrelation would imply that the

[5] In the growth of investments, persistence may reflect the existence of a long term relationship as conduits of knowledge helping countries to continuously upgrade and maintain their generation capacity.

[6] We estimate two version of the model, obtaining similar standard errors. In the former, we include all the instruments while in the latter we consider only the most recent.

estimates are inconsistent (Arellano and Bond, 1991- pp. 281-282). The test statistic satisfies the specification requirements. In eq. (4.1) we assume that there is a first order autocorrelation present for the observed responses. Moreover, we fail to reject the null hypothesis of no second order autocorrelation in all specifications. Having annual data, we also report AR(3) and AR(4) autocorrelation test. Both tests accept the null hypothesis[7].

Table 2: Parameter estimates and test statistics

Variable	Estimates
$ShRen_{(-1)}$	0.77***
$lnCO_2$	-0.1***
$lnCO_{2(-1)}$	0.10***
$\Delta lnGDP$	0.17***
lnEI	0.06***
lnConsumption	-0.06***
lnOil	-0.02***
Constant	-0.63***
Test Statistics	
Wald test	675.31***
1st order autocorrelation	-2.05**
2nd order autocorrelation	-0.79
3rd order autocorrelation	1.12
4th order autocorrelation	-0.61

Significance levels: ***: 1%; **: 5%

The estimation results for eq. (4.1) are in Table 2.

The result of the estimations shows that GDP, energy efficiency, per capita electricity consumption and oil supply are significant. Almost all coefficients also show the expected signs. Only the CO_2 emission, which is traditionally seen as directly linked to investments in renewable energy, and the electricity consumption have a negative sign. Furthermore, the share of renewable presents a significant and positive coefficient. Obviously, the investments made over the years are to increase the share of energy produced from renewable sources.

The GDP growth is significant in the sample, and it has a positive sign. This expected result, suggests the progressive increasing of the living condition of the population give to these countries the opportunity to increase the investments in RES.

[7] Sargan test for the validity of the instruments is not reported in Table 2 because we employ a one-step GMM robust estimator. Arellano and Bond (1991) recommend using the one step results for inference on the coefficients and using two – step Sargan test for inference on model specification. In our model, two-step Sargan test supports the assumption that model is correctly specified (χ^2=129.56).

Evidently, GDP grew at a faster average rate than investments in renewable energy sources. This result is also encouraged by the consistency with energy efficiency.

The per capita electricity consumption depresses investment in RES. This result is unexpected. In fact, main idea suggest that need to meet the increasing electricity consumption is to invest in new power plants based on renewable sources. This is supported by the cost of raw materials for thermic power plants which in the recent years have increased. However, considering the nature of the countries, we observe that the dynamics of production and the energy demand has led the system to find an equilibrium using more traditional sources and with a little attention to energy efficiency. The high availability of fossil fuel suggests to satisfy the increasing consumption with thermic power plants.

The CO_2 emissions are significant and show a negative sign in level and a positive sign at lag 1. The combined effect is still negative (-0.015). An increasing in carbon emissions depresses the investments in RES. This is partly unexpected even if this phenomenon has been repeatedly highlighted in the literature (e.g. Marques et al, 2010; Romano and Scandurra, forthcoming-a), especially when rich countries are analyzed. It portends an energy production system more advanced but still tied to traditional sources that compress the dynamics of development of RES. We remember, however, that these countries have no CO_2 emission targets.

The coefficient for the oil supply is also significant and presents a positive sign. Increasing in oil extraction encourages the investment in renewable energy, and the positive effect prevails.

The amount of energy required for the production of a unit of GDP is in line with the expected results. This result confirms that the technological progress increase the investment in RES. Energy efficiency offers a powerful and cost-effective tool for achieving a sustainable energy future. Improvements in energy efficiency can reduce the need for investment in energy infrastructure, cut fuel costs, increase competitiveness and improve consumer welfare. Environmental benefits can also be achieved by the reduction of GHG emissions.

There are many similarities among the key factors in investments in OPEC countries and other countries. Comparing the results with other studies we observe that the decisions depend by the diversification of the energy mix.

The environmental aspect is primary aspect and the estimates have revealed as CO_2 emissions depress investments. This aspect is robust with most of the literature, where the effect is often negative because of the mix of generation based mainly on fossil fuels (e.g. Marques et al, 2010; Romano and Scandurra, forthcoming-a). The breakdown by source of generation allows, however, assessing the impact of emissions on investment and ensuring that it depends directly from the sources themselves.

Stable with the literature (e.g. Romano and Scandurra, forthcoming-a) is the sign of the GDP. Basic idea is that larger income allows countries to handle the costs of developing the RES. The positive effect of income in the investments in RES, yet verified by Menz and Vachon (2006) and Marques et al. (2010) is confirmed also for OPEC.

5 Summary and conclusions

This paper analyzes the driving of investment in RES in a sample of OPEC members. In the model proposed we include environmental and socio – economic determinants identified by literature (Carley, 2009; Marques et al, 2010; Romano and Scandurra, forthcoming-a), through a dynamic panel regression that takes into account past investments in renewable energy sources.

Results suggest that these countries invest in renewable sources but their use is conditioned by the orography of territory. In general, these countries have invested in RES only in the recent years and, at this moment, their use is limited and the investments are not relevant. Furthermore, there are not policies promoted by Government in order to stimulate the investments in RES and this could be a point that depresses their use. As previously demonstrated, policies to support investment in renewable energy sources have positive and significant coefficients and promote the growth in generation capacity. In fact, renewable power generation policies remain the most common type of support policy. The Feed-in-tariffs (FITs) and/or renewable portfolio standards (RPS) are the most commonly used policies in this sector and many countries adopt this policies in order to promote the investments in RES. Probably, OPEC members have to adopt some grants to ensure a rapid development of generation based on renewable power plant. Lack of policy grants and/or incentives in order to promote the investments in RES is a criticism for the future. It does not stimulate the renewable power generation and could be a limit for a sustainable future.

There has been little linking of energy efficiency and renewable energy in the policy arena to date, but countries are beginning to wake up to the importance of tapping their potential synergies. We think that enhanced scientific and engineering knowledge should lead to performance improvements and cost reductions in RE technologies. Knowledge about RE and its climate change mitigation potential continues to advance. The existing scientific knowledge is significant and can facilitate the decision-making process. Under most conditions, increasing the share of renewable sources in the energy mix will require policies to stimulate changes in the energy system.

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Appendix

All of the data analyses were done using *xtabond* procedure implemented in Stata ver. 11. Data employed are freely available from U.S. Energy Information Administration (http://www.eia.gov) and International Energy Agency (http://www.iea.org).