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Kahia, Montassar and kadria, Mohamed and Ben Aissa, Mohamed Safouane

LAREQUAD FSEGT, University of Tunis El Manar, Tunisia,
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7 June 2014

Do renewable energy policies promote economic growth? A non-parametric approach

Montassar Kahia[a], Mohamed Kadria[a], Mohamed Safouane Ben Aïssa[a,1]

[a]LAREQUAD & FSEGT, University of Tunis El Manar, Tunisia.

Abstract:

This paper investigates the effects of renewable energy (RE) policies on economic growth in MENA countries. Using the propensity score matching methodology, our empirical analysis, conducted on a sample of 24 economies (17 RE and 7 non-RE countries) from 1980 to 2012, shows that the treatment effect of RE policies has a significant and positive impact on stimulating and promoting economic growth in MENA economies that have implemented these energy policies. RE policies alone, however, are not sufficient. This change requires the collective long-term commitment of all stakeholders, including governments, citizens, financiers, private companies and international agencies. This would help impede policy overlaps and incoherence as well as consequently improve the overall policy effectiveness.

Keywords: Renewable energy policies; economic growth; treatment effect evaluation; propensity score matching; MENA countries.

JEL Classification: C21, C52, O44, Q2

[1] E-mail addresses: kahia.montassar2013@gmail.com (M. Kahia);
mohamed.kadria@gmail.com (M. Kadria);
safouane.benaissa@univmed.fr (M.S.Ben Aïssa).

1. Introduction

Burgeoning populations, with improved living standards, have considerably raised the global demand for energy services which is anticipated to be about 33% higher in the year 2035 compared to 2010 (IEA,2011). According to IEA (2010), the world's population grew from 4 billion to 7 billion people and electricity generation grew by more than 250% over the past 40 years. Simultaneously, a growing consensus over the dangers posed by climate change has incited people and governments worldwide to seek ways to generate that energy while minimizing greenhouse gas emissions and other environmental impacts. Hence, renewables give a convinced answer not only to climate change, but also to many of the most pressing socio-economic challenges faced by governments nowadays (REN, 2012). Considerably, renewables offer a potentially significant supplement to energy supply, the perspective of abundant low-cost electricity, with lower levels of price volatility, less reliance on insecure trade flows, as well as opportunities for economic and social development, industrial diversification, electricity exports, better environmental and carbon footprints, increasing energy access, improving energy security, new value chain activities and an unprecedented opportunity to reduce their dependence on imports from regions experiencing political and economic uncertainty (REN, 2012; IPCC,2011). Dwelling to more than half of the world's crude oil and more than a third of its natural gas reserves, the Middle East and North Africa (MENA) region has, for the past fifty years, gained enormous significance as a worldwide producer and exporter of energy (BP, 2013). Similar to other countries, MENA countries must by some means react to the fundamental global energy and environmental challenges of our time, namely the massive increase in global energy demand and climate change to which the use of non-renewable energy is considerably contributing. The region's energy demand is anticipated to keep on rising over the world average, by around 3% per year from 2010 to 2030, and electricity demand is forecast to rise by 6% per year over the same period[2]. This involves considerable increases in the need for power-generating capacity and the energy resources to match. As a consequence, the MENA region became a speedily emergent energy consumer (IEA, 2012). Since 2000, annual primary energy consumption in MENA has increasing on average by 5.2% (BP, 2012). MENA Renewable energy sources represent

[2] Al Masah Capital Limited, 2010, p.8.

promising responses to energy mix diversification and energy security as well as economic growth enhancement of all countries whilst responding to their sustainability ambition. However, the enormous potential for renewables in the region remains unexploited, seeing that only 1% of the MENA region's primary energy mix is supplied with energy from renewable sources (Jalilvand, 2012). Given that the MENA countries hold the world's largest fossil fuel reserves, this might appear evident. Concurrently, however, the MENA countries also have the greatest potential for renewable energy in the world. Nevertheless, notwithstanding their several environmental, economic and social advantages, the investment in renewable energy projects still faces major constraints in MENA countries. In reality, the typical high production, resulting from principally new or novel technologies, lead to soaring costs. These costs are borne by the MENA governments which typically sustain the energy market in the MENA region by subsidizing energy prices (fuel oil and electricity) for end-users. As a consequence, it creates barriers for investors, ranging from market failure to domestic policy frameworks that keep on favouring fossil fuels. Wholly, interviews with private sector actors revealed three main consistent barriers to private investment in renewable energy in the MENA area[3]: the lack of profitability of renewable energy projects with insufficient positive cash flow to recover the investment costs of installation; high investment costs due to the long installation life of renewable energy projects; and, therefore, difficulties for investors in accessing finance (OECD, 2013). To avoid the high number of failure and bankruptcies, Incentives applied to renewable energy projects aim at overcoming the barrier mentioned before of the high risks of such projects. The main support mechanisms for increasing renewable energy in the MENA region are divided into: financial incentives including feed-in tariffs, power purchase agreements, capital subsidies (grants, investment tax credits and training incentives); regulatory incentives such as net metering; market-based incentives including tradable clean development mechanisms (CDMs) and competitive bidding processes; and fiscal incentives including various reductions in taxes(OECD, 2013). Additionally, these support mechanisms mentioned above can contribute to economic growth by ensuring that the resulting energy mix is delivered efficiently, at least cost, sustainably, and securely (REN, 2013). Consequently, a failure in any of these policies will considerably create future economic and social costs that would certainly harm well-being, and so avoiding such failures can widely foster economic growth and improve social well-being. The majority

[3] These were identified in an Energy Task Force work meeting and detailed during one-to-one interviews with private sector actors (OECD, 2013).

of studies on the effectiveness of various renewable energy policies have attempted to examine, through exploratory analyses, case studies and econometric methods, the impacts of renewable energy policies on the development and the deploying of its target sector (i.e., Menanteau et al., 2003; Huber et al., 2004; Wiser et al., 2005; Menz and Vachon, 2006; Held et al., 2006; Ragwitz et al., 2007; Carley, 2009; Lund, 2009; Yin and Powers, 2010 ; Sarzynski et al., 2012; Aslani et al., 2013; Lean and Smyth, 2013; Zhao et al., 2013; Wang et al., 2014).Generally, they find evidence that renewable electricity policies play a crucial role in promoting renewable energy sector. Against this background, researchers have recently started to scrutinize the effectiveness of renewable energy policies on social welfare and economic growth. For instance, Chien and Hu (2007) confirm that increasing the use of different renewable energy categories can significantly improve an economy's technical efficiency and hence bring higher economic growth and promotional renewable energy policies are necessary to enhance renewables utilization. Additionally, Sadorsky (2009) find that renewable energy consumption, which is one of the basic indicators of economic development (Halicioglu,2009), is much more sensitive to price change than electricity demand and in the case of falling electricity prices since a drop in electricity prices spurs renewable energy consumption, which is in favor of consumer. This paper aims to contribute to this literature using a panel dataset of MENA countries so as to inspect the effectiveness of renewable energy policies on economic growth. The present study is different from the literature identified above. In fact, empirical analysis on the effectiveness of renewable energy policies on economic growth remains scarce; the few investigations mainly focus on case studies rather than econometric approach. In this paper, we empirically investigate and quantify, using a non parametric approach, whether renewable energy policies impact economic growth. To the best of our knowledge, it is the first time that such an approach is taken for this category of an analysis.

The remainder of the paper is organized as follows. The second section presents an overview of the related literature. Section 3 describes the used data and methodology. Section 4 discusses our econometric results. Section 5 concludes by highlighting the main policy implications of our empirical findings.

2. Literature review

There is much debate about the effectiveness of policies mainly designed to increase the share of renewable energy in the energy mix through exploratory analyses, case studies and econometric methods. A central component of this debate is whether it is feasible to rise the generation of renewable energy for electricity and how best to do this. Chendo (1997) points out that the main factors mitigating against the development, diffusion and rational use of PV in Nigeria are technological, institutional, socio-cultural, educational and the attitude of scientists and economists. Additionally, the widespread adoption development and diffusion of PV in the country will depend on how urgently the issues raised above are tackled, especially technology acquisition, which is weak and sketchy because of the lack of critical mass and infrastructure, and degree of political will and commitment. Bolinger et al. (2001) depict in detail 14 different state Clean Energy Funds, specifing the regulatory background, funding approaches, the current status of the fund, and the resulting impacts on renewable energy. Hence, programs that fund utility-scale projects are found to be the most effective at increasing renewable capacity deployment. Menanteau et al. (2003) study the efficiency of the different incentive schemes for the development of renewable energy sources, both from a theoretical point of view by comparing price-based approaches with quantity-based approaches, and from a practical point of view by looking at concrete examples of how these different instruments have been implemented. They firstly conclude that a system of feed-in tariffs is more efficient than a bidding system, but highlights the theoretical interest of green certificate trading which must be confirmed through practice, since the influence of market structures and rules on the performance of this type of approach. Secondly, feed-in tariffs enable manufacturers to invest more heavily in R&D and to strengthen their industrial base. Langniss and Wiser (2003) investigate the Texas renewables portfolio standard, including the achievements of the policy mechanism and the design characteristics that allowed the policy to be effective at increasing renewable energy capacity. They confirm that the clearly defined capacity requirements have been effective in increasing renewable capacity in Texas. Petersik (2004) presents a non-econometric analysis of the effectiveness of different types of renewable portfolio standards as of 2003 for the United States Energy Information Association (EIA). It proves that only renewable portfolio standards that mandate a certain level of capacity have had any significant impact on renewable capacity deployment. Additionally, Policies with renewable generation or sales requirements as well as voluntary policy programs were found to have no significant effect. Huber et al. (2004) present a brief summary of comprehensive effects of different design elements of renewable energy policy instruments. Their main conclusions are that the careful design of strategies is by far the most important aspect and that the promotion of newly installed plants rather than already existing plant is essential for a successful strategy. Additionally, they argue that so far well-designed FITs were more effective and cost-efficient than other promotion schemes. Van der Linden et al. (2005) discuss the success of renewable energy obligation support mechanisms in Europe and the U.S. Their main conclusion is that "a [TGC-based] obligation is effective and cost effective in theory. However, it seems too early to conclude that the system delivers these promises in practice". Wiser et al. (2005) extend Langniss and Wiser (2003) by assuming all renewable portfolio standards(RPS), find pitfalls in current policy designs, and state that a carefully designed RPS requirement policy for promoting in-state deployment of renewable source would have the features as follows: first, a well-designed RPS should perfectly apply equally and fairly to all load-serving entities in a state; second, it should require that it must be filled with generation from new investments in renewable resources; third, it should limit the amount of sales requirements fulfilled by sources external to the state; finally, it should have credible and significant penalties in case of non-compliance. Dinica (2006) examines an investor-oriented perspective to analyze the diffusion potential of support systems for renewable energy Technology. Her main argument is that it is not the type of support instrument but rather its risk or profitability characteristics that influence investor behavior and the diffusion rate. The two instruments mainly discussed and compared are the feed in-tariff and the quota model. Her analysis concludes that policy design is essential: while often feed-in tariffs are applauded and quota system feared, feed-in tariffs possibly will also bring about disappointing diffusion results when poorly designed while quota systems may be also conceived as attractive instruments for independent power producers. Briefly, she argues that a sound and secure investment climate which allows sufficient profitability combined with low investment risks is vital for a significant development of RE Sources. Mitchell et al. (2006) make comparison between the UK quota obligation system with the German FIT system regarding the correlation between risks for generators or investors and policy effectiveness. They conclude that low risks implicate high policy effectiveness and that the German FIT-system provides higher security for investors than the British Renewables Obligation. Menz and Vachon (2006) econometrically estimate the effects of state renewable energy policy on renewable energy capacity. They perform ordinary least squares to estimate state policy effects on wind power capacity and generation with a dataset for 39 states for 1998–2002. They found that renewables portfolio standard requirements and required green power option have a statistically significant effect on wind capacity deployment. Held et al. (2006) and Ragwitz et al. (2007) scrutinize the success of policy strategies for the promotion of electricity from renewable energy sources in the EU. They prove that instruments, which are effective for the promotion of RE sources, are frequently economically efficient as well. Besides, they conclude that "promotion strategies with low policy risks have lower profit requirements for investors and, hence, cause lower costs to society". Toke (2007) evaluates the effectiveness of the UK's Renewable Obligation (RO). He concludes that "there are problems with the British RO, and it certainly does not deliver renewable energy any more cheaply than a feed-in tariff." Haas et al. (2007) make comparison between different promotion schemes for renewable energy sources world-wide. Their major conclusion is that "promotional schemes that are properly designed within a stable framework and offer long-term investment continuity produce better results." Meyer (2007) scrutinizes the major lessons learned from wind energy policy in the EU: Lessons from Denmark, Sweden and Spain. His major conclusion is that "the lack or delayed development of such a supportive, stable environment explains the different patterns of wind development seen in Sweden and Spain" and points to the problems created by liberalized and short-sighted commercial energy markets even for wind energy pioneers like Denmark. Brown and Busche (2008) rank states based on the effectiveness of their renewable energy policies and review the best practices for state renewable energy policy design. They find a significant correlation of renewable portfolio standards with increased renewable energy generation in a state. Lund (2009) investigates, through case studies, the impacts of energy policies on industry growth in renewable energy. His results point out that there are increased industrial opportunities in renewable energy to be captured not only by large countries or through large public resources, but also smaller countries can gain success through clever policies and optimal managing of the commercialization process. Briefly, he shows that energy policies can considerably contribute to the expansion of domestic industrial activities in sustainable energy. Carley (2009) employs a variant of a standard fixed-effects model, referred to as fixed-effects vector decomposition, with state- level data for 1998–2006. His results point out that renewable portfolio standards (RPS) implementation is not a significant predictor of the percentage of renewable energy generation out of the total generation mix, yet for each additional year that a state has an RPS policy, they are found to augment the total amount of renewable energy generation. These results disclose a potentially significant limitation of RPS policies. Moreover, political institutions, natural resource endowments, deregulation, gross state product per capita, electricity use per person, electricity price, and the presence of regional RPS policies are also found to be considerably linked to renewable energy deployment. Delmas et al. (2010) show that mandatory disclosure programs have a positive and significant effect upon a firm's generated fuel mix: the existence of mandatory disclosure programs increases the amount of renewable sources provided by electric utilities, and decreases the amount of fossil fuel sources. This is consistent with the studies of Green Power Demand, undertaken by Zarnikau (2003) and Roe et al. (2001), who conclude that disclosure policies have a positive and significant impact on consumers' willingness to pay for green power. Yin and Powers (2010) investigate the impacts of renewable portfolio standards (RPS) on in-state renewable electricity development using panel data (for 1993–2006). The results prove that RPS policies have had a significant and positive effect on in-state renewable energy development. Wang (2010) reviews the main renewable energy policies regarding to China's wind power, including the Wind Power Concession Program, Renewable Energy Law, and a couple of additional laws and regulations. His analysis provides evidence that such policies have effectively reduced the cost of wind power installed capacity, stimulated the localization of wind power manufacture, and driven the company investment in wind power. Zhang et al. (2011) analyze the factors affecting photovoltaic (PV) system diffusion on all 47 prefectures of Japan during the period 1996–2006. They show that the regional government policy clearly facilitates to promote PV system adoption. They also found that installation costs have a significant negative effect on PV system adoption, whereas housing investment and environmental awareness among residents have a positive effect. Additionally, their findings suggest the importance of regional diffusion policies reflecting the environmental awareness of regional residents. Thiam (2011) aims to investigate price support for market penetration of renewable energy in developing nations through a decentralized supply process. He integrates the new decentralized energy support: renewable premium tariff, so as to scrutinize impacts of tariff incentives on the diffusion of renewable technology in Senegal. The results indicate that this support mechanism could strengthen the sustainable deployment of renewable energy in remote areas of Senegal. Haas et al. (2011) historically elaborate the implemented promotion strategies of renewable energy sources and the associated deployment using several cases studies of different European Member States within the European electricity market. Generally, they mainly conclude that it is important for a promotional system to place a strong focus on new capacities and not mix existing and new capacities. Additionally, they depict that the dissemination effectiveness of energy policy instruments depends significantly on the credibility of the system for potential investors. Thus, it must be guaranteed that the promotional strategy, regardless of which instrument is implemented, persists for a specified planning horizon. Otherwise the uncertainty for potential investors is too high and it is likely that no investments will take place at all. Delmas and Montes-Sancho(2011) focus on the effect of renewable energy policies such as Renewable Portfolio Standards and Mandatory Green Power Options on the building of energy infrastructure in US, which will be critical for the development of green power in the future. They conclude therefore that factors other than natural resources can predict successful renewable policies. These factors contain the social and political context in which the policy is implemented, the type of renewable policy, and the type of electric utility implementing it. Their findings point out that a high presence of Sierra Club membership, green residential customers, and democratic representatives facilitate successful policies. Shrimali and Kniefel (2011) perform a state fixed-effects model with state-specific time-trends by using a panel data over 50 US states and years 1991–2007 so as to estimate the effects of state policies on the penetration of various emerging renewable electricity sources, including wind, biomass, geothermal, and solar photovoltaic., their findings generally suggest the crucial role of policy in increasing the penetration of renewables. Zhao et al. (2011) analyze the regulatory framework for the renewable energy industry in China. Their results showed that there is a strong positive correlation between the promulgation of relevant policies such as financial subsidy, tax deduction and exemption, preferential feed-in tariff, as well as technological support and the increasing rate of renewable energy projects. They also prove that national laws, regulations, policies and strategic plans play a key role to moderate the structure, scale and development speed of renewable energy projects. Sarzynski et al. (2012) look at the effectiveness of state financial incentives in promoting the deployment of solar technologies: thermal and PV. Other than financial incentives, they also study the effect of RPS. They show that mere presence of policies is not effective in increasing the deployment of solar technologies; however, they do prove that policies become effective at increasing the deployment of solar technologies as states gain experience with implementing these policies. Dong (2012) proves that feed-in tariffs increase total wind energy production capacity above the renewable portfolio standards. Pfeiffer and Mulder (2013) study the diffusion of non-hydro renewable energy (NHRE) technologies for electricity generation across 108 developing countries between 1980 and 2010. They reveal that NHRE diffusion accelerates with the implementation of economic and regulatory instruments, higher per capita income and schooling levels, and stable democratic regimes. In contrast, increasing openness and aid, institutional and strategic policy support programs, growth of electricity consumption, and high fossil fuel production appear to delay NHRE diffusion. Additionally, they find that a diverse energy mix increases the probability of NHRE adoption. Aslani et al. (2013) studied, in the frame of a strategic conceptual analysis, the policies and achievements of the Nordic region in their development of renewable energy. Their study showed how the policies and decisions of RE promotion in the Nordic countries have provided a successful case to be followed by other developed and developing countries. They mainly concluded that it is impossible to attain successful implementation by a single dimensional approach. Consequently, a mix of policy is the key driver to increase the installed capacity and energy generation from RE technologies, reductions in cost and price, domestic manufacturing capacity and related jobs and public acceptance. Aslani and Wong (2013) demonstrate that the US is one of the richest countries in terms of renewable energy portfolio. Nevertheless, they principally conclude that commercial development of renewable energy systems in US is highly dependent to the utilization costs and government policies. Zhao et al. (2013) evaluate, via the Poisson pseudo-maximum likelihood estimation technique, the effects of renewable electricity policies on renewable electricity generation with a large panel dataset that covers 122 countries over the period of 1980–2010. Their results show that renewable electricity policies play a crucial role in promoting renewable electricity generation; however, their effectiveness is subject to diminishing returns as the number of policies increases. They also find that the effects of renewable electricity policies are more marked before 1996 as well as in developed and emerging market countries, and the negative policy interaction effect fades with the stage of economic development. Finally, they assert that policy effectiveness varies by the type of renewable electricity policy and energy source and only investment incentives and feed-in tariffs are found to be effective in promoting the development of all types of renewable energy sources for electricity. Lean and Smyth (2013) examine whether policies to promote renewable electricity generation are likely to be effective by applying panel unit root and stationarity tests to time series data on renewable electricity generation for 115 countries over the period 1980–2008. They wholly find for the panel that policies designed to have a permanent positive impact on renewable electricity generation that generate continuing annual shocks are likely to be successful, rather than policies which result in one-time shocks, such as investment incentives or tax credits. Wang et al. (2014) have mainly presented a review on promoting share of renewable energy by green-trading mechanisms in power system with a focus on promotion effects of three mechanisms: feed-in tariff, renewable portfolio standard and emission trading scheme. Their review suggests that feed-in tariff and renewable portfolio standard can effectively increase the share of renewable energy power and lead to renewable resource diversity. In addition, emission trading also provides stimulus for development of renewable energy besides mitigation of carbon emission. Against this background, researchers have recently started to scrutinize the effectiveness of renewable energy policies on social welfare and economic growth. Chien and Hu (2007) confirm that increasing the use of different renewable energy categories can significantly improve an economy's technical efficiency and hence bring higher economic growth and promotional renewable energy policies are necessary to enhance renewables utilization. Additionally, Sadorsky (2009) find that renewable energy consumption, which is one of the basic indicators of economic development (Halicioglu,2009), is much more sensitive to price change than electricity demand and in the case of falling electricity prices since a drop in electricity prices spurs renewable energy consumption, which is in favor of consumer. In a recent work, Sadeghi et al. (2014) deal with the impacts of Feed-In-Tariff (FIT) mechanism on the social welfare in an integrated renewable-conventional Generation expansion planning (GEP) framework, while consumers are considered for patronizing the financial burden of FIT. Their findings emphasize that implementation of FIT regime leads to social welfare improvement. Even more interesting, Ohler and Fetters (2014) investigate the causal relationship between economic growth and electricity generation from renewable sources (biomass, geothermal, hydroelectric, solar, waste, and wind) across 20 OECD countries over 1990 to 2008. Their results from a commonly used panel error correction model find a bidirectional relationship between aggregate renewable generation and real GDP. Additionally, biomass, hydroelectricity, waste, and wind energy show evidence of a positive long-run relationship with GDP. Furthermore, hydroelectricity and waste generation reveal a short-run positive bidirectional relationship with GDP growth, and biomass, hydroelectric, and waste electricity generation have the largest impact on real GDP in the long-run.

Our work intends to contribute to this literature mentioned above using a panel dataset of MENA countries so as to examine the effectiveness of renewable energy policies on economic growth. The present study is different from the literature identified above. In fact, empirical analysis on the effectiveness of renewable energy policies on economic growth remains scarce or untested; the few investigations mainly focus on case studies rather than econometric approach. In this paper, we empirically investigate and quantify, using a non parametric approach called Propensity Score Matching, whether renewable energy policy impact economic growth. There is a strong motivation for us to apply a non-parametric approach to analyzing the impact of renewable energy policies on economic growth. We were principally motivated by the fact that there are no studies till date that model the effectiveness of renewable energy policies on economic growth using a Propensity Score Matching approach.

3. Data and methodology

To investigate whether the adoption of renewable energy (hereafter RE) policy in MENA countries promote the economic growth, we implement the propensity score matching (hereafter PSM) methodology initiated by Rubin (1977) and developed by Rosenbaum and Rubin (1983) and Heckman et al. (1998). This method is becoming increasingly popular and widely used in micro-econometrics as well as in different areas such as health, education, etc. The PSM approach has nevertheless been recently employed in macroeconomic studies by, for e.g., Vega and Winkelried (2005), Lin and Ye (2007, 2009), Walsh (2009), De Mendonca and Guimaraes e Souza (2011), Kadria and Ben Aissa (2014).

Our panel dataset consists of twenty four MENA economies over the period of 1980-2012. The data are drawn from various sources, including in particular the World Development Indicators (WDI); Noting that the definitions/sources of all variables and the descriptive statistics are in the appendices.

3.1. Data

3.1.1. Sample

We start from a set of annual data, 17 are renewable energizers (hereafter REers) i.e. all MENA countries that have adopted the RE policy (treatment group) and 7 non-REers (control group), covering the 1980-2012 period. In addition, our control group was selected relying on the criteria defined by Lin and Ye (2009), based on the level of economic development and the size of the country[4]. Table 1 shows the sample of countries selected for this study, as well as the respective adoption(s') dates for the REers.

Table 1
List of the sample countries with dates of renewable energy adoption.

RE countries	Adoption's dates	Non-RE Countries

[4] Given these two criteria, the authors do not include in the control group that countries with a GDP/capita at least as high as the poorest targeting country and having a population at least as important as the least populated RE country.

Algeria	1999	Bahrain
Armania	2001	Georgia
Cyprus	2003	Iraq
Egypt	2008	Lebanon
Iran	2005	Mauritania
Israel	1980	Oman
Jordan	2005	Qatar
Kuwait	2009	
Libya	2007	
Malta	2000	
Morocco	2008	
Saudi Arabia	2008	
Syrian	2009	
Tunisia	1995	
Turkey	2001	
United Arab Emirates	2004	
Yemen	2010	

Source: International Energy Agency (IEA).

3.1.2. Variables

i. Treatment versus outcome variables

In our study, the treatment variable is the RE (RE_{it}). It is considered as a dummy variable, taking the value 1 if a country adopts an RE policy during the considered year i.e. if the country implements any of the six policy instruments[5] or RE policies, and 0 otherwise. Concerning the outcome variable, we have retained the real GDP per capita growth (*GDPpc_G*).

ii. The conditioning variables

The departure conditioning variables applied in our study to estimate the propensity scores and expected to affect both the outcome indicator and the treatment variable are ten in number, thus satisfying the conditional independence hypothesis that will develop in the methodology section. These variables are the financial development (*FD*) measured by domestic credit for the private sector to GDP ratio; the democracy indicator of polity IV (*POLITY2*); the energy imports (*EM*) measured by the ratio of net energy imports to total energy consumption i.e. this variable captures the degree of energy dependence on foreign

[5] Based on the database on public policies for RE compiled by the IEA, we consider the following six policy instruments used by Zhao et al. (2013) such as *investment incentives (risk guarantees and capital grants that aim at reducing the capital cost of RE production); tax incentives (used to encourage RE production); feed-in tariffs (which are a form of price regulation designed to guarantee producers of RE power a cost-based price); voluntary programs (in which members agree to undertake socially beneficial actions, such as buying RE); production quotas (which place a requirement on the minimum amount of electricity supply that comes from renewable sources); and tradable certificates (which provide a tool for trading and meeting RE obligations among consumers and producers, and a mechanism for tracking and verifying RE sources).*

countries; the human capital (*HK*) measured by secondary school enrollment as a percentage of gross enrollment; the foreign direct investment (*FDI*) measured by FDI net inflows as a proportion of GDP; the degree of trade openness (*OPEN*) which is measured by the sum of exports and imports as a percentage of GDP; the working age population (*WAP*) as a proportion of total population and the female variable (*FEMALE*) as ratio of female to total population. We expect, on the basis of several studies (see, e.g., De Mello, 1999; Benhabib and Spiegel, 2005; Torgler and Garcia-Valinas, 2007; Torgler et al., 2008; Del Rio Gonzalez, 2009; Huang, 2009; Brunnschweiler, 2010; Waldhier, 2010; Sawhney and Kahn, 2011; Vona et al., 2011; Dong, 2012), a positive correlation between these variables and the probability of RE adoption. The other conditioning variables that theoretically affect both *RE* and *GDPpc_G* variables and whose objective is to satisfy the conditional independence assumption, are the CO2 intensity (*CO2intensity*) measured by CO2 emissions per GDP and the total public debt as a percentage of GDP (*PUB_DEBT*). We expect that the public debt has a negative effect on the probability of RE implementation while the CO2 intensity has a mitigate effect on this probability.

3.2. Econometric methodology

Particularly in this subsection, we will try to precise and to detail the econometric methodology mentioned above in order to empirically test the impact of the adoption of the RE policy on the real GDP per capita growth in MENA countries that have adopted this policy. To do this, we used the treatment effect approach with PSM.

Indeed, we consider equation (1) below to estimate the average treatment effect on the treated (*ATT*):

$$ATT = E\left[\left(Y_{i1} - Y_{i0}\right) \backslash RE_i = 1\right] = E\left[Y_{i1} \backslash RE_i = 1\right] - E\left[Y_{i0} \backslash RE_i = 1\right] \quad (1)$$

With RE_i is the adoption variable of RE which is a dummy variable of treatment; Y_{i1} is the value of the outcome variable for REer i, which corresponds within the framework of our study to the real GDP per capita growth, and Y_{i0} if not; $Y_{i0} \mid RE_i = 1$ is the value of the result that would have been observed if a REer has not adopted RE regime and $Y_{i1} \mid RE_i = 1$ is the value of the result really observed in the same REer. The estimate of (ATT) poses a problem with the term E [$Y_{i0} \mid RE_i = 1$], of the equation (1), which is not observable; that is to say, in our case, we cannot observe the performance in terms of the economic growth of a MENA

REer if it did not apply this policy. Therefore, in order to counteract this problem, a common approach consists in estimating (ATT) by comparing the sample mean of the treatment group (REers) with that of the control group (non-REers).

However, MENA countries constitute a relatively heterogeneous group. Thus, such a statistical approach raises the question of selection bias, which can lead to an overestimation of the impact of RE adoption on economic growth. In response to this selectivity bias problem, Rosenbaum and Rubin (1983) have developed the PSM methodology. This is a non-experimental method which consists of matching a treated observation with an untreated observation whose observable characteristics are comparable (and) considering the result Y_{i0} of the latter as the counterfactual of the treated observation. In other words, it accomplishes the matching of the REers with the non-REers that have the same observed characteristics, so that the difference between the result of an adopter and the matching counterfactual can be attributed to the treatment (the adoption of RE). Therefore, the ATT can be estimated as follows:

$$ATT = E\left[Y_{i1} \backslash RE_i = 1, P\left(X_i\right)\right] - E\left[Y_{i0} \backslash RE_i = 0, P\left(X_i\right)\right] \quad (2)$$

Where $Y_{i0}|RE_i = 0$ represents the economic growth observed in the counterfactual. $P(X_i)$ is the propensity score and which in our study means the probability for an MENA country *i* to adopt in year *t* an RE policy conditionally to the observable covariates X_{it}. The propensity score is noted as:

$$P\left(X_i\right) = E\left[RE_i \backslash \mathrm{X}_i\right] = \Pr\left(RE_i = 1 \backslash X_i\right) \quad (3)$$

In addition, the empirical validity of the PSM is based on two fundamental assumptions. The first is *the conditional independence* assumption which implies that conditional on a set of observable characteristics X_{it}, the results variables Y_0 and Y_1 are independent from the treatment variable RE_{it}. This assumption is expressed as follows[6] :

$$\left(Y_0, Y_1 \perp RE_{it} \backslash \mathrm{X}_{it}\right) \quad (4)$$

However, as shown by the theorem of Rosenbaum and Rubin (1983), compliance with the conditional independence assumption is essential because it allows to match the treated and

[6] This assumption can be relaxed as follows: $(Y_0 \perp RE_{it}|P(X_{it}))$, since we want to estimate the average treatment effect on the treated and not on the entire sample and therefore it is sufficient that the random variables Y_0 and RE_{it} are independent.

untreated observations on the basis of their propensity score $P(X_{it})$, and not on all the conditioning variables as was the case with the matching method previously developed by Rubin (1977), in order to overcome the difficulty of matching X_{it} in the practical case, that the number of covariates in these variables tends to increase. This therefore means that:

$$\left(Y_0, Y_1 \perp RE_{it} \setminus P\left(X_{it}\right)\right) \text{or else} \left(Y_0 \perp RE_{it} \setminus P\left(X_{it}\right)\right) \quad (5)$$

The second hypothesis is the *common support* condition of propensity scores, whose importance for the application of PSM was emphasized by Heckman et al. (1998). This condition ensures the existence of some control countries comparable to each of the treated countries. Formally, the condition of common support can be written as:

$$0 < P\left(X_{it}\right) < 1 \quad (6)$$

Moreover, the process of estimating the average treatment effect on the treated includes four steps referring in particular to Caliendo and Kopeinig (2008) and Khander et al. (2010). Indeed, the first step consists in estimating the propensity scores[7] relying on the retained conditioning variables X_{it}. Once the estimated propensity scores, we proceed to the determination of the area of the common support densities of the two groups of countries propensity scores (REers and non-REers) inside which will be calculated the ATT, (and) relying on the "Min-Max" technique developed by Dehejia and Wahba (1999) and detailed by Smith and Todd (2005). The third step is to estimate the ATT, specifically the average effect of the RE's adoption on the economic growth of economies that have adopted this monetary policy framework. To do this, we have chosen to retain three among four propensity score matching methods which there are four types[8]. First, it refers to the estimator of N nearest neighbor (Nearest-neighbor matching) paired with replacement and consists of matching each treated or treatment observation with N control units (or the N non-treated observations) having the scores of the nearest propensity (we consider N=1, N=2 and N=3). The second method is the Local linear regression matching (LLRM) developed by Heckman et al. (1998). Finally, we use the method of Kernel matching (Epanechnikov[9]) which consists to be retained all untreated units (non-REers) (of retaining all the untreated units) belonging to the common support for the construction of the counterfactual; i.e. where each observation being weighted

[7] According to Caliendo and Kopeinig (2008), the use of probit/logit models, where the treatment variable is a dichotomous variable, provide almost the same results.
[8] Nearest-Neighbor Matching, Radius Matching, Local Linear Regression Matching and Kernel Matching.
[9] There are others types of functions aside from Epanechnikov namely Gaussian, tricube, biweight, uniform.

untreated so decreasing in function of its distance to the considered treated observation. In other words, this method proposed by Heckman et al. (1998) allows matching a treatment unit (an REer) to all control units (non-REers) proportionally weighted in function to their proximity (in terms of propensity scores) to the treated unit. The last step is to calculate the standard deviation which allows the assessment of the statistical significance of the ATT using the bootstrap technique proposed by Lechner (2002) and detailed by Brownstone and Valletta (2001); noting that the retained number of replications is 1000.

4. Results

4.1. Estimation of propensity scores

We estimate the propensity scores using a probit model[10] and the results of the probit estimates are presented in Table 2 where the considered endogenous variable is the RE adoption (*RE*). We note that apart from the financial development and the foreign direct investment, the estimated coefficients associated with the other retained conditioning variables such as *POLITY2, EM, HK, OPEN, WAP, FEMALE, CO2intensity and PUB_DEBT* are statistically significant at 1%, 5% and 10% and these variables have the expected sign, except for the degree of trade openness, the total public debt and the democracy indicator. Concerning the negative sign of the *CO2intensity*, we can explain this result and say that greater pollution is accompanied with larger economic investment, which will reduce the propensity to invest in renewable sources for electricity (Marques et al., 2010; Romano and Scandurra, 2011). In addition, the explanatory power of the model is medium, with a pseudo-R^2 of McFadden equal to 36.11%.

Table 2
Probit estimates of propensity scores.

[10] Logit model does not change the results significantly.

	RE (1)
FD	0.001 (0.001)
POLITY2	-0.063*** (0.016)
EM	0.001** (0.000)
HK	0.028*** (0.004)
FDI	-0.007 (0.016)
OPEN	-0.008* (0.004)
WAP	0.130*** (0.019)
FEMALE	0.164*** (0.024)
CO2intensity	-0.822*** (0.143)
PUB_DEBT	0.003* (0.001)
Number of observations	776
Pseudo-R^2	0.3611

Note: Values in parentheses are standard deviations.
***, **, * represent respectively the statistical significance at threshold of 1%, 5% and 10%.

4.2. The results of matching

Before leaning on the results of our estimates for different matching methods which are shown in Table 3, we first of all interested in the analysis of (we need to analyze) the common support area. Indeed, it is clear that the procedure of determining the common support area has led to the elimination of 148 treated observations among the 167 initial ones, which is about 88.6% of the total sample of treaties group. Concerning the estimation results, they are generally satisfactory and considerable enough to observe a significant impact of the RE adoption on promoting the economic growth of economies have implemented this energy policy, except for Nearest-neighbor matching (N=2 and N=3). On average, this impact east of the order of 0.048 percentage points. Given this average value, the contribution of RE to the economic growth promotion can be rather important, as it enhances the real GDP per capita growth in MENA countries by at least 0.021 (with LLRM) and up to 0.088 (with Nearest-neighbor matching, N=1) percentage points. So our estimation results largely corroborate the theoretical arguments and the empirical findings mentioned above.

Table 3
Matching estimates of RE's treatment effect on economic growth.

	Algorithms of matching				
	Nearest-neighbor matching			**LLRM**	**Kernel matching**
	N=1	N=2	N=3	(Epanechnikov)	(Epanechnikov)
			IT_FF		
(2) Average Treatment on Treated (ATT)	**0.088****	**0.331**	**0.006**	**0.021***	**0.035***
	(1.350)	(1.208)	(1.141)	(0.979)	(1.002)
Nb. of treated units on common support	148	148	148	148	148
Nb. of treated units off common support	19	19	19	19	19
Nb. of untreated observations	609	609	609	609	609

Note: Bootstrapped standard errors on the basis of 1000 replications are in parentheses.
**, * represent respectively the statistical significance at threshold of 5% and 10%.

5. Conclusion and Policy implications

In this study, we examine the effectiveness of renewable energy policies adopted in promoting the economic growth in MENA economies over the period 1980-2012. Unlike previous studies, we implement a non parametric approach, the propensity score matching, so as to investigate the issue mentioned above. The estimation matching results robustly suggest that renewable energy policies have significant positive impacts on stimulation and promoting the economic growth of MENA economies, which have implemented these energy policies. Our empirical studies have strong policy implications. Given that renewable energy policies are major stimulus of economic growth, it is viable for MENA economies to learn the best policy practice from successful countries so as to avoid the negative effect of 'policy crowdedness', which diminishes the considerable impacts of renewable energy policies as more and more they are put in place and to promote their economic growth. However, RE policies alone will not be enough. This transformation requires the collective long-term commitment of all stakeholders, including governments, citizens, financiers, private companies and international agencies. Additionally, International cooperation can further strengthen global efforts to accelerate the adoption of renewable energy policies by assessing the compatibility among them through effective regulatory mechanisms. This would help impede policy overlapping and incoherence and improve the overall policy effectiveness.

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Appendices

Appendix 1. Variables definitions and sources.

Variables	Definitions	Sources
RE	Dummy variable, coded as 1 if any of renewable energy policies are adopted, 0 otherwise.	International Energy Agency (IEA)
GDPpc_G	Real GDP per capita growth.	World Development Indicators (WDI)
FD	Domestic credit to private sector ratio in % of GDP.	WDI
POLITY2	Indicator of democracy taking values from -10 (very autocratic) to +10 (very democratic).	Polity IV Project
EM	Ratio of net energy imports to total energy consumption.	WDI
HK	Secondary school enrollment as a proportion of gross enrollment (Human capital).	WDI
FDI	FDI net inflows as a proportion of GDP.	WDI
OPEN	Trade openness (as the sum of exports and imports of goods and services as a share of GDP).	WDI
WAP	Working-age population a proportion of total population.	WDI
FEMALE	Ratio of female to total population.	WDI
CO2intensity	CO2 emissions per GDP.	WDI
PUB_DEBT	Total public debt as a share of GDP.	International Monetary Fund (IMF); Abbas et al. (2010)

Appendix 2

Descriptive Statistics.

Variables	Obs.	Mean	Std. Dev.	Min	Max
		(1980-2012)			
FD	776	41.32005	38.67639	1.021006	305.0869
POLITY2	782	-2.71867	6.967099	-10	10
EM	782	-145.9	277.6544	-1679.262	100
HK	782	70.48903	25.15425	8.78114	114.8685
FDI	782	2.360135	4.243758	-13.60488	37.26805
OPEN	782	42.06055	18.09372	6.886219	125.5694
WAP	782	61.25081	7.711623	45.28674	85.80555
FEMALE	782	47.23638	5.382196	23.53917	53.11026
CO2intensity	782	1.133816	0.6506637	0.2947308	3.987139
PUB_DEBT	780	66.56525	52.65148	0	356.33

Source :Authors'calculations