Key drivers of renewable energy deployment in the MENA Region: Empirical evidence using panel quantile regression

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Abstract

With the growing pressure from the adverse impact of environmental pollution and climate change, the deployment of renewable sources becoming one of the economic priorities for governments worldwide. Despite potential gains of renewable sources, little evidences are provided in the literature about the determinants of renewable energy deployment in the MENA region. In particular, whether political stability, governance quality and financial development matter or not for unleashing the potentials of renewable energy programs. To this end, this paper aims to fill the gap by examining the impact of political stability, quality of governance and institutions, and financial development on the deployment of renewable energy production in 9 selected MENA countries using annual data over the period 1984-2014. Accordingly, an innovative panel quantile regression model with non-additive fixed effect has been developed to tackle this issue. Our findings confirm that the effect of the political stability is clearly heterogeneous and supports earlier claims about the importance of political stability to foster the investments in renewable energy sector. Findings also show that financial development has a positive impact on renewable energy production. In addition, we also find that the interaction term between governance effectiveness and financial development is negative for the lower quantiles but positive for the highest quantiles. These findings support our hypotheses and suggest that political stability, governance effectiveness and financial development are important drivers for promoting renewable energy production in the MENA region.

Keywords: Renewable energy; Political stability; Financial development; Governance; Panel quantile; MENA Region.

1. Introduction

Faced to the ecological crisis and the scarcity of oil, our societies are summoned to find new modes of development, life and displacement. In this context, the need to reduce our energy needs, on the one hand, and to find new sources of energy, on the other hand, is unanimously recognized. Therefore, energy economics academics, policy makers, and industries have thus drawn more attention to the potential drivers of renewable energy deployment, which has been a component of national planning agenda for several developed countries over the last few decades. Unfortunately, at present, most developing economies are not on the path of transition to renewable energies, which requires major efforts to reduce barriers to this transition. Those barriers include lack of funding, institutional and regulatory barriers, lack of stability and transparency of instruments used, non-participation of the private sector, bureaucracy, corruption, political stability, etc. (e.g., Wiser and Pickle, 1998; Becker and Fischer, 2013; Liang and Fiorino, 2013; Scholten and Bosman 2016). The main contribution of the present study is to examine whether political stability, government effectiveness, and financial development drive the deployment of renewable energy in the case of 9 selected Middle East and North Africa (MENA) countries using an innovative estimation approach based on a panel quantile framework with non-additive fixed effects, proposed recently by Powell (2016).

The positioning of this inquiry is motivated by at least six reasons. First, while energy was absent in the Millennium Development Goals (MDGs), Sustainable Development Goals (SDGs) through the seventh goal integrates the access for all to reliable, sustainable and modern energy services at an affordable cost. It wants to significantly increase the share of renewable energy in the global energy mix, at a time when more than 80% of the world's consumption is based on fossil fuels, and double the global rate of improvement in energy efficiency by 2030 (Mirchi et al., 2012; Goldemberg, 2018). In this context, countries in the MENA region are pursuing increasingly ambitious strategies for the deployment of renewable energies and for the improvement of their energy balance. Large parts of them benefit from a privileged location, which makes them the next promising monopoly in terms of sustainable energy development. Moreover, the region has more and more achievements, which tends to confirm the fact that North Africa and the Middle East will participate in the establishment of a part of the future energy supply of the world. Many power plants are already operational, and others are in the planning phase. By 2050, access to renewable energy will meet the energy needs of nearly 1.2 billion of people. Note that for the entire MENA region, the target announced for 2020 is a production of 50 GW, which is quite consistent (Bardolet, 2014). Despite the excellent potentials for generating electricity from renewable sources, little is however known about the drivers of its deployment in no one focused on MENA region is available. This is the gap that the study seeks to fill. To advance the existing energy economics literature, we address the question whether the quality of institutions and financial development affect the deployment of renewable energy in MENA region.

Second, in terms of financial development, the transition towards renewable energy requires more developed financial systems that foster and develop the promising renewable energy technologies. The missing relationship between financial sector development and renewable energy production has been pointed out by several practitioners, who see the absence of well-developed financial sector and the consequent financing difficulties as one of the most important barriers in promoting the renewable energy projects in less developed countries (e.g., Sonntag-O'Brien and Usher, 2004; Painuly and Wohlgemuth, 2006; Becker and Fischer, 2013; Mazzucato and Semieniuk, 2018). Despite that the significant role played by financial development in promoting renewable energy sector has been approved by a lot of case studies and events, the academic researches on this topic is still missing, in particular those regarding the empirical researches on the effect of financial development on renewable energy deployment. This study contributes to the knowledge on whether financial development contributes to the deployment of renewable energy, with a focus on the MENA countries.

Third, in terms of political stability, the access to renewable energy sources of a country is closely related to the political stability (Liang and Fiorino, 2013). For instance, for the United States and its Western European counterparts, the Access to finance and overall political stability have been identified as major prerequisites to the achievement of renewable energy schemes (Wiser et al.,1998; Brunnschweiler, 2010). However, existing empirical economics studies seems insufficient to solve the puzzle about political stability and its externalities on renewable energy sector. This paper aims to fill this gap by examining the impact of political stability on the deployment of renewable energy in MENA countries.

Fourth, regarding the quality of governance, the recent literature documented that the investment in renewable energy sector is very sensitive to the country's institutions quality (e.g., Becker and Fischer, 2013; Fouinhas and Marques, 2013; García, 2013). Theoretically, the weak institutions have various harmful impacts on energy sector policies, in particular the electricity sector. Accordingly, Gutermuth (2000) considers that the legal and institutional framework is of great importance in the transition to clean energies. Indeed, legal and institutional factors can be barriers to the transition to renewable energy as they can be a way to have a quick and efficient transition. In the same context, García (2013) tried to collect the different institutional mechanisms used to accelerate the promotion of renewable energies based upon a report published by the International Energy Agency (IEA, 2008) and from various other studies. Among the divergences of the Chinese policy compared to the best practices of the promotion of the renewable energies, the author noted: the absence of targets, the lack of stability and transparency of the instruments used, the weak coordination, the bureaucracy, the corruption, and the lack of incentives for innovation. Due that, there is not much empirical evidence considering the link between renewable energy deployment and quality of governance in MENA region, this study aims to fill this research gap by bringing new empirical evidence on whether governance matter or not for the focal nexus.

Five, in the existing literature, several studies have assessed the importance of institutions in determining financial development. Among them, Girma and Shortland (2008) have used data for selected developing and developed countries to investigate how regime changes and democracy contribute to the development of financial sector. Their findings reveal that political stability and the level of democracy are key determining factors of financial development. This idea was examined further in Huang (2010), who found a positive impact of institutional improvement on financial development in case of low-income countries. Accordingly, since both institutions quality and financial development are interrelated and each of them has a positive impact on the production of renewable energy, we also aim to demonstrate, in this study, how governance complements financial development to influence the deployment of renewable energy in MENA region, i.e. governance is used as policy variable that can enhance financial sector for better production of renewable energy. To the best of our knowledge, none of the existing studies has interested in examining how the interaction between governance and financial sector could improve the production of renewable energy.

Finally, compared to the existing literature on the determinant of renewable energy deployment, we apply the fixed-effect panel quantile regression method for the following reasons. First, this method is helpful in examining asymmetric features of the outcome variables distributions. Compared with the Ordinary Least Square (OLS) method (Yan et al., 2019), which is very responsive to outliers, quantile regression enables the model to account for outliers and investigate the drivers of renewable energy production across the conditional distribution. In addition, since the OLS regression appreciates the mean effect, its results describe the "average" renewable energy production country. Koenker (2005) highlighted that the mean effect resulted from OLS regression is not robust to elucidate the estimated coefficients from heterogeneous responses' models. Second, quantile regression model is suitable when the factors of interest have different impacts at different points of the conditional distribution of the dependent factor (Yan et al., 2019). Third, interest on combining quantile regression models with panel data has been recently intensified (Graham et al., 2018; Cheng et al., 2019). It is worth mentioning that in mean regression model, to substantiate the within group variation, panel data enable the incorporation of a fixed effects. Nonetheless, the additive fixed effect will alter the underlying model (Cheng et al., 2019).

Based on the five motivations discussed below, this study contributes to the existing literature in the following ways. First, there are gaps in the previous empirical studies regarding how political stability, quality of governance, and financial development promote the deployment of renewable energy in the case of 9 selected MENA countries over the period 1984-2014. Studies in this trend are relatively so far sparse in the existing literature. Second, while some of existing studies discussed the importance of governance and financial sector in the development of renewable energy sector, none of them has considered the complementarity between governance quality and financial development in determining the production of renewable energy. In this inquiry, quality of governance is considered as policy variable that complements financial development to influence the deployment of renewable energy in the MENA region. Third, one of the main shortcomings in the existing literature is that factors affecting the investments in renewable energy sector has not been sufficiently examined for some regions and countries where the production of renewable energy constitute a big challenge, as the case of the MENA region. This is the gap that this study seeks to fill. Fourth, we implemented an innovative estimation approach based on a panel quantile framework with non-additive fixed effects, proposed recently by Powell (2016). Therefore, the main contribution of the findings to the existing literature is that it illustrates the effects of each explicative factor across the renewable energy production conditional distribution, instead of focusing only on their conditional mean.

The remainder of the article is structured as follows: In Section 2, we give a brief assessment of the current knowledge regarding the drivers of renewable energy production, and we introduce the main hypothesis of our research. Section 3 reports the data and econometric methodology. Section 4 outlines and discusses the empirical results, while the fifth Section (Section 5) concludes and offers policy implications based on the empirical results.

2. Literature review and hypotheses

Economic theory has been much solicited by the actors of energy sector but, in return, energy debates have allowed economic theorists to feed some of their reflections. The fact is that the energy sector often uses exhaustible resources (3/4 of the energy consumed in the world belongs to so-called non-renewable resources), that it is very capital-intensive and often organized around integrated monopolies, private or public, with regard to the transportation and distribution of certain fluids (gas, electricity in particular). It is also an activity generating strong externalities. These debates are not new: we remember the "coal question" raised by Jevons (1865) or the pricing of energy monopolies addressed by Dupuit (1844) in the nineteenth century. It is relevant to see how the dynamic nexus between energy and economic theory has evolved over the last few years and what are the themes that are now the focus of energy economist

Recent energy economics literature has been extensively discussing the significant role of renewable energy sector in the economic activity. Existing studies on this topic may be divided in two main strands of research: those looking at the relationship between renewable energy and the macroeconomic activities and those looking at the determinants of renewable energy production and consumption. For the first strand, most of the existing studies focused on (i) the questions of the causal relationships among renewable and non-renewable energy consumption and economic growth (e.g., Sadorsky, 2009a; Ozturk, 2010; Ocal and Aslan, 2013; Belaid and Abderrahmani, 2013; Pao et al., 2014; Omri, 2014; Destek and Aslan, 2017, Belaid and Youssef, 2017); and (ii) the relationship among renewable and non-renewable energy, CO2 emissions and economic growth (e.g., Apergis et al., 2010; Tiwari, 2011; López-Menéndez , 2014; Cherni and Jouini, 2017; Dong et al., 2018; Chen et al., 2019; Lin and Zhu, 2019; Belaid and Zrelli, 2019). For instance, Omri (2014) reported that the relationship between economic growth and energy variables (total, electricity, nuclear, and renewable) could be summarized into four testable hypotheses, namely conservation, growth, feedback, and neutrality hypotheses. The *conservation hypothesis* indicates that policies that the use of energy do not have a negative effect on economic growth. This assumption is verified if an upsurge in economic growth leads to a rise in energy use. The *growth hypothesis* assumes that an increase (decrease) in energy use leads to an increase (decrease) in economic growth. In this case, energy causes economic growth and the economy is considerably dependent on energy. The *feedback hypothesis* suggests that there is a two-way causality between economic growth and energy use. It indicates that economic growth and energy are interrelated and may very well serve as complements to each other. Finally, the *neutrality hypothesis* considers that energy consumption is only a small part of the components of production and that its effect on economic growth is low or zero. This hypothesis holds true in the absence of causality between energy use and economic growth. Using data for 18 emerging economies, Destek and Aslan (2017) empirically investigated the causality between economic growth and renewable and non-renewable energy using bootstrap panel causality method over 1980-2012 period. Their findings show that, for the renewable energy-growth causality nexus, the conservation hypothesis is found in cases of Colombia and Thailand; the growth hypothesis is validated only for Peru; the feedback hypothesis is supported in cases of Greece and South Korea; and the neutrality hypothesis is found in the rest 12 emerging economies. For the causality nexus between non-renewable energy and economic growth, the findings show that the conservation hypothesis is found in cases of Egypt, Peru and Portugal; the growth hypothesis is confirmed only in case of China; the feedback hypothesis is validated only in case of Turkey; and the neutrality hypothesis is validated in cases of the 9 rest countries. Furthermore, Ito (2017) examined the relationships among economic growth, CO2 emissions, renewable and non-renewable energy in case of 42 developing economies over the 2002-2011 period. They found that non-renewable energy has a negative effect on economic growth, while the effect of renewable energy consumption is positive in the long-run. Using data for Tunisia, Cherni and Jouini (2017) examined the relationships among CO2 emissions, renewable energy and economic growth using Granger causality test. They found a feedback relationship between economic growth and CO2 emissions.

The second strand consists of the studies that analyse the determinants of renewable energy demand. As these studies are directly connected to the objective of our study, they are summarized in detail. For instance, Sadorsky (2009b) examined the determinants of renewable energy consumption for the G7 countries using panel cointegration technique. They found that per capita GDP and CO2 emissions are the major drivers behind the demand of renewable energy, while oil price has a smaller although negative effect. Using the same determinants in case of 6 Central

American countries, Apergis and Payne (2010) found that per capita GDP, CO_2 emissions, oil prices, and coal prices have positive and statistically significant impacts on renewable energy consumption. Similarly, in examining the factors accelerating the adoption of renewable energy for some emerging economies, Salim and Rafiq (2012) found that, using Fully modified ordinary least square (FMOLS) and Dynamic ordinary least square (DOLS), renewable energy consumption is significantly determined by per capita GDP and CO_2 emissions in cases of Brazil, China, India and Indonesia, while mainly by per capita GDP in cases of Philippines and Turkey. They also found that there exist bidirectional relationships between per capita GDP and renewable energy consumption, and between CO_2 emissions and renewable energy consumption. Compared to the above three studies on the determinants of renewable energy demand, Omri and Nguyen (2014) included international trade as determinant of renewable energy consumption for a panel consisting by 64 countries over the period 1990-2011. They found, using dynamic panel data, that oil price has a smaller negative impact on renewable energy consumption in cases of high-, middle-, and low-income countries; CO_2 emissions positively contributes to the demand of renewable energy for all groups of economies; an increase in per capita seems to have an effect in increasing renewable energy consumption only in cases of low- and high-income countries; and international trade was also found to have statistically significant and a positive effect only in cases low- and middle-income countries.

In light of the above, the present inquiry, as a contribution to the second strand of literature, differs from the earlier ones not only by considering the context of MENA countries but also by (i) examining whether governance quality and financial development drive the deployment of renewable energy. These missing relationships have been pointed out by several practitioners, who see the absence of good governance and institutions and well-developed financial sector constitute the most important barriers in promoting the renewable energy projects in developing countries (e.g., Painuly and Wohlgemuth, 2006; García, 2013)[1]; and (ii) demonstrating how quality of governance complements financial development to influence the deployment of renewable energy in MENA region, i.e. quality of institutions is used as policy variable that can enhance financial sector for better production of renewable energy.

Considering the above arguments, we formulate the following two hypotheses:

Proposition 1: Renewable energy deployment in MENA countries is closely related to the levels of political stability, financial development, and governance quality.

Proposition 2: Governance quality complements financial development in influencing the deployment of renewable energy in MENA countries.

3. Data and methodology

3.1. Data description

Empirical analysis has been conducted using annual data covering the period 1984-2014 for 9 MENA countries; namely, Algeria, Egypt, Iran, Iraq, Jordan, Lebanon, Morocco, Tunisia, and Yemen. The selected MENA countries and the time period have been determined by the availability of data. In terms of data sources, renewable energy production and total energy consumption data have been taken from International Energy Agency (IEA) whereas data for political stability and absence of violence and governance effectiveness are collected from International Country Risk Guide (ICRG.)

The ICRG database provides data for four types of country risk indices including political risk, economic risk, financial risk, and composite risk. The annual data for political stability and absence of violence and governance effectiveness indices have been constructed using ten indicators out of twelve that comprise the ICRG political risk, group them into two categories, where each index comprises five indicators. In particular, political stability and absence of violence

[1] Other studies argue that financial development might have a heterogeneous impact on environmental degradation. In some countries, financial development would spur adoption of eco-friendly policies and investment in green sectors which in turn decreases environmental deterioration whereas, in other economies, it would increase environmental degradation by increasing consumption of fossil fuel and investments in polluting industries. For further details see Saud et al., (2019).

index includes government stability, internal conflict, external conflict, religious tension and ethnic tension. So, it measures the perception of the likelihood that the government will be destabilized or overthrown by unconstitutional and violent means, including domestic violence and terrorism. Whereas, government effectiveness index measures the quality of public services, the quality and degree of independence from political pressures of the civil service, the quality of policy formulation and implementation, and the credibility of governments' commitments to such policies and it comprises five indicators, namely, bureaucracy quality, democratic accountability, law and order, military in politics and corruption.

Table 1
Definition of the variables and data sources.

Variable name	Abbreviation	Description	Source
Renewable energy production	RENP	Total energy generation from various renewable sources, including hydroelectric, includes geothermal, solar, tides, wind, biomass, and biofuels.	IEA
Political Stability and Absence of Violence index	POLS	This index includes government stability, internal conflict, external conflict, religious tension and ethnic tension.	ICRG
Governance quality index	GOV	This index comprises bureaucracy quality, democratic accountability, law and order, military in politics and corruption.	ICRG
Domestic credit to private sector	FD	Private credit by deposit banks and other financial institutions (% of GDP)	WDI
Gross Domestic Product	GDP	GDP (constant 2010 US$)	WDI
Total natural resources rents	RENT	Total rent from natural resources including oil, natural gas, coal, mineral and forest rents (% of GDP).	WDI
CO_2 emissions	CO_2	Carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.	WDI
Foreign investment	FDI	Foreign Direct Investment net inflows (% of GDP).	WDI
Total factor productivity	TFP	TFP used as a proxy for quality of investment, which represents growth in output due to technological changes, efficiency improvements, innovation, and other inputs rather than capital and labor.	TED
Trade openness	TRADE	Total of exports plus imports (% of GDP).	WDI
Total energy consumption	TENRG	Total final energy consumption	IEA

Notes: IEA: International Energy Agency; ICRG: International Country Risk Guide; WDI: World Development Indicators; and TED: Total Economy Database.

Following the literature, a number of control variables have been included in the model to control for omitting a relevant variable and avoid biased estimators; namely, private credit by deposit banks and other financial institutions as share of GDP as a proxy for financial development, GDP (constant 2010 US$) as a measure of economic growth rate, total rent from natural resources as a share of GDP to control for natural resource dependency, CO_2 emissions proxied by total Carbon dioxide produced during consumption of solid, liquid, gas fuels, and gas flaring, net inflows of foreign direct investment as a share of GDP as an indicator of foreign direct investment, total factor productivity as a proxy for quality of investment, total trade as a share of GDP is a representative of trade openness, and finally total energy consumption as a proxy of energy consumption. For further details on the definition of variables, abbreviations, and data sources, see Table 1)

3.2. Descriptive statistics

Descriptive statistics along the correlation matrix for all variables are reported in Table 2. Panel A shows the summary statistics of different variables used in the panel, which indicates that the production of renewable energy in the selected MENA countries ranging from 1 to 3074 ktoe with average production of 715.8 ktoe. Political stability and government effectiveness indicators expand from 4.8 and 10.7 to 91.3 and 75 with mean equal 63.3 and 48.1, respectively, where a higher value indicates a more sound and stable political system and effective governance. In addition, on average financial development, estimated as a share of domestic credit to private sector, is recorded at 40.5%.

The correlation matrix among dependent and independent variables is presented in panel B. On the one hand, correlation coefficients indicate that renewable energy production is positively connected with political stability, governance effectiveness, economic growth, financial development, CO_2 emissions, total factor productivity, total energy consumption but negatively associated with natural resources dependency and trade openness. On the other hand, political stability and government effectiveness are positively correlated among themselves and with financial development, trade openness and FDI. However, it's negatively correlated with natural resources dependency and total energy consumption. Furthermore, economic growth rate has a positive and strong correlation with total energy consumption and CO_2 emission but negatively correlated with foreign direct investment and trade openness. Finally, there is a strong positive connection between total energy consumption and CO_2 emission. These results suggest that political stability, government effectiveness, and financial development are key determinants of renewable energy production in the selected MENA countries. Nonetheless, this intuitive proposition needs a more concise and concrete analysis since correlation coefficients only indicates the strength of the linear relationship between each pair of variables. To this end, the study developed a multivariate model to further investigate this assumption based on cointegration approach and panel quantile regression model.

3.3. Empirical model

This research study examines a crucial question, which has risen in the last few years both in policy and the economic literature; that is, the main determinants of renewable energy production. In order to evaluate the relationship between renewable energy production and governance effectiveness, political stability, financial development and others control variables, we estimate the following regression equation:

$$RENP_{it} = \alpha_0 + \alpha_1 FD_{it} + \alpha_2 GOV_{it} + \alpha_3 FD_{it} * GOV_{it} + \alpha_3 POLS_{it} + \sum_{j=1}^{K} \lambda_j Z'_{jit} + \tau_i + \varepsilon_{it} \qquad [1]$$

Where RENP is the natural logarithm of renewable energy production; i is country and t is time period; a_0 is the constant parameter that varies across countries but not over time; FD, GOV, FD*GOV, and POLS denotes the natural logarithm of financial development, government effectiveness, the interaction term between financial development and government effectiveness, and political stability, respectively. Z' is a vector of relevant control variables (Oil dependence (RENT), per capita GDP (GDP), environmental quality (CO2), foreign direct investment (FDI), total factor productivity as proxy for investment quality (TFP), total energy consumption (TENRG), and trade openness (TRADE)) hypothesized to affect the production of renewable energy. The variables are included in order to avoid variable omission bias. t_i is the country-specific effect; and e is the error term.

Table 2
Summary statistics and correlation matrix.

Panel A: Summary Statistics

	RENP	POLS	GOV	FD	GDP	RENT	CO2	FDI	TFP	TRADE	TENRG
Mean	715.8	63.33	48.12	40.52	9.21E+10	11.35	86674	2.772	0.314	70.21	62211.08
Maximum	3074	91.32	75	98.76	5.00E+11	64.11	649481	23.54	7.095	154.2	345647
Minimum	1.000	4.861	10.71	0.394	5.79E+09	0.0013	7051.6	-5.112	-17.59	0.0209	1.000
Std. Dev.	809.6	17.62	14.13	26.96	1.05E+11	12.63	121611	4.141	1.916	30.50	84203.77

Panel B: Correlation Matrix

	RENP	POLS	GOV	FD	GDP	RENT	CO2	FDI	TFP	TRADE	TENRG
RENP	1.00										
POLS	0.21*	1.00									
GOV	0.20*	0.65*	1.00								
FD	0.24*	0.48*	0.57*	1.00							
GDP	0.40*	0.18*	0.07	-0.08	1.00						
RENT	-0.17*	-0.27*	-0.30*	-0.56*	0.35*	1.00					
CO_2	0.35*	-0.18*	0.08	-0.04	0.98*	0.34*	1.00				
FDI	0.04	0.33*	0.28*	0.40*	-0.16**	-0.18*	-0.14**	1.00			
TFP	0.25*	-0.09	-0.03	0.16**	0.13**	-0.12	0.13**	0.11	1.00		
TRADE	-0.28*	0.33*	0.15**	0.46*	-0.39*	-0.16**	-0.36*	0.39*	0.07	1.00	
TENRG	0.10*	-0.31*	-0.10	-0.27*	0.92*	0.48*	0.90*	-0.23*	0.08	-0.36*	1.00

Notes: This table reports the descriptive statistics for all variables used in the empirical analysis over the full sample starting from 1984 to 2014; RENP stands for renewable energy production, POLS denotes political stability and absence of violence index, GOV is governance effectiveness index, FD represents financial development, GDP is a measure of economic growth rate, RENT stands for total natural resources rents, CO2 is shows total CO2 emissions, FDI means Foreign direct investment, TFP signifies total factor productivity, and finally TRADE and TENRG represent trade openness and total energy consumption respectively. * and ** represent the statistical significance at 1% and 5% levels, respectively.

3.4. Estimations method

In this article, we developed a panel quantile regression model to examine the main drivers of renewable energy production in selected MENA countries. Based on the Hausman test results we opted for a fixed effect model. The chosen fixed effect panel quantile model allows us to clarify the main determinants of renewable energy production across the conditional distribution, particularly in the countries with the least and highest renewable energy production, while the standard regression models focus on the conditional mean effects, which could lead to over- or under-estimating the suitable parameters. More precisely, we develop an innovative approach via a non-additive fixed effect panel quantile approach substantiated recently by Powell (2016). This new estimation approach alleviates the endogeneity issue associated with the fixed effects factor in panel quantiles regressions. Further, for robustness purposes, we develop a fixed-effect quantile model, derived from the fixed effect OLS approach proposed by Canay (2011). This approach is derived from the fixed effect OLS model.

Quantile regression approach initiated by Koenker and Bassett (1978) with the main purpose of generalizing the idea of univariate quantile estimation to assess the conditional quantile functions, i.e. the quantiles of the conditional distribution of the variable of interest are formulated as functions of the observed explanatory variables. This method is helpful in examining asymmetric features of the outcome variables distributions. Compared with the Ordinary Least Square (OLS) method, which is very responsive to outliers, quantile regression enables the model to account for outliers and investigate the drivers of renewable energy production across the conditional distribution. In addition, since the OLS regression appreciates the mean effect, its results describe the "average" renewable energy production country. Koenker (2005) highlighted that the mean effect resulted from OLS regression is not robust to elucidate the estimated coefficients from heterogeneous responses' models.

In other words, quantile regression model is suitable when the factors of interest have different impacts at different points of the conditional distribution of the dependent factor. More recently, interest on combining quantile regression models with panel data has been intensified (Graham et al., 2018). It is worth mentioning that in mean regression model, to substantiate the within group variation, panel data enable the incorporation of a fixed effects. Nonetheless, the additive fixed effect will alter the underlying model.

The newly method proposed by Powell designed to provide robust inference concerning the long-run cover ability for extensive persistence patterns. This approach, which is adequate to quantile estimators with fixed effect (μ_i), relies on the estimation of the distribution of $Y_{it}|X_{it}$ (Y_{it} given X_{it}) instead of $Y_{it}-\mu_i|X_{it}$ ($Y_{it}-\mu_i$ given X_{it}). According to Powell, the latter estimate is not consistent in many empirical applications. The main argument advanced by Powell is that the additive fixed effects models are not able to generate information about the policy effects factors on the outcome distribution because observations at the top of $Y_{it}-\mu_i$ distribution probably be at the bottom of Y_{it}. Therefore, the approach proposed by Powell (2016) furnishes point estimates that we can explain in similar fashion as the ones resulting from cross-sectional regression models. In addition, Powell's method is consistent in the case of short panel.

Following Powell's approach, the underling model of this article is specified as follows:

$$Y_{it} = \sum_j X'_{it}\alpha_j(\varepsilon *_{it}), \quad \varepsilon *_{it} \sim \varepsilon(0,1) \qquad [2]$$

Where Y_{it} is the renewable energy production, X'_{it} is our main explanatory factors, the $\alpha_j$is the parameter of interest, and $\varepsilon *_{it}$ is the error terms and the proneness for the outcome, which can be expressed by a function of various error terms, some time-varying and some time-fixed. This model is considered as linear in coefficients and $X'_{it}\alpha_j(\emptyset)$ is strictly rising in $\emptyset$. Usually, for the $\emptyset^{th}$ quantile of Y_{it}, quantile regression depends on the following conditional restriction:

$$P\left(Y_{it} \leq X'_{it}\alpha_j(\emptyset)|X_{it}\right) = \emptyset, \quad \emptyset \in [0,1] \qquad [3]$$

Eq.3 stipulates that probability of the latent outcome factor is lower than the quantile function, is identical to all X_{it}; and identical to $\emptyset$.

The quantile regression estimator for panel data of Powell (2016) permit to this probability to fluctuate both by unit and within unit, as long as such fluctuation is orthogonal to the instrument. Therefore, the Powell's estimator, based on conditional and unconditional restriction, is expressed as follows:

$$P\left(Y_{it} \leq X'_{it}\alpha_j(\emptyset)|X_i\right) = P\left(Y_{is} \leq X'_{is}\alpha_j(\emptyset)|X_i\right), \quad X_i = (X_{i1}, \dots, X_{iT}) \qquad [4]$$

The quantile regression model is estimated employing a numerical optimization based upon the adaptive Markov Chain Monte Carlo sampling (MCMC). The MCMC optimization approach relies on multivariate normal distribution proposed by Baker (2014).

4. Empirical results and discussion

In addition to the cross-sectional dependence, to assess the validity of our model we implement various tests, including variance inflation factor, serial correlation, normality, and Ramsey misspecification test. The results of this test are provided in Appendix A1-A5.

We begin our analysis by examining the potential existing correlation among the units (countries) and investigate the adequate unit root and cointegration tests that best fit our model. Therefore, we employed various cross-sectional dependencies tests, including Freidman (1937), Frees (1995), and Breusch & Pagan (1980), and Pesaran (2004), tests. Table 3 displays the results of the proposed tests. We notice from this table that the results indicate that the null hypothesis of cross-sectional dependence is statistically rejected by all the tests at the 1% significant level.

Therefore, each series contains cross-sectional dependence. To deal with this issue we implemented various unit root tests, all these tests are robust to the presence of the cross-sectional dependence.

Table 3

Pesaran(2004), Frees(1995), Freidman(1937), and Breusch & Pagan cross-sectional dependence tests.

Test	**Pesaran**	**Frees**	**Freidman**	**Breusch & Pagan**
	CD test	CD(Q)	CD	Chi2
FE model	-3.585	0.379	22.059	107.235
	(0.018)	(0.000)	(0.004)	(0.000)
RE model	0.867	0.558	44.371	----
	(0.386)	(0.000)	(0.000)	

Note: FE and RE denote fixed and random effects. ***Indicate statistical significance à 1% level.

Accordingly, before estimating the non-additive fixed effects panel quantile models, we employed various unit root tests to investigate the series stationarity, including second-generation unit-root tests. Therefore, four-panel unit root tests have been implemented, including Breitung, Levin-Lin-

Chu Test (LLC), Moon and Perron (MP), and Pesaran CADF (Pesaran, 2007) tests. The second-generation unit root tests have been developed by the recent econometrics literature to control the issue of cross-sectional dependence throughout the panel units (Moon and Perron, 2004; Pesaran, 2007). The output of the tests, which are illustrated in Table 4 highlight that all the factors included in our model follows an I(0) or I(1) process, i.e. all the series are stationary at their levels or at the 1st difference. Given the results of the panel unit root tests discussed above, we can pursue to investigate the existence of a long-run relationship across the variable using the Westerlund (2007) panel cointegration test.

Table 4
Panel unit root tests.

	Level				First difference			
Variables	LLC	Breitung	CADF	MP	LLC	Breitung	CADF	MP
GDP	-1.738**	0.999	-1.545*	271.482*	-3.819***	-5.880***	-6.821***	211.044***
	(0.041)	(0.841)	(0.061)	(0.070)	(0.000)	(0.000)	(0.000)	(0.000)
CO2	-1.695**	-2.064**	0.0387	25.242	-6.795***	-4.914***	-7.665***	275.626***
	(0.045)	(0.019)	(0.515)	(0.118)	(0.000)	(0.000)	(0.000)	(0.000)
FD	0.875	-0.092	0.650	24.326	-1.167	-4.980***	-3.661***	112.347***
	(0.809)	(0.463)	(0.742)	(0.144)	0.121	(0.000)	(0.000)	(0.000)
FDI	-1.423*	-1.788**	-0.933	32.393**	-6.977***	-9.612***	-7.698***	495.752***
	(0.077)	(0.036)	(0.176)	(0.025)	(0.000)	(0.000)	(0.000)	(0.000)
GOV	-0.392	-0.994	0.727	8.458	-4.860***	-5.914***	-4.855***	91.462***
	(0.347)	(0.160)	(0.766)	(0.971)	(0.000)	(0.000)	(0.000)	(0.000)
POLS	-0.881	0.261	1.887	7.138	-8.759***	-5.974***	-8.880***	129.280***
	(0.189)	(0.603)	(0.970)	(0.988)	(0.000)	(0.000)	(0.000)	(0.000)
RENP	1.178	-1.457*	0.955	17.210	-3.384***	-2.146**	-4.709***	402.701***
	(0.880)	(0.072)	(0.830)	(0.508)	(0.000)	(0.000)	(0.000)	(0.000)
RENT	-0.938	-1.412	-0.693	26.508*	-6.910***	-5.404***	-9.308***	211.838***
	(0.174)	(0.078)	(0.244)	(0.088)	(0.000)	(0.000)	(0.000)	(0.000)
TENRG	-5.881***	1.893***	-3.454***	85.269***	-6.523***	-1.942***	-6.861***	115.609***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
TFP	-0.981	0.334	-0.887	42.896***	-4.466***	-4.228***	-7.699***	669.980***
	(0.163)	(0.631)	(0.187)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
TRADE	-1.473*	-3.159***	-1.915**	19.185	-8.484***	-5.119***	-8.329***	122.283***
	(0.070)	(0.000)	(0.027)	(0.380)	(0.000)	(0.000)	(0.000)	(0.000)

Note: ***, **, and * indicate statistical significance at 1%, 5%; and 10% level, respectively. Number in parentheses represents the P-values.

Based on the findings presented above, we can continue to examine the cointegration relationship among all the selected factors, i.e., we investigate whether a long-run equilibrium process exists among the series. Therefore, we employed the Westland variance ratio cointegration (VR) test (Westerlund, 2005). The results displayed in Table 5 highlight that the long-run relationship is supported by the VR test. The results show a variance ratio test statistic (-7.316) significant at the 1% level, indicating the rejection of the no cointegration hypothesis. The result supports the hypothesis of the existence of long-run equilibrium among renewable energy production and the explanatory variables (determinants) within the whole panel and nine subpanel countries during the period 1984-2014.

Table 5
Westerlund VR cointegration test

Westerlund VR test	Statistic	P-Value
Variance Ratio	-7.316	0.000
	Ho: No cointegration vs. Ha: Some panels are cointegrated	

To choose the most appropriate econometric specifications we perform a fixed effect and a random effect estimation, based on Hausman test (Hausman, 1978). According to the Hausman test results displayed in Table 6, the fixed effects model performs better in our case also.

Table 6
Fixed and random effect specification

VARIABLES	Fixed LRENP	Random LRENP
LPOLS	-0.191	-0.262
	(0.120)	(0.198)
LGOV	0.701***	1.188***
	(0.163)	(0.333)
LDCPS	-0.271**	0.750***
	(0.111)	(0.197)
GOVFD	0.113	-0.369***
	(0.069)	(0.133)
LGDP	0.347*	2.447***
	(0.188)	(0.307)
LRENT	0.140***	0.167***
	(0.041)	(0.041)
LCO2	0.428**	-1.798***
	(0.209)	(0.296)

LFDI	0.038***	0.037*
	(0.011)	(0.022)
LTFP	-0.002	0.164***
	(0.019)	(0.040)
Constant	-9.504***	-39.130***
	(2.926)	(4.700)
Hausman FE-RE	11.93	
	[0.002]	
Observations	279	279
R-squared	0.426	
Number of Contry Code	9	9

Note: Standard errors in parentheses (the values in square brackets for the Wald Chi2, Hausman test

Table 7 reports the results of panel quantile with non-additive regression model at five different percentiles of the renewable energy production distribution. The corresponding Powell's panel quantile regression diagrams are displayed in Fig. 1. Hence, renewable energy production represents our dependent variable and political stability and governance effectiveness, and other control factors are the independents variables of our model.

Table 7

Powell's (2016) panel quantile regression with non-additive fixed effects results

VARIABLES	**Q1** **0.10**	**Q2** **0.25**	**Q3** **0.50**	**Q4** **0.75**	**Q5** **0.90**
POLS	-.586***	0.062*	0.098*	-0.406***	-0.291***
	(0.145)	(0.204)	(0.224)	(0.143)	(0.058)
GOV	1.860***	1.111**	0.604*	0.485**	0.373***
	(0.085)	(0.661)	(0.369)	(0.279)	(0.107)
FD	0.212**	0.988***	0.781***	0.331***	0.163**
	(0.090)	(0.303)	(0.193)	(0.127)	(0.065)
FD*GOV	-0.459***	-0.401**	-0.231**	0.062**	0.119***
	(0.068)	(0.231)	(0.151)	(0.109)	(0.040)
GDP	2.004***	2.773***	1.898***	1.673***	1.424***
	(0.262)	(0.266)	(0.282)	(0.196)	(0.165)
RENT	-0.116***	0.163***	0.173***	0.122***	0.087***
	(0.017)	(0.046)	(0.034)	(0.020)	(0.013)
LCO2	-1.337***	-2.133***	-1.479***	-0.944***	-0.687***
	(0.249)	(0.309)	(0.261)	(0.225)	(0.139)
LFDI	0.027***	-0.013	-0.008	-0.040***	-0.039***
	(0.004)	(0.013)	(0.013)	(0.015)	(0.009)
LTFP	0.148***	0.250***	0.266***	0.299***	0.114***
	(0.023)	(0.061)	(0.029)	(0.030)	(0.015)
Constant	-48.690***	-44.925***	-28.167***	-26.385***	-22.476***
	(4.493)	(4.079)	(4.485)	(2.456)	(2.530)
Sparsity	10.1371	3.3351	2.2177	4.5517	3.2113
Quasi-LR statistic	23.1377	50.9193	90.1317	111.1324	130.4571
Prob (Quasi-LR stat)	0.000****	0.000****	0.000****	0.000****	0.000****
Observations	279	279	279	279	279

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.10

To investigate the heterogeneous distribution of the estimated quantile parameters, we implemented the Quantile slope equality test and Symmetric quantiles test. The results are presented in Tables 8 and 9. The Wald's test statistic contrasts all the considered quantiles coefficients, resulted from the estimated equations for both slope equality quantile test and symmetric test quantiles.

Table 8 shows that Wald's test statistic value is about 212.15 and statistically significant at 1% level. This suggests that the coefficients are heterogeneous and differ across quantile values and the conditional quantile are not identical. In addition, the overall p-value of the Wald test in table 9 is about 104, and statistically significant at 1% level, suggesting evidence of asymmetry across the considered quantiles. The results of these two tests support the choice of quantile modeling.

Table 8

Wald's quantile slope equality test

Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Wald Test		212.1554	32	0.0000
Restriction Detail: b(tau_h) - b(tau_k) = 0				
Quantiles	Variable	Restr. Value	Std. Error	Prob.
0.1, 0.25	LPOLS	0.076097	1.356026	0.9552
	LGOV	-0.058470	0.572730	0.9187
	LGOVFD	0.577897	0.392666	0.1411
	LFDI	-0.019470	0.028290	0.4913
	LDCPS	-2.359986	1.506380	0.1172
	LCO2	-0.241044	0.196594	0.2202
	LRENT	0.090145	0.149500	0.5465
	LTFP	-0.063574	0.087305	0.4665
0.25, 0.5	LPOLS	-0.438059	0.209953	0.0369
	LGOV	0.750311	0.394508	0.0572
	LGOVFD	-0.170343	0.159131	0.2844
	LFDI	0.062730	0.032798	0.0558
	LDCPS	0.111059	0.537703	0.8364
	LCO2	0.333464	0.116190	0.0041
	LRENT	-0.093546	0.079213	0.2376
	LTFP	-0.047192	0.099197	0.6343
0.5, 0.75	LPOLS	-0.061546	0.200576	0.7590
	LGOV	-1.062593	0.374454	0.0045
	LGOVFD	0.245568	0.152837	0.1081
	LFDI	0.034960	0.031761	0.2710

	LDCPS	-0.706337	0.502634	0.1599
	LCO2	-0.199227	0.139715	0.1539
	LRENT	0.071065	0.043722	0.1041
	LTFP	-0.072257	0.134872	0.5921
0.75, 0.9	LPOLS	-0.168143	0.202790	0.4070
	LGOV	-0.796798	0.518260	0.1242
	LGOVFD	0.274880	0.154586	0.0754
	LFDI	0.009041	0.035876	0.8010
	LDCPS	-0.777837	0.453585	0.0864
	LCO2	0.084190	0.151494	0.5784
	LRENT	-0.005918	0.046945	0.8997
	LTFP	0.179745	0.143109	0.2091

Table 9
Wald symmetric quantiles test results

User-specified test quantiles: 0.1 0.25 0.5 0.75 0.9
Test statistic compares all coefficients

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Wald Test	103.8231	18	0.0000

Restriction Detail: b(tau) + b(1-tau) - 2*b(.5) = 0

Quantiles	Variable	Restr. Value	Std. Error	Prob.
0.1, 0.9	LPOLS	-0.132271	1.391236	0.9243
	LGOV	2.551233	0.939417	0.0066
	LGOVFD	-0.112893	0.497720	0.8206
	LFDI	-0.000741	0.073325	0.9919
	LDCPS	-0.764753	1.808703	0.6724
	LCO2	0.207457	0.255863	0.4175
	LRENT	-0.068548	0.186902	0.7138
	LTFP	-0.218253	0.202648	0.2815
	C	-8.370860	7.009424	0.2324
0.25, 0.75	LPOLS	-0.376512	0.296709	0.2045
	LGOV	1.812905	0.574623	0.0016
	LGOVFD	-0.415910	0.242517	0.0864
	LFDI	0.027770	0.054806	0.6124
	LDCPS	0.817396	0.818059	0.3177
	LCO2	0.532691	0.173746	0.0022
	LRENT	-0.164611	0.096335	0.0875
	LTFP	0.025066	0.173042	0.8848
	C	-8.827494	2.779068	0.0015

The parameter estimates in Table 7 of these models may be interpreted as long-run elasticities coefficients of the determinants of renewable energy production for the MENA countries considered in this study. One of the first things to notice about the estimates in this table is that, almost all the variables considered in the model, the panel estimated elasticities, are remarkably statistically significant.

Looking for the different determinants of renewable energy production, we can first notice that the effect of the political stability index on renewable energy production is clearly heterogeneous. The results indicate that the effect is statistically significant and negative at a 1% level at the lower (10th) and the higher quantile (90th). However, the political stability elasticity is statistically significant and positive at the 25th and the 50th quantile. The positive coefficient of the political stability index is sufficient to support the second hypothesis of this study, i.e. the political stability is a significant driver of renewable energy production in MENA countries. This statement supports earlier claims about the importance of political stability to spur the development of renewable energy sector. In fact, political stability is highly linked with the economic development sustainability and the economic policy uncertainty, which is closely connected to the reliability of access to green energy resources. This implies that political stability is one prerequisite for renewable energy development. In the last decades many factors have renewed interest on the determinants of economic policy uncertainty, including, the last financial crisis of 2007-09, the Eurozone crisis since the end of 2009, the crude oil price crash since 2014, the Brexit vote in 2016, Trump's election in the US and the recent trade tensions between the US, China Russia and Turkey (Bloom, 2009; Popescu et al., 2010; Benchmann et al. 2013; Antonakakis et al., 2014; Degiannakis et al., 2018; Su et al., 2018). Given the existence of ambitious policy goals aimed at fostering renewable energy production in MENA region, the effects of political stability represent a challenging issue for both researchers and policy makers as unintended side effects of the future conditions.

In addition, regarding the government effectiveness variable, the quantile regression model estimates indicate that governess efficiency index has a statistically significant and positive impact on renewable energy production at a 1% level at the10th, 25th; 50th and the higher quantile (90th). The results suggest that governance effectiveness is a significant driver of the renewable energy production in MENA countries. The coefficients' magnitude is ranging from 0.7 to 3.44, which imply that a 1% increase in the governance efficiency index increases the renewable energy production of MENA countries from 0.7% to 3.44%, respectively. It is worth noting, that the effect is more pronounced at the lower quantile, indicating that impact of governance effectiveness is more important in magnitude in low renewable energy production countries. As a result, government authorities in these countries should imperatively enhance their governance effectiveness to succeed in energy sector reforms and take the highest gains from growth in which renewable energy will be one of its key determinants (Saidi et al., 2019). This finding is in line with Bellakhal et al. (2019), who find that good governance is associated with renewable energy investment in MENA countries. They also add country that do not favor governance quality improvements or those in which these improvements could take time, trade openness constitutes a good alternative to increase their investments in renewable energy.

Our findings also show that financial development has a positive statistically substantial effect, at 1% level, across the renewable energy production distribution. The financial development effect is stronger for the 0.25 quantile and weaker for the lowest quantile. This finding suggests that financial development is an important driver to promote renewable energy production in MENA region. This result is consistent with Tamazian and Rao (2010), who find that a developed financial sector is more likely to facilitate financing through environment-friendly technologies with lower costs. Similarly, the importance of financial development in promoting the clean energy sector is coherent with the recent claim in the empirical literature about the importance of financial development as prerequisite to enhance the energy transition (Kim and Park, 2016; Pham, 2019; Anton and Nucu, 2020). Hence, a developed credit sector with easier staged financing facilitates renewable projects (Kim and Park, 2016). In fact, financing is not only a prerequisite to the renewable energy development in MENA Region, but is also fundamental for the ongoing

Research and Development process to enhance economic feasibility, investment in economic agents' awareness, maximizing stockholder engagement, and designing new policy interventions, such us maximizing consumer engagement in green energy investment.

Finally, the interaction between financial development and governance effectiveness significance varies throughout the renewable energy production distribution. We notice that the effect is positive only in cases of the highest quantiles (0.75 and 0.90), which means that there is a complementarity between government effectiveness and financial sector in determining the production of renewable energy in these two quantiles. This result confirms the findings of García (2013), Kim and Park (2016), among others, who see the absence of good governance and well-developed financial sector constitute the most important barriers in promoting the renewable energy projects in developing countries. In the same spirit, by examining the moderating role of governance quality on the nexus between financial development, renewable energy and economic growth, Kassi et al. (2020) also conclude that policymakers in the Asia Pacific, MENA, and SSA regions improve the level of governance quality and the efficiency of financial systems and renewable energy consumption to promote sustainable development.

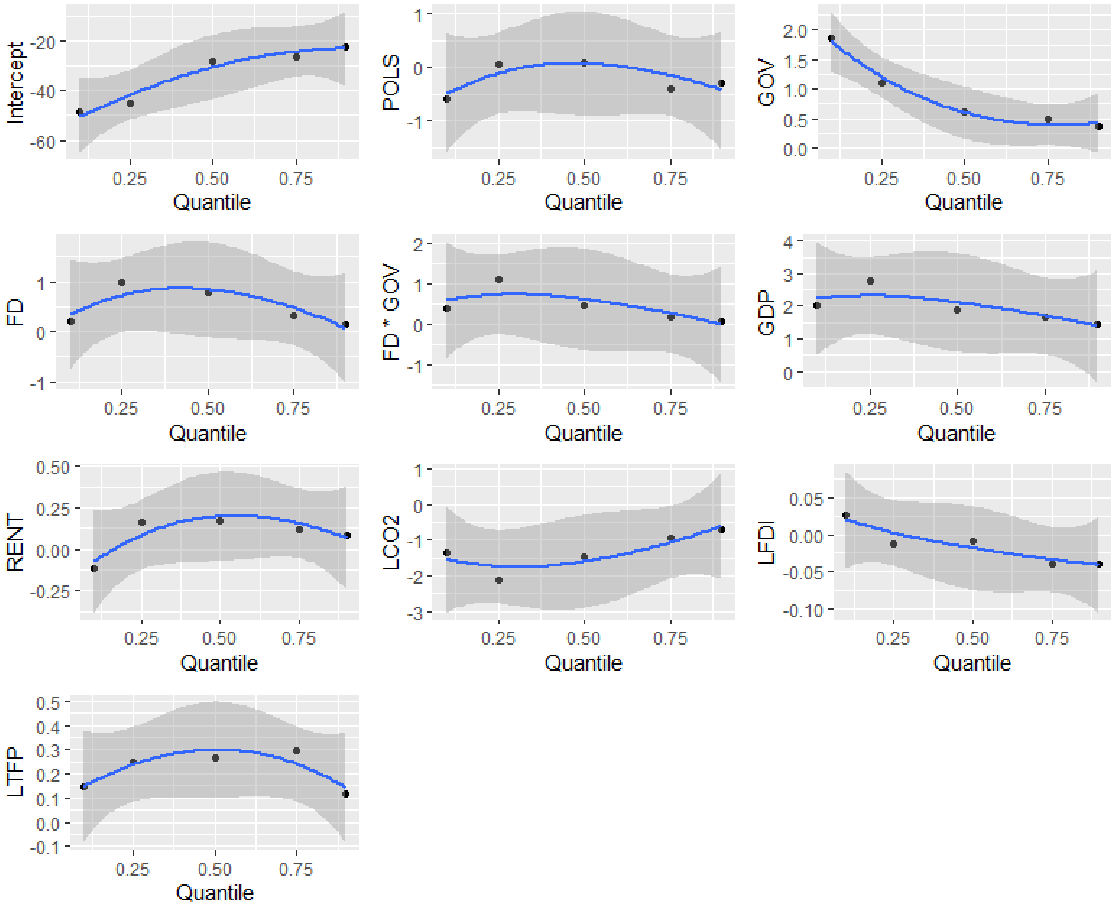

Fig. 1. Quantile process coefficient estimation with 95% confidence intervals Powell (2016).

Regarding the control variables, the findings indicate that GDP has a positive and strong statistically significant effect on renewable energy production in MENA countries. Increase in GDP raises the level of renewable energy production. These results are robust across the entire distribution of renewable energy consumption. The coefficients' magnitude is ranging from 1 to 2.4%. However, the effects are less pronounced at the lower quantile. The impacts of GDP on renewable energy production are almost two times higher for the o.25, 0.50, 0.75, and 0.90 quantiles relative to the 0.10 one; suggesting that rising economic growth leads to more disposable income, which can be used to develop environmental-friendly technology and spur renewables energies deployment. These empirical findings support the claim of Sadorsky (2009), who argued that increases in real GDP is a substantial determinant behind renewable energy consumption per capita in G7 countries. Moreover, Omri and Nguyen (2014) highlighted that GDP has a statistically significant and positive effects on renewable energy consumption for a panel of 64 selected countries. We can suppose the effect of economic growth on renewable energy development in MENA countries seems dependent on the levels of GDP. We also found that the significance of the natural resources dependency coefficients fluctuates across the renewable energy production distribution but without any specific trend pattern. The natural resources dependence affects negatively on renewable energy production in the lower quantile (10^{th}), while the natural resources dependence impacts positively the remaining quantiles. We interpret this as possible evidence of the resources curse in the case of the countries with lower energy production, suggesting that resources endowments in these countries seem to lead to inefficient state behavior, unsustainable budgetary policies and inefficient policy interventions related to energy transition. In terms of FDI, its significance varies across the renewable energy production distribution but without any specific trend pattern. The impact of the FDI is negative with a weaker effect at the 0.25 quantile (-0.001) and turns positive and significant at all other quantiles. The results suggest that foreign direct investment may affect positively renewable energy development in MENA countries, but the effect of FDI is secondary comparing to the effect of GDP. Total factor productivity (TFP), as a proxy of investment quality, has a positive impact on renewable energy production across the quantile distribution and the effect is remarkably similar in sign and magnitude throughout the quantiles. TFP has been used in previous work (Badeeb et al., 2016; Hakimian and Nugent, 2005) and is derived from a standard neoclassical Cobb-Douglas production functions as follow: $Y = A\,K^{\alpha}L^{1-\alpha}$. These results argue that investment efficiency may play an important role in shaping energy transition in MENA region. Furthermore, the findings also show that the impact of trade openness on renewable energy production is clearly homogenous across the quantiles. The resulted coefficients are negative, statistically significant at the 1% level, and notably similar in magnitude. The estimated elasticities range from -0.191 to -0.420.

Robustness check

To examine the robustness of our empirical analysis we develop a Canay's (2011) fixed-effect quantile model, derived from the fixed effect OLS model. Regression estimates are provided in Table 10. The corresponding Canay's panel quantile regression diagrams are displayed in Fig. 2. As we can see from Table 10, broadly, the results of the Canay's model are in agreement with the results of Powell's model, and support our previous assertions regarding the key drivers of renewable energy production in MENA region.

Table 10
Canay's (2011) fixed-effect quantile regression results

VARIABLES	**Q1** **0.10**	**Q2** **0.25**	**Q3** **0.50**	**Q4** **0.75**	**Q5** **0.90**
POLS	-.407**	0.062*	0.098*	-0.406***	-0.432***
	(1.452)	(0.204)	(0.224)	(0.143)	(0.070)
GOV	1.863	1.111*	0.604	0.485*	0.585***
	(1.307)	(0.661)	(0.369)	(0.279)	(0.150)
FD	0.346*	0.988***	0.781***	0.331***	0.238**
	(0.549)	(0.303)	(0.193)	(0.127)	(0.114)
FD*GOV	-0.541*	-0.401*	-0.231	0.062	0.038
	(0.312)	(0.231)	(0.151)	(0.109)	(0.074)
GDP	2.353***	2.773***	1.898***	1.673***	1.818***
	(0.854)	(0.266)	(0.282)	(0.196)	(0.156)
RENT	-0.090	0.163***	0.173***	0.122***	0.117***
	(0.097)	(0.046)	(0.034)	(0.020)	(0.015)
CO2	-1.675**	-2.133***	-1.479***	-0.944***	-1.016***
	(0.834)	(0.309)	(0.261)	(0.225)	(0.146)
FDI	0.029	-0.013	-0.008	-0.040***	-0.022**
	(0.036)	(0.013)	(0.013)	(0.015)	(0.009)
TFP	0.141	0.250***	0.266***	0.299***	0.097
	(0.107)	(0.061)	(0.029)	(0.030)	(0.090)
Constant	-46.441***	-44.925***	-28.167***	-26.385***	-22.667***
	(14.045)	(4.079)	(4.485)	(2.456)	(2.416)
Sparsity	09.7171	3.2351	2.4177	4.7512	3.3111
Quasi-LR statistic	22.9277	49.8197	91.2315	109.1325	129.1370
Prob (Quasi-LR stat)	0.000****	0.000****	0.000****	0.000****	0.000****
Observations	279	279	279	279	279

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.10

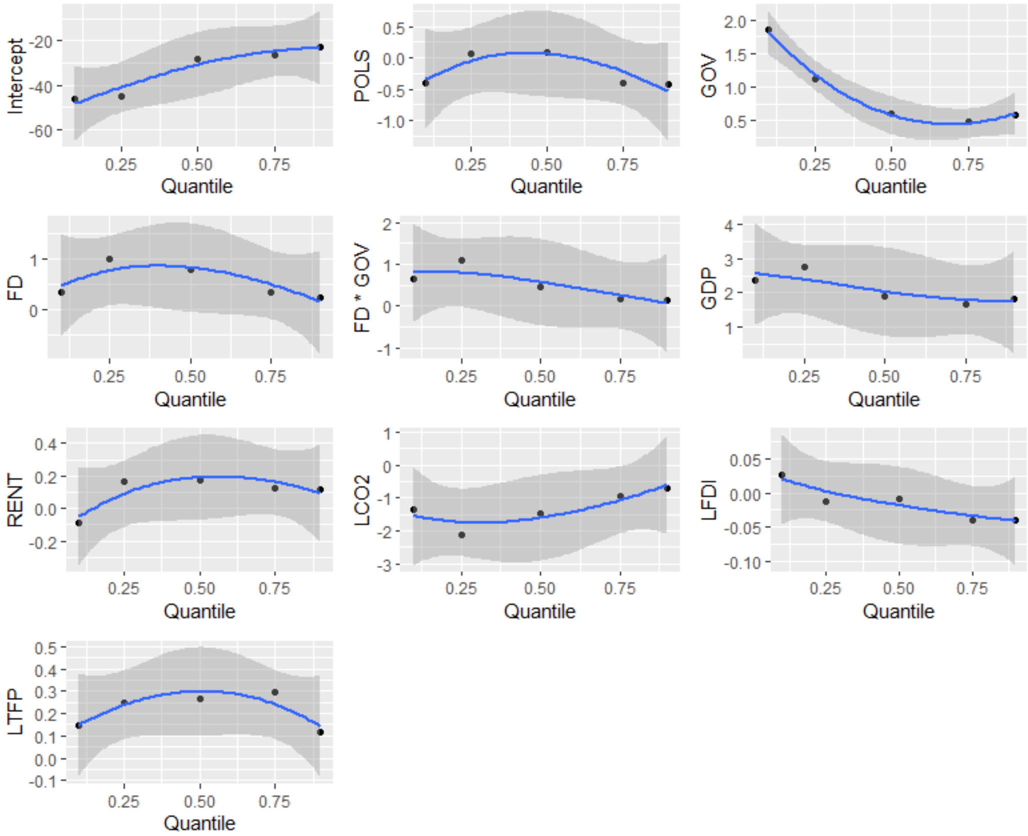

Fig.2. Quantile process coefficients estimation with 95% confidence intervals (Canay's (2011) fixed-effect quantile model)

5. Conclusion and policy implications

Despite potential gains of renewable energy production, little evidences are provided in the literature about the determinants of renewable energy deployment in MENA region. This paper aims to fill the gap in the literature by examining the impact of political stability, quality of governance and institutions, and financial development on the deployment of renewable energy production in 9 selected MENA countries using annual data over the period 1984-2014. In addition, the study aims at investigating the joint influence of governance quality and financial development on deployment of renewable energy. To this end, the study implemented the newly developed estimation technique based on a panel quantile framework with non-additive fixed effects proposed by Powell (2016), which is consistent in the case of short panel and accounts for outliers.

Empirical results shows that the effect of political stability on renewable energy production is heterogeneous across quantiles, where political stability coefficient is statistically significant and only positive at the 25th and the 50th quantile. Furthermore, government effectiveness and efficiency have a positive and statistically significant impact on renewable energy production. Yet, this effect is more pronounced at the lower quantile, indicating that effect of governance effectiveness is more pronounced in low renewable energy production countries such as MENA countries. Findings also show that financial development has a positive statistically significant effect across the distribution of renewable energy production. More importantly, the interaction term between governance effectiveness and financial development is negative for lower quantiles but positive for highest quantiles. These findings support our hypotheses that political stability, governance effectiveness and financial development are important drivers for promoting renewable energy production in MENA region. Overall, these results appear to be robust to the estimation approach and are consistent with prior literature such as (e.g., Painuly and Wohlgemuth, 2006; García, 2013).

From a policy perspective, the findings of this research have several potential policy implications that encourage renewable energy production in the MENA region. The study recommends further developments and improvements in the governance quality and financial sectors in the MENA region. On the one hand, countries with good regulatory practices, enforcement of laws, and politically stable systems would be in a better position to foster renewable energy production and meet their social and economic objectives in general. On the other hand, well-developed financial systems tend to promote and encourage the production of renewable energy through easier access to finance and more efficient and cheap financing opportunities for renewable energy firms.

Finally, the paper also emphasises the complementary relationship between high-quality governance, financial development, and the production of renewable energy as a way of promoting and achieving sustainable development in the MENA region. A sound institutional environment coupled with high-quality governance and a more developed financial system would have a positive impact on the production of renewable energy. Policymakers can leverage the effects of financial development and high-quality governance by enacting legislations and policies that progressively enforce the expansion of renewable energy technologies that are cost-competitive compared to conventional energy sources and smoothing the availability of finances and public funds to leverage and encourage firms to invest in renewable energy projects and deployment of cost-efficient renewable energy technologies.

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Appendix

A1. Predictors Variance inflation factors

From Table A1, we notice the all the VIF values are less than 5, with an average value of 1.6. This confirms the absence of autocorrelation issues in our model.

Table A1.
Predictors Variance inflation factors

Variable	VIF	VIF
LGOV	2.37	0.422018
LDCPS	2.12	0.472796
LPOLS	1.51	0.661730
LFDI	1.45	0.687462
LCO2	1.20	0.833938
LTFP	1.06	0.939168
Mean VIF	1.62	

A2. Normality test

Figure A displays the distributions of the residuals. The shape is not quite normal. However, this will not undermine the robustness of our results. Although normality is not a mandatory requirement in panel data analysis, in this study we use a quantile model, which is a robust procedure that does not assume a particular parametric distribution for the response, nor does it assume a constant variance for the response, unlike standard panel regression.

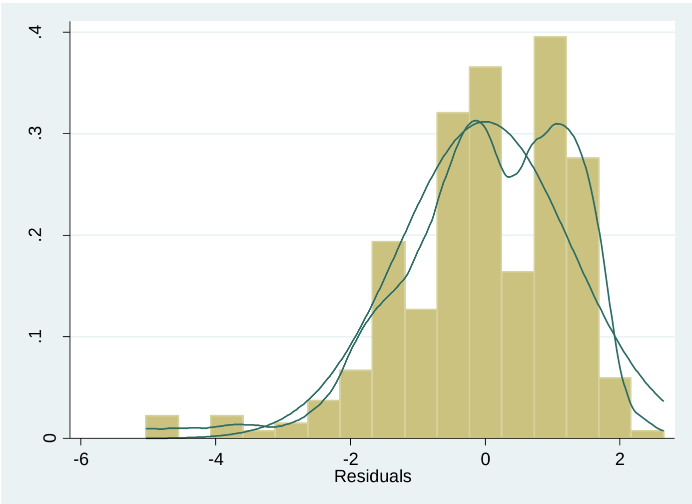

Figure A2. Residuals distribution.

A3. Panel Autocorrelation test:

Table A3.

Wooldridge test for autocorrelation results

H0: no first-order autocorrelation	
F(1, 8)	3.252
Prob > F	0.0715

A4. Breusch-Pagan heteroskedasticity Test

We use the Breusch-Pagan to test investigates the presence of heteroskedasticity in the model. The results shown in Table A4, fail to reject the null hypothesis, suggesting that the residuals of our model are homoscedastic.

Table A4

Breusch-Pagan Test results output for cross-sectional data

$\text{Test} - \text{statistics} = 1.44$
$\text{p} - \text{value} = 0.11$

A5. Ramsey specification test

The results of Ramsey RESET test in table A5 suggest that there is no evidence of misspecification.

Table A5

Ramsey RESET test using powers of the fitted values of LRENP

Ho: model has no omitted variables	
F(3, 269)	0.025
Prob > F	0.607