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Revue de littérature sur la relation entre les énergies vertes et la croissance économique : Une comparaison régionale critique

Literature survey on the relationships between green energy and economic growth : A critical regional comparison

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Résumé

L'objectif de ce travail de recherche est d'étendre la revue de la littérature croissante sur le lien entre les énergies renouvelables et la croissance économique. La méthodologie adoptée est à la fois descriptive, comparative et critique afin de souligner les différences entre les études qui portent sur un seul pays ou une seule région. Les conclusions de ces études sont fragmentées en raison des diverses méthodologies adoptées et de la nature spécifique de chaque région analysé. Les politiques du pays influencent de manière significative son efficacité énergétique. L'enquête met en exergue les principales lacunes des études passées et ouvre la voie à d'autres pistes de recherches futures. La principale implication étant le fait d'inclure la variable environnementale dans ce genre d'études pour avoir une vision plus large sur l'impact environnemental et évaluer le potentiel de ces énergies vertes en matière de réduction de la pollution. L'analyse désagrégée de l'impact énergétique est également sous explorée.

Mots clés :

Energies renouvelables ; Croissance économique ; Revue de littérature ; Comparaison régionale ; Développement énergétique

Abstract

The objective of this study is to extend the review of the growing literature on the link between renewable energy and economic growth. The methodology adopted is descriptive, comparative and critical in order to highlight the differences between studies that focus on the same country or region. The country's policies significantly influence its energy efficiency. The survey highlights the main shortcomings of past studies and paves the way for further research. The main implication is the inclusion of the environmental variable in such studies to gain a broader view of the environmental impact and assess the potential of green energy to reduce pollution. Disaggregated analysis of energy impact is also under-explored.

Keywords :

Renewable energy ; Economic growth ; Literature review ; Regional comparison ; Energy development

Introduction

Ecological concerns and energy dependence have pushed all countries to seek alternative sources. This has prompted researchers and policy makers to turn to renewable energy sources that promise safe and environmentally friendly supplies. Thus and since their emergence, the impact of renewable energies on countries' economies has been widely discussed. Several research studies have examined this link in different countries using different econometric methodologies over several periods. To our knowledge, studies examining solely the literature on the energy-growth link are scarse : Ozturk (2010); Payne, (2010a); Omri, (2014) and Tiba and Omri (2017). Adewuyi and Awodumi (2017) were the only ones to include renewable energy in their study. The period covered by previous studies ends in 2016, while several studies were addressed afterwards. Moreover, previous studies focused only on the the narrative method ; Adewuyi and Awodumi (2017) are the only ones who incorporated the description of studies.

Therefore, the objective of this article is to systematically review the main work linking renewable energy and economic growth and then to rank them clearly in order of importance to identify gaps and opportunities for further research. At this stage it is appropriate to ask : What impact do these new forms of energy have on the economic growth of countries ?

Our study combines the description of the studies as well as the discussion, comparison and criticism of single country and multi-country studies published between 2007 and 2019.

To delimit the number of results, we used the following keywords : "Renewable Energy", "Economic Growth", "GDP" and "Causality Link". The studies reviewed are published in both peer- reviewed and non-peer-reviewed journals and include all types of empirical contributions. Furthermore, we excluded highly technical studies that focus on the technological side, this seems justified considering the objective of this work.

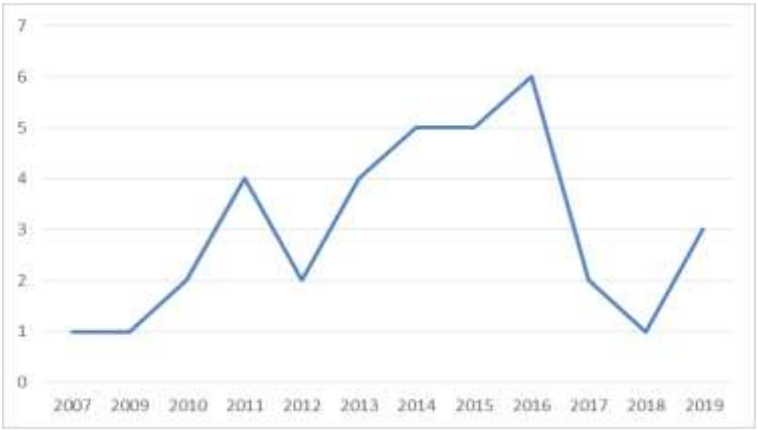
It should be noted that the research context is international and the original language of studies is english. 37 studies were retained for analysis

Our article consists of the following: In the first part, we will present the literature review on the renewable energy-growth nexus by conducting an external observation of the studies and then in the second part, we were going to proceed with a deep analysis and comparison of the results highlighting the differences between the studies that cover the same region. The main criticisms Scientific and policy implications are presented in the conclusion.

1. The literature on the causality between renewable energy and economic growth : A descriptive analysis

The first observation that emerges from (Figure 1) is that most studies between renewable energy and growth were conducted between 2012 and 2017 (68%) with a peak in 2016.
The main objective of these studies is to assist in the design of energy policies, focused on renewable energy and their impacts on economic growth.

Figure 1: Distribution of studies on the nexus between Renewable energy-Growth

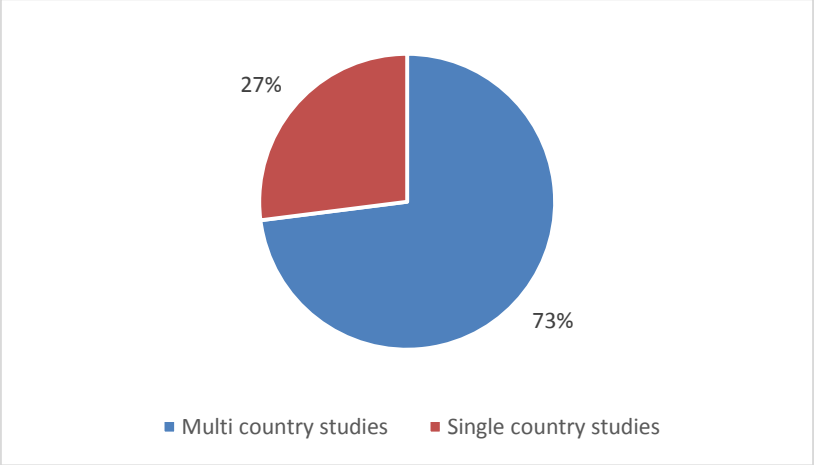


Source : Authors

An observation of the structure of the reviewed studies reveals a distinction between studies that focus on a single country and those that focus on several countries (Figure 2). After analysis, it turns out that there are more studies on multi-country with a percentage of 72% as opposed to 28% which concern a single country. In the studies that were conducted on a single country, we notice a dominance of USA (35%).

The analyses include mainly developed and emerging countries, while studies on developing countries are rare (they are usually included in other panel studies). This can be explained by the fact that the use of renewable energy in most developing countries is still in its embryonic stages.

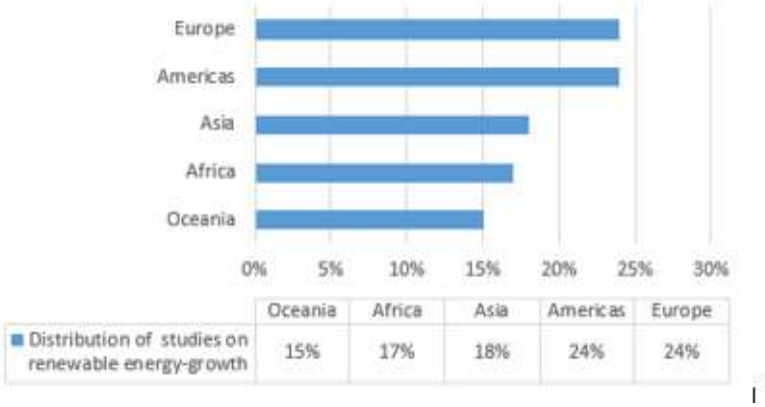
Figure 2 : Distribution of multi country and single country studies



Source : Authors

Most of the studies were conducted in Europe (24%) and America (24%). Next come Asia (18%), Africa (17%) and Oceania (15%) (Figure N° 3). The variables used in the studies differ : almost the majority of cases (95%) used GDP to measure economic growth.

Figure 3 : Distribution of studies on Renewable energy-Growth all over the world



Source : Authors

Most studies or analyses are disaggregated. They have considered the consumption of renewable energy, all branches combined as a variable (81.25%), while others have chosen to study only one specific branch (18.75%) such as biomass consumption (Aslan (2016) ; Bildirici (2013) ; Bilgili and Ozturk (2015) ; Ozturk and Bilgili (2015) ; Payne (2011b) ; Shahbaz, Rasool, Ahmed & Mahalik (2016)).

The authors in their work also include other variables that play an important role. Of particular note are Labor and Capital. The most common distinctions found among the

authors are the hypotheses deduced from their studies. We distinguish four possible scenarios : Growth[1]; Conservation[2]; Feedback[3] and Neutrality[4].

The reviewed studies on the causal relationship between renewable energy consumption and economic growth used a wide range of methodologies : VECM-Granger causality (29%), OLS, FMOLS and DOLS methods (29%), ARDL (16%), Toda Yamamoto (5%) and other varied methodologies (21%).

2. The literature on the causality between renewable energy and economic growth : A critical analysis

2.1. United States

Studies by Aslan (2016) ; Payne (2011b) ; Yildirim, Saraç & Aslan (2012) specific to the United States point in the same direction and conclude that the consumption of energy from biomass leads to an increase in GDP. Using the Toda-Yamamoto procedure, Payne (2011b) examines the relationship between biomass energy consumption and real GDP in the United States over the period 1949-2007 by including other variables such as gross fixed capital formation and labor. The Granger causality test reveals a positive causal link from biomass energy consumption to real GDP. The author also argues that biomass energy consumption has a positive impact on capital formation and employment. The study of Aslan (2016) complements the Payne (2011b) study and confirms the same results.

Note that all the studies that have dealt with the link between biomass energy consumption and economic growth even those outside the united states have a certain consensus, they reveal the hypothesis of growth (Bilgili & Ozturk (2015); Ozturk & Bilgili (2015)) and feedback (Bildirici (2013); Shahbaz and al. (2016).

While the study by Yildirim and al. (2012) confirms a single growth hypothesis, Bilgili (2015) carried out a study that aimed to analyze the interrelation between the consumption of renewable energies (coal, natural gas and oil) and industrial production in the United States using wavelet analysis for the period 1981-2013. The author concluded that the consumption

[1] A causality from renewable energy consumption to economic growth.
[2] A causality from economic growth to renewable energy consumption.
[3] A bidirectional causality
[4] Lack of causality

of renewable energy in all sectors has a positive and significant impact on industrial production and consequently on economic growth. This may be due to the establishment of new companies and plants over a specific period. However, the study does not include other variables that could improve the model.

In multi-country studies, Bayraktutan, Yilgör & Uçak (2011) analyze the effect of electricity generation from renewable sources and economic growth as measured by real GDP in 30 OECD countries, including the USA, using panel data from 1980-2007. Pedroni, Kao and Fischer's co-integration tests indicated that there is a long-term causal relationship between the variables, with bidirectionality subsequently proven using the Holtz-Eakin test. This means that renewable electricity generation has a positive impact on economic growth, which in turn, enables even more electricity generation.

Lin, Yeh & Chien (2013) have opted for a division of renewable energy consumption into four sectors, namely industrial energy consumption, residential and commercial energy consumption, transport energy consumption and electrical renewable energy consumption. They are in line with the conclusion of Bayraktutan and al. (2011) and confirm, through linear and non-linear causality tests, the bidirectionality between the consumption of electrical and industrial renewable energies and real GDP. Isik, Dogru &Turk (2018) also confirm the feedback hypothesis for the USA through the innovative Bootstrap panel Granger causality model. However, Halkos & Tzeremes (2014), who highlight in their study the effect of electricity consumption from renewable sources on the economic growth of 36 economies including the USA, did point out the same feedback hypothesis. Only the growth hypothesis is confirmed in the case of developed countries where renewable electricity consumption is an engine of growth.

2.2. China

We note that in the case of China, a contrast in results is present even between multi-country studies. The only study that focused on China is the one by Fang (2011) which, according to him, reveals a strong correlation between welfare economics variables and renewable energy. Using the OLS method, the results of his study indicated that an increase in renewable energy consumption increases real GDP. The author suggested that if the scenario of this impact of renewable energy consumption on indicators of the welfare economy is respected, the benefits by 2050 will be promising. However, the impact of Share of renewable energy sources is not

really related to indicators of welfare economics : it could be mainly due to policy and institutional factors.

The other studies that have dealt with the case of China are cross-country, Bayar & Gavriletea (2019) investigated the effects of energy efficiency measured by the growth rate of GDP per unit of energy consumed and renewable energy consumption on economic growth measured by real GDP. Over the long term, empirical results have indicated that energy efficiency has a positive influence on economic growth, unlike the consumption of renewable energy, which has no effect on the latter. In the short term, economic growth is impacted by renewable energy consumption and energy efficiency, respectively, confirming the growth hypothesis.

Bhattacharya, Paramati, Ozturk & Bhattacharya (2016) examine the effects of renewable energy consumption on economic growth in 38 countries selected according to the RECAI[5] index developed by Ernst and Young, which ranks the most attractive countries for investment in renewable energy. To do this, the authors used estimation techniques on panel data for the period 1991-2012, during which most of the initiatives were undertaken. The results reveal heterogeneity and cross-country dependence. The analysis of long-term production elasticities reveals a division of countries into three broad categories. China is part of the group for which the authors recognize that renewable energy is a major driver of economic growth. Contrary to previous results that favor the growth hypothesis.

The study conducted by Ozcan & Ozturk (2019) analyses the dynamics between renewable electricity consumption and economic growth for 17 emerging countries over the period 1990-2016. Using Bootstrap techniques and the Konya causality test, they deduce a lack of link between all the variables, which supports the hypothesis of neutrality for 16 emerging countries including China. According to the authors, this could be explained by the low level of production and consumption of renewable energy in emerging countries as opposed to developed countries. Halkos & tzeremes (2014) also support the absence of a link in emerging countries, including China, this is mainly due, according to the authors, to barriers to the implementation of renewable energy sources owing to costs, regulatory policies and market efficiency factors.

[5] Renewable Energy Country Attractiveness Index

Other studies also conducted on China point to the feedback hypothesis. (Amri, 2017 ; Apergis & Danuletiu, 2014). The study by Amri (2017) revealed by the co-integration and causality tests the existence of a feedback relationship between renewable energy consumption and economic growth, between trade and renewable energy consumption and between trade and economic growth in all countries, indicating that these variables are interdependent. Apergis & Danuletiu (2014) first estimated a model that includes capital and labor measures in addition to renewable energy consumption and real GDP using multivariate error correction methods for 80 countries over the period 1990 to 2012. They then conducted the Granger causality test to determine the direction of causality between the variables.

The study of the selected samples leads to the conclusion that the consumption of renewable energy leads to an increase in GDP in the long term. Similarly, the increase in GDP leads to an increase in the consumption of renewable energy, which means that the feedback hypothesis is confirmed. Isik and al. (2018) and Sadorsky (2009), for their part, approve the conservation hypothesis. Isik and al. (2018) confirm through its study on a set of 7 countries, using the Innovative bootstrap panel Granger causality model, a unidirectional link from economic growth to renewable energy consumption in China. Sadorsky (2009) estimates two empirical models of renewable energy consumption in emerging countries.

The author stresses the importance of the conclusion that the elasticity between renewables and income is much higher than the elasticity between electricity and income. The growth of renewable energy consumption in emerging countries will become faster as economic development continues. Finally, the study by Shahbaz and al. (2016) supports the feedback hypothesis for China, the authors examine the relationship between biomass energy consumption and economic growth for a panel of BRICS countries for the period 1991-2015 by incorporating other explanatory variables, namely gross fixed capital formation and trade openness. The results of the VECM confirm the existence of a co-integration between the variables and the causality test shows the presence of a feedback link between biomass energy consumption and economic growth, hence the need to take this type of energy into consideration.

2.3. Turkey

The contrast between single and multi-country studies also extends to the case of Turkey, Ocal & Aslan (2013) examine the relationship between renewable energy consumption, capital, labor and economic growth for Turkey from 1990 to 2010 using the ARDL method and the Toda-Yamamoto causality test. Empirical results indicate that there is a unidirectional link from economic growth to renewable energy consumption, which supports the conservation hypothesis. The author notes, however, that this does not mean that the consumption of renewable energy is not beneficial to the Turkish economy, but that it is relatively low compared to other sources.

Although cross-country studies such as those of Isik and al. (2018) and Sadorsky (2009) agree with the conclusion of Ocal and Aslan (2013), for the case of Turkey. Another stream of cross-country studies conclude different results that support the neutrality hypothesis (Bhattacharya and al. (2016) ; Ben Jebli & Ben Youssef (2013) ; Halkos & Tzeremes (2014) ; Ozcan & Ozturk (2019)).

Also for the case of Turkey, studies by Amri (2017) ; Apergis & Danuletiu (2014) and Bayraktutan (2011) indicate the presence of a bidirectional relationship between economic growth and renewable energy variables.

At the same time, Bayar & Gavriletea (2019) concludes in the case of Turkey that there is a link from renewable energy consumption and energy efficiency to economic growth in the short term. However, in the long term only energy efficiency is responsible for growth. In the same vein, Destek (2016) studies the relationship between renewable energy consumption and economic growth over the period 1971-2011 in the newly industrialized countries of Brazil, India, Turkey, South Africa, Mexico and Malaysia using the ARDL approach to determine co-integration and the Hatemi-J causality test.

In Turkey, only one unidirectional causality is found : a positive shock in economic growth induces a negative shock in renewable energy consumption.

2.4. Pakistan

The studies on the case of Pakistan, on the other hand, reached some levels of agreement. Shahbaz and al. (2016) on the relationship between renewable energy consumption and

economic growth using the Cobb-Douglas production function in the case of Pakistan for the period 1972-2011. The results deduced from the ARDL approach and causality tests indicate that renewable energy consumption and economic growth have a mutual impact. In addition, capital and labor are important factors for economic growth that contribute to the country's domestic production. The same conclusion can be drawn between non-renewable energy and economic growth.

Amri (2017) and Apergis & Danuletiu (2014) obtain the same results from their multi-country studies and defend the feedback hypothesis. Bayar & Gavriletea (2019) puts forward the hypothesis of growth for the case of Pakistan in the short term.

2.5. Germany

The case of Germany has in turn, been addressed by several studies: Rafindadi & Ozturk (2017) investigate the impact of renewable energy consumption on economic growth in Germany over the period 1971-2013 by integrating labor and capital variables and using the Bayer-Hanck combined co-integration test to examine the relationship between all these variables. The robustness of the long-term link was tested using the ARDL approach, while the causal link was inferred through the Granger causality test (VECM). The results indicate that the variables are co-integrated over the long term and that capital and labor have a significant impact on growth prospects.

The causality test reveals the existence of a feedback relationship between renewable energy consumption and economic growth, between economic growth and capital, between renewable energy consumption and capital and that all three variables are caused by labor.

The feedback relationship is also confirmed by three multi-country studies : Apergis & Payne (2010) ; Apergis & Danuletiu (2014) ; Bayraktutan (2011).

However, other panel studies, including the case of Germany, have confirmed the growth hypothesis : Bhattacharya and al. (2016) ; Bilgili & Ozturk (2015) ; Chang, Gupta, Inglesi-Lotz, Simo-Kengne, Smithers & Trembling (2015) ; Chien & Hu (2007) ; Hung-Pin (2014) and Inglesi-Lotz (2016).

The conservation hypothesis was supported by Kula (2014) and Isik and al. (2018).

The only study that focuses on the German case and defends neutrality is that of Simionescu (2019) which examines the impact between the share of renewable energy sources in electricity and economic growth.

2.6. OECD countries

OECD countries were covered by 4 panel studies, namely Apergis & Payne (2010), Bayraktutan and al. (2011), Kula (2014), Hung-Pin (2014) and Inglesi-Lotz (2016). The period covered by the studies varies between 1980 and 2011.

Apergis & Payne (2010) attempt to explain the relationship between renewable energy consumption and economic growth using panel data for 20 OECD countries over the period 1985-2005. The different co-integration tests revealed the existence of a strong long-term equilibrium relationship between the variables. A two-way relationship in the short and long term has been proven between renewable energy consumption and economic growth.

The empirical results of the study by Bayraktutan and al.(2011) agree with those of Apergis & Payne (2010), and defend the hypothesis of feedback for the same countries studied between renewable electricity generation and economic growth.

However, Kula (2014), which covers 18 countries contradicts these results and confirms the conservation hypothesis for all OECD countries covered by the two previous studies, in addition to Mexico and Poland, which were not covered previously.

Inglesi-Lotz (2016) determines in his study the impact of renewable energy consumption on economic growth measured by GDP in 30 OECD countries which include the countries treated jointly by Apergis & Payne (2010a) and Bayraktutan and al. (2011) except Luxembourg and Australia. The author uses panel data in a multi-varied framework based on Douglas' production function. Pedroni's co-integration test revealed a long-term equilibrium relationship between the variables. The results indicate that an increase in renewable energy consumption leads to an increase in GDP. These results thus attest to the presence of a growth hypothesis.

As for Hung-Pin (2014) his results are conflicting. He confirms the conservation hypothesis for the case of Italy (joined the conclusion of the Kula (2014) study) for the United Kingdom in the short term. However, in the long term, he demonstrates the existence of a growth

hypothesis for Germany, Italy and the United Kingdom (joined Inglesi-Lotz (2016), conservation for the USA and Japan (joined Kula (2014) for Japan) and neutrality for France, Denmark, Portugal and Spain.

2.7. African countries

By reviewing the studies that cover African countries, we will compare the results across studies and highlight the contrasts between the findings of multi-country studies.

Ben Aïssa, Ben Jebli & Ben Youssef (2014) examine the relationship between renewable energy consumption, trade and production in a sample of 11 African countries over the period 1980-2008. The Granger test indicates that there is a mutual relationship between production and trade in the short and long term, which means that international trade has a positive impact on real GDP and contributes to the development of emerging countries. However, there is no relationship between trade and the consumption of renewable energy either in the short or long term.

Furthermore, the authors conclude that there is no relationship between the production and consumption of renewable energy since the quantities of renewable energy consumed are small compared to non-renewable energy sources. In the long term, renewable energy consumption and trade have a positive impact on real GDP.

Hamit-Haggar's (2016) study examines the link between renewable energy consumption and economic growth in a panel of 11 sub-Saharan countries from 1971 to 2007 using co-integration tests that take into account the presence of cross-cutting dependency and structural breaks. The results indicate the existence of a unidirectional relationship in the short and long term from clean energy consumption to economic growth.

The studies of Ben Aïssa and al. (2014) and Hamit-Haggar (2016) on the sub-Saharan countries both support the growth hypothesis for the same countries. Nevertheless, the studies by Abanda, Ng'ombe , Keivani & Tah (2012) says otherwise.

Abanda and al. (2012) who examine the relationship between renewable energy production and economic growth in different African countries divided by regions or by oil production over the period 1980-2008, reveal that the general trend that emerges is the absence of

causality between the variables. The correlation between renewable energy and economic growth is negative only in the case of the Southern African region.

2.8. G7 countries

In the same year 2015, Bilgili & Ozturk (2015) and Chang and al. (2015) examined the relationship between renewable energy and GDP in G7 countries.

Chang and al. (2015) examine the relationship between renewable energy consumption and economic growth in the G7 countries using annual data for the period 1990-2011. To test the causal links, the authors opted for the method proposed by Emirmahmutoglu and Kose which takes into account the cross-sectional dependence and the possible heterogeneity of slopes in a multi-varied panel. The results indicate the existence of a two-way relationship between economic growth and the generation of energy from renewable sources for all countries. However, if we consider countries on a case-by-case basis, we find the hypothesis of neutrality for Canada, Italy and the United States, conservation for France and the United Kingdom, and growth for Germany and Japan.

As for Bilgili & Ozturk (2015), they estimate the impact of biomass consumption on GDP growth in the G7 countries from 1980 to 2009. The variables capital stock, human capital index and biomass consumption are considered as explanatory variables. Co-integration tests and OLS and DOLS analyses conducted in homogeneous and heterogeneous variance panel structures revealed that the long-term elasticity's are positive and significant. Considering all the tests carried out, we can conclude that there is a significant influence of biomass consumption on GDP growth either directly or as a complement to capital and labor, which underlines the growth hypothesis.
We note that Bilgili & Ozturk (2015) concluded the growth hypothesis for all countries, while Chang and al. (2015) specified Germany and Japan by growth.

Conclusion

The objective of this study is to extend the literature review on the link between renewable energy-growth in order to draw conclusions that will be useful to scientific researchers and politicians in their decision-making.

This study observes, describes and compares studies from 2007 to 2019 that examine the dynamics between variables according to several criteria (specific or multi-country, methodology used or aggregated or disaggregated energy) in order to identify existing gaps and open the way for further research.

The difference in the findings of the studies between renewable energy and growth is due to the various methodologies adopted as well as the particular characteristics of the regions analysed. It is important to note that studies using the same methodologies for the same countries have shown mixed results, which underlines the importance of the specificity of each country for policy-makers and also reveals the need to use new methodologies.

Moreover, a main criticism that emerges from some studies is that they do not incorporate enough control variables into their model, they simply examine the impact of renewable energy consumption on growth without taking into account the many factors that also govern economic development. The addition of the variable of fossil energy consumption is not sufficient to improve the quality of the model.

Moreover, the determinants of growth differ from one country to another, although there is a common feature, the authors must take into account the specific context of each country or region and base themselves on it, accompanied by a good literature review to determine the variables that best explain the model.

Some studies that cover several countries must take into account the possible interdependence and heterogeneity between countries in the same panel.

At the managerial level, it is recommended that the policies of a given country be adapted to its context. There is therefore not a single rule to follow and which will define the direction to be followed. Rather, one should always situate oneself in the context and adapt one's policies to one's specificities. The ultimate goal, which is to improve energy efficiency, performance, necessarily requires knowledge of the environment, of the fiscal and financial policies adopted by the country concerned and of all the requirements and restrictions in place there. To summarize, it is fundamentally the knowledge of the environment that will help a government or a company to opt for the right strategies or orientations that are consistent with their energy context.

Future research needs also to consider the environmental dimension. More particular attention should be addressed to developing countries such as Morocco, Jordan, Afghanistan, Iran, Saudi Arabia who have a high energy potential and especially the solar. Innovation in the

field of renewable energy should also encourage researchers to explore other less covered energy sources such as Sustainable Natural Gas.

To our knowledge, this study is the first one that organizes a comparison between studies on the same countries and addressing the differences between single country and multi country studies.

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