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RENEWABLE ENERGY AND SUSTAINABLE DEVELOPMENT: EVIDENCE FROM 17 OECD COUNTRIES

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Abstract

The achievement of sustainable development goals is depending on different factors. The aim of this article is to investigate the relationship between the renewable energy and the sustainable development. We employed the endogenous variable the adjusted net savings as the sustainable development factor, the renewable energy consumption as the exogenous variable, following by the control variables the gross fixed capital formation and the labour force. This work is done for 17 OECD countries during the period of 1990-2017. We assumed a balanced panel model, and we employed a panel random effect model and a panel ARDL cointegration model. The outcomes showed that the renewable energy consumption has a negative and significant impact on the adjusted net saving in the short-run, but in the long-term the renewable energy consumption has a positive influence on the sustainable development factor. Also, a bidirectional panel Granger causality was established between both variables.

Keywords: *The Sustainable Development, The Adjusted Net Saving, The Renewable Energy, OECD Countries, Panel Model*

1. Introduction

The world is no longer the same as it used to be in the past. Today, more than 80% of the energy used in the world comes from fossil sources such as coal, oil and natural gas (Sari Hassoun and Mekidiche, 2018a). However, such sources are becoming scarce and limited, especially with the rise of the energy demand. Thus, such situation can lead inevitably to the drying out of these sources and it will affect negatively the development of any country.

In prevention of such crisis, the world major power was obliged to make researches and studies that will push them to look after new sources as a supplier or as an alternative to fossil energy (Sari Hassoun and Mekidiche, 2018b). Amongst of these sources, there is renewable energy which is considered as a cleaner and an unlimited source. Despite the fact that this cleaner energy has a high cost of its

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technology and innovation machinery, which it makes them almost uncompetitive with fossil fuel for now, but such energy will remain a towering figure to avoid the dependence on fossil-fuel and support the economic growth.

Moreover, most of the developed countries have almost the necessary equipment and machinery that can use the renewable energy suitably, but the developing countries have not enough financial assets that can allow them to support the renewable projects. Nevertheless, many nations are starting to recognize the renewable energy as a good alternative to other energy and they are beginning to make great investments to possess renewables like the installation of solar power plants and wind farms.

Therefore, the adoption of renewables will give an extra support to any country and will allow realising impeccably the objectives of sustainable development, which are 17 objectives described by The United Nation for Development Program (UNDP). According to United Nations (2015) and Brundtland (1987), the sustainable development (SD) is a process of changes that makes the exploitation of the resources, the orientation of the investments, and the government institution work together and reinforces their current and future situation to satisfy their needs. The sustainable development process is based on three main objectives, the development of the economic growth (economic objective), the satisfaction of human needs, equity and social cohesion (social objective), and reducing the pollution rate (environment objective).

Besides, the renewable energy is considered as a priority for the sustainable development programs, because relying to World Bank and International Energy Agency (IEA), they are approximately two billion people without energy (energy security). According to the Sustainable Energy for all Initiative (SEFA, 2011), which has stated that ensuring the universal access to modern energy services, enhancing the global share of improvement in the energy efficiency and increasing the part of renewable energy in the global energy mix from 15% to 30% in 2030 represent the biggest step forward to achieve the goals of sustainable development. The World Bank, IEA and UNDP have also confirmed that the renewable energy will participate to increase annually the rate of the economic growth per 1 to 2%.

Furthermore, the countries of the Organisation for Economic Co-operation and Development (OECD) see that the implementation of renewables can improve the economic and social well-being of people around the world, and may achieve the sustainable development goals, which enables them to reach profitability, increase the energy supply, and reduce costs and time.

Several studies used the variable of Gross Domestic Product as the indicator of economic growth or sustainable development or the Human Development Index representing sustainability (You, 2011). However, GDP or other indicators are insufficient to evaluate the sustainable development. Indeed, GDP cannot measure environmental damage and it is inefficient for quantifying social welfare (Gasper et al., 2017). As Hamilton argued, genuine savings (GS) index includes all kinds of capital and captures the depreciation of both man-made and natural capital. Based on intertemporal optimisation with underlined social welfare, GS "equate to a modification of the so-called Hartwick rule" and serve as an indicator of weak sustainability (You, 2011).

In the light of this statement, the objective of this paper is to analyse the effect of renewable energy on the genuine savings for 17 countries of OECD over the period of 1990-2016. We shall make a panel model analysis to describe the dynamic relationship between different variables. This study is divided into 5 sections, introduction, literature review, data and methodology, empirical result and conclusion.

2. Literature review

A number of investigations showed the importance to include the renewable energy into the energy system and its positive relationship with the economic growth (Inglesi-Lotz, 2016; Rafindadi and Ozturk, 2017; Armeanu et al., 2017; Koçak and Şarkgüneşi, 2017; Atems and Hotaling, 2018; Adams et al., 2018; Sari Hassoun and Mekidiche, 2019). These scholars employed different methodologies with several econometrics models, and they used many control variables such as the gross fixed capital formation (capital), the labour force, the non-renewable energy consumption and production, institution variables…etc. Almost all of them concluded for a positive and significant link among renewable energy and gross domestic product, indicating that the production or the consumption from renewable sources increases the level of the economic growth. However, (Gasper et al., 2017) stated that GDP cannot evaluate the level of sustainable development, because it does not take into consideration the social and environment aspect. Also, Sari Hassoun et al. (2018) demonstrated that the human development index can be a good variable to measure the social aspect of sustainable development, but it does not take into consideration the depletion of natural resources.

According to Stiglitz commission[3] in 2008, the classical macroeconomic instrument like GDP, are insufficient to measure the sustainable development, so the economic growth alone cannot realise the goals of sustainable development.

Despite this, several researchers have conducted many studies about different variables and factors of sustainable development, such as the sustained environment, footprint, greenhouse gas, energy consumption…etc. the following scholars (Hamilton, 1994; Hamilton and Clemens, 1999; Pezzey, 2004; Gnégné, 2009; Pezzey and Burke, 2014; Boos, 2015; Dupuy et al., 2017) focussed mainly on the variable of adjusted net saving (ANS) as they stated that it is a decent index to quantify the sustainable development in several nations.

As stated by the Environment Department of World Bank[4], the adjusted net saving measures the true rate of saving in an economy after taking into account investments in human capital, depletion of natural resources and damages caused by pollution. Adjusted net saving, known informally as genuine saving, is an indicator that aims to assess an economy's sustainability based on the concepts of extended

[3] https://www.ladocumentationfrancaise.fr/var/storage/rapports-publics/094000427.pdf
[4] http://ec.europa.eu/environment/beyond_gdp/download/factsheets/bgdp-ve-ans.pdf

national accounts. Positive savings allow wealth to grow over time, thus ensuring that future generations enjoy at least as many opportunities as current generations. In this sense, adjusted net saving seeks to offer policymakers who have committed their countries to a “sustainable” development pathway, an indicator to track their progress in this endeavour. The adjusted net saving is derived from the standard national accounting measure of gross saving by making four adjustments, the consumption of fixed capital is deducted to obtain net national saving; the current public expenditure on education is added to account for investment in human capital; estimates of the depletion of a variety of natural resources are deducted to reflect the decline in asset values associated with extraction and depletion; and the deductions are made for damages from carbon dioxide and particulate emissions.

On the other hand, a negative adjusted net saving rate means a decline in the total wealth, especially for the countries that are excessively relying on the exportation of the non-renewable resources. In contrast, almost all developed countries display a positive adjusted net saving. Indeed, the different kinds of capital are considered substitutable: the growth of the economy or the human capital may compensate for the decline of the natural patrimony. Also, the environmental damage is poorly valued in the current version of this indicator.

According to Hamilton (1994), the adjusted net saving is used with different factors and it measures the depletion of human and natural capital. Dietz and Neumayer (2004) and You (2011) confirmed that the adjusted net saving is based on intertemporal optimization with undeclined social welfare, ANS “equate to a modification to the so-called Hartwick rule” and serve as an indicator of weak sustainability. Thus, a negative adjusted net saving will imply a declining utility in the future.

In contrast, the variable of adjusted net saving is not frequently used in several studies that are based on energy-economic growth nexus and also as a factor of sustainable development, so there is not a lot of studies about the relationship between (ANS) and renewable energy. Nevertheless, some scholars (You, 2011; Hanley et al., 2014; Bouacida, 2016) see that the sustainable development depends not only on limited natural resources, which are left for the future generations, but also on how we maintain the quantity and quality of all other renewable natural resources.

Nonetheless, there are some studies about the adjusted net saving and energy. World Bank (1998)[5] stated that a diminution of non-renewable resource (crude oil) will affect negatively the level of the adjusted net saving, especially in the case of Latin and Caribbean America. Dietz et al. (2007) studied the effect of institutional quality and natural resources on adjusted genuine saving over the period of 1984-2001. They found that the variable of natural resources has a negative effect on adjusted genuine saving in the long run. You (2011) analysed the relationship between energy and (ANS) in China during the period of 1980-2004. They found that the consumption from renewables and non-renewables contribute positively to

[5] http://documents.worldbank.org/curated/en/745241468135933997/World-development-indicators-1998

increase the rate of the adjusted net saving. Boos and Holm-Muller (2012) established that the countries, which rely on their natural resources cannot improve the level of their adjusted net saving. Mele (2014) demonstrated that the rate of the adjusted net saving has been negative since 2006 in Mauritania, due to the depletion of natural resources. Behboudi and Moosavi (2014) investigated the connection amongst sustainable development (the adjusted net saving), human development index, the natural resources export and the quality of the government institution (rule of law, political instability…etc.) on 11 MENA countries during the period of 1996-2010. They found with the methodology of panel cointegration that the variable of natural resources has a negative and significant influence on the factor of sustainable development. Boos (2015) showed in his analysis that if the renewable resource growth exceed the level of the natural resource depletion, it will improve the rate of the adjusted net saving for different nations. Blum et al. (2016) conducted an investigation about several countries over the period of 1990-2000 and they stated that the natural resource depletion from renewable and non-renewable energy can decrease the rate of the adjusted net saving in the case of Latin America. Behboudi et al. (2017) employed a Bayesian vector autoregressive to study the link among the adjusted net saving, carbon dioxide emissions (CO2), renewable and non-renewable energy for the case of Iran during the period of 1980-2013. They concluded with impulse response that there is a positive influence of renewable and non-renewable consumption on (ANS), while the adjusted net saving has a positive impact on renewable energy consumption, but a negative effect on non-renewable energy consumption. In 2016, a study[6] showed that a reduction by 13.73% of energy consumption will increase the level of the adjusted net saving by 618,296 $ in Seychelles.

3. Data and Methodology

3.1. Data

In this paper, we shall focus on four variables which are divided by the number of population of each country (per capita), as the population growth is one of the factors of sustainable development and it represents a good tool for comparison between countries in panel analysis, according to different researchers. Then, the variables are transformed into natural logarithm specification, because the coefficient on the natural-log scare is directly interpretable as approximate proportional differences and as elasticity. This transformation has provided us with the following benefits, problems related to dynamic qualifications of the data set are avoided log-linear specification and it gives more consistent and efficient empirical results (Gujarati et al., 2009).

Therefore, this article will focus on a panel of 17 OECD countries (N=17) which are Mexico, Brazil, Chile, Denmark, France, Germany, Netherland, Norway, Spain, Sweden, Switzerland, Turkey, South Africa, Australia, China, India and Korea Republic over the period of 1990-2017 (T=28), so the number of observation was 476. We selected those countries due to their data availability, and they have almost the

[6] http://seychellessustainable.org/wp-content/uploads/2018/09/Case_study_SSTL_Judith_Rybka.pdf

same renewable energy development strategy, but there are some countries that are not included due to unavailability of their data, so did not take them into consideration. The following table describes these variables:

Table 1: Variables Definition

Variables	**Units**	**Data source**
LNREC: Natural logarithm of per capita renewable energy consumption	Ton of oil equivalent	British Petroleum
LNANS: Natural logarithm of per capita adjusted net saving	Current US $	World Bank
LNGFCF: Natural logarithm of per capita gross fixed capital formation	Current US $	World Bank
LNLF: Natural logarithm of per capita labour force	Number of workers	World Bank

3.2. Methodology

The model is based on the neoclassical theory of the growth of Solow (1956) who recognizes the role of the technology and the natural resources into economic activities. Solow (1974) and Hartwick (1977) confirmed that the energy (non-renewable and renewable energy) enhances the level of the economic growth and permit the sustainability.

This study is carried out two panel models, a static panel data analysis under fixed or random effect model, which permits us to estimate coefficients in short-run. However, in the long-run, we should use a panel cointegration model such as the fully modified ordinary least square (FMOLS) or dynamic ordinary least square (DOLS).

Therefore, the 1st panel model can be written as following:

$$\mathrm{LNANS}_{i,t} = a_0 + a_{0i} + a_1\mathrm{LNREC}_{i,t} + a_2\mathrm{LNGFCF}_{i,t} + a_3\mathrm{LNLF}_{i,t} + \varepsilon_{i,t} \quad (1)$$

In Equation (1), i=1,... , n is the country index, t=1,... , T is the time index and $\varepsilon_{I,t}$ is a random disturbance term.

a_0 : Is the intercept term and it is identical for all cross-sections (individuals);

a_{0i} : Defines the term of fixed effect for the countries (i);

However, if the relationship between the endogenous variable and the exogenous variables is not fixed but random, the individual effect cannot be a fixed parameter (a_{0i}), but a random one, thus in this case, we shall reformulate the equation with:

$$\varepsilon_{i,t} = a_{0i} + \Delta_t + v_{i,t} \quad (2)$$

a_{0i}: In this case, the term is random effect for the countries (i);

Δ_t : Represents the temporal effect;

$v_{i,t}$: Designs the error term, which is orthogonal to cross-section and temporal effects

The 2nd panel model is formulated as following:

$$\Delta LNANS_{it} = \beta_1 + \sum_{i=1}^{k} a_{ij}\,\Delta LNANS_{j,t-i} + \sum_{i=0}^{k} b_{ij}\,\Delta LNREC_{j,t-i} + \sum_{i=0}^{k} c_{ij}\,\Delta LNGFCF_{j,t-i} + \sum_{i=0}^{k} d_{ij}\,\Delta LNLF_{j,t-i} + \theta_1 LNANS_{j,t-1} + \theta_2 LNREC_{j,t-1} + \theta_3 LNGFCF_{j,t-1} + \theta_4 LNLF_{j,t-1} + \varepsilon_{jt} \quad (3)$$

Δ : is the 1st variation factor, and k is the ideal lag length.

LNANS: Represents the variable of sustainable development of the country (i) over the period of (t). Generally, the net national saving is equal to gross national saving minus the consumption of fixed capital. However, the adjusted net saving is equal to net national saving plus education expenditure minus energy depletion minus mineral depletion minus net forest depletion minus damage from carbon dioxide emissions minus damage from particulate emissions.

LNREC: Defines the variable of renewable energy consumption of the country (i) over the period of (t). This series takes into consideration the consumption of solar, wind, hydropower, biomass, and geothermal.

GFCF: Is the variable of the capital of the country (i) over the period of (t). It is also a factor of investment in the production process as it can provide a financial support such as the building of different infrastructure based on renewable energy project or the application of sustainable development goals.

LF: Symbolises the number of workers or the labour force of the country (i) over the period of (t).

$\varepsilon_{i,t}$: Denotes the error term or the specified error of the country (i) over the period of (t).

This research is one of the few studies that emphasize the adjusted net saving as a factor of sustainable development in a panel framework of 17 OECD countries over the period of 1991-2017. The aim is to examine the relationship amongst the adjusted net savings, renewable energy consumption, labour force and capital. This work estimate two methods in the short-term (Fixed or random effect panel model) and long-term (ARDL analysis to the cointegration method) using EViews (10) and Stata (15.1). We started by testing the short-term panel model, whether it is affected by a fixed or random effect with the Hausman (1978) test and then estimating the appropriate model.

Afterward, the panel ARDL method was used to analyse the long and short-run cointegration associations between the factors and extract the ECM (error correction version) of the panel characteristics to identify the short-term dynamic. We employ the panel autoregressive distributed lag method due to its additional benefits in the individual briefed form of equation and it could be employed with the investigations factors regardless of whether they were I(0), I(1), or both I(0) and I(1) Pesaran et al. (1995). Then, the panel unit root test was performed to see whether the variables have the same order of integration. Later, the no cointegration assumption can be examined and associated with the assumption of cointegration relating on the F test, which does not have a characteristic allocation that relies on whether the aspects involved in the model are fully I(0), fully I(1), or a combination of I(0) and I(1); the number of estimators; and either the model has a trend, intercept, or both. Keeping in mind the volume of the studied sample of this paper, which is relatively small, the analytical estimations developed by Narayan and Narayan (2005), which are established for the application of a small sample volume (N>20). The test uses panel autoregressive distributed lag bounds, which relies on whether the factors are purely I(0), purely I(1), or a combination of I(0) and I(1). Two groups of main rates were computed; I(0) identified with lower restriction, and I(1) identified with higher restriction. If the F statistics surpass the I(1), we disapprove the null assumption and conclude that there is a cointegration correlation. If they result below the I(0), we cannot decline the null assumption, and if they result between the I(0) and I(1), a derivation cannot be generated properly. Therefore, we end this research with the causality connection between variable with panel Granger causality.

3.2.1. Horizontal Cross-Section Dependent Test

In order to examine the influence of the exogenous variable and the control variables on the adjusted net saving, all series must be stationary in the panel data model to be established. The panel unit root tests to be performed for this purpose vary depending on whether there is a cross-sectional dependence in the model. Therefore, first of all, whether there is a cross-sectional dependency in the model was tested with Breusch-Pagan (1980), Pesaran (2004) with scaled LM statistic, and the average of the pairwise correlation coefficient named the Peasaran CD test.

3.2.2. Panel unit root test

After testing the horizontal cross-section dependence, we shall select the appropriate panel unit root test whether it is the panel unit root test 1st generation with Levin et al. (2002), and Im et al. (2003)…etc, or the panel unit root test 2nd generation when there is an existence of the cross-sectional dependence with Pesaran (2007).

3.2.3. Panel cointegration test

The analyse of the cointegration test in panel data was done with the procedure of Pedroni (1999, 2004), because the method uses 11 different tests that take into consideration the heterogeneity and examines the dynamic relationship in the long-term.

3.2.4. The panel autoregressive model:

In the panel ARDL, we may find model made individually for each cross section and arithmetic mean of coefficients is obtained. This procedure is known as Mean Group (MG) estimator presented by Pesaran and Smith (1995). In MG technique the intercepts, slope coefficients, and error variances are all allowed to differ across cross sections. Then, Pesaran et al. (1997, 1999) popularize novel technique known as Pooled Mean Group (PMG) to estimate nonstationary dynamic panels as with an increase in time period of analysis, dynamic panels; nonstationarity is very important issue. PMG estimator is based on a blend of amalgamating and averaging of coefficients.

4. Empirical Result

4.1. The First Panel Model Estimation

We used an estimation of pooled data to work with the standard error robustness of the estimator of within group, incomplete panel, and heterogeneous panel.

The Hausman test indicates 6.014 (0.11), denoting that we cannot accept the alternative hypothesis, rather we accept the null hypothesis at the level of 1%, so we can say that this panel model can be estimated with a random-effect model.

Therefore, we estimate three panel models (pooled model, panel model with individual random-effect and panel model with individual and temporal effect) described in the table 2.

The regression coefficient was good for both three models, exceeding 0.60, meaning that the three exogenous coefficients explain more than 60% of the model, while the fisher statistic indicates that we cannot reject the alternative hypothesis at the level of 1%, so we can say that the three models are statistically accepted.

The intercept term appears negative and significant at the level of 1%, demonstrating that there are some omitted variables or variables that are not introduced in these models, which affect negatively and significantly the factor of sustainable development.

The variable of renewable energy consumption is negative and statistically accepted at the level of 1%. This coefficient appears very strange due to the importance to include the renewable energy in such countries energy cycle, but this outcome means that such energy is still not convenient for the OECD countries for now (short-term), so maybe some of them have not the necessary equipment that makes the renewable energy reach its maturity and to become a powerful source of income and then achieving the sustainable development goals in the short-run.

The variable of capital is positive and statically accepted at the level of 1%, showing that the investment in such countries is efficient and it can encourage the achievement of sustainable development goals.

The variable of (LNLF) is positive and insignificant for both panel models with random-effect, but for pooled model, the labour force is positive and significant at the level of 1%.

The result of the individual random-effect is presented in the table 3, the outcome demonstrates that 10 countries (Mexico, Chile, Denmark, Netherland, Norway, Sweden, Switzerland, China, India, and South Korea) have a positive effect, denoting that such countries are encouraging the achievement of the sustainable development goals, but the 7 countries (Brazil, France, Germany, Spain, Turkey, South Africa, and Australia) have a negative effect, meaning that they are still not working enough for the adoption of sustainable development.

The finding of the temporal random-effect is displayed in the table 4, so the random-effect coefficients are negative for the periods of 1990-1994, 1996-1999, 2001, 2009, 2012-2014 and 2016, while for the periods of 1995, 2000, 2002-2008, 2010-2011, 2015 and 2017 the coefficients are positive.

4.2. The Second Panel Model Estimation

4.2.1. Horizontal Cross-Section Dependency Results

Table 5 displays outcomes of the cross-sectional dependency test for the model. As a result of Breusch-Pagan test, the coefficient was calculated at 654.109 and the p-value estimated at 0, the Pesaran scaled LM test coefficient was 31.415 and the p-value was calculated as 0 and the Pesaran CD test coefficient was estimated as 6.712 and the p-value was calculated as 0. Since the time dimension in the panel data structure is T=28 and we have 17 countries, N=17, so we can say that T is larger than N. In this case, Breusch-Pagan and Pesaran CD test cross-sectional dependency tests give results that are more consistent. Therefore, relating to both tests, we cannot reject the alternative hypothesis, so there is a cross-sectional dependence in the model and we will use the second generation test of panel unit root test on dependent and independent variables.

4.2.1. Panel Unit Root Results

The table 05 displays the results of the Pesaran (2007) panel unit root test indicate that the test statistic for adjusted net saving was calculated as -5.379 with 0 p-value for model without trend specification and -3.417 with 0 p-value for model with trend specification, thus, the variable has no unit root, so we cannot afford to reject the alternative hypothesis at 99% confidence. However, the test statistic for renewable energy consumption was estimated as 1.761 with 0.961 p-value for model without trend specification and 0.990 with 0.839 p-value for model with trend specification. As a result, the variable has the unit root, so we accept the null hypothesis and there is a unit root at 90% confidence. Therefore, by taking the difference of the series (D_REC), the related test was reapplied. The test calculated as -9.459 with 0 p-value for model without trend specification and -9.349 with 0 p-values for model with trend specification. The unit root hypothesis in this case is rejected in the 99% confidence interval. On the other hand, the test statistic for gross fixed capital formation was estimated as -3.492 with 0 p-value for model without trend specification and -1.352 with 0.088 p-value for model with trend specification. Consequently, this variable has no unit root, so we reject the null hypothesis; rather we accept the alternative hypothesis at 99% confidence and at 90% confidence. Conversely, the test statistic for labour force was calculated as 1.854 with 0.968 p-value for model without trend specification and 3.592 with 1 p-value for model with trend specification, so we established that the variable has an unit root, so we cannot reject the null hypothesis and there is a unit root at 90% confidence. Therefore, by taking the difference of the series (D_LF), the associated test was done again. The test calculated as -9.823 with 0 p-value for model without trend specification and -10.192 with 0 p-values for model with trend specification. Therefore, we accept the alternative hypothesis at 99% confidence interval.

The panel unit root test displays that the adjusted net saving and the gross fixed capital formation series are stationary I(0) on level, but the renewable energy consumption and labour force series are stationary I(1) on the first level.

4.2.2. Panel Cointegration Results

Since we have two variables stationary on level and two series stationary on first difference, we shall perform the panel autoregressive distributed lag. The table 07 indicates the result of the panel cointegration from the statistics of Pedroni. Our findings suggest that both 3 Pedroni models have at least 7 tests of the 11 tests are statistically important at the 1% and 5% scale, so we reject the null hypothesis of no cointegration and we say that the variables move together in the long-run. The implication is that there is a long-run relationship between the adjusted net saving, the renewable energy consumption, the gross fixed capital formation and the labour force.

4.2.3. The Panel Autoregressive Distributed Lag Estimations

The best combination of panel ARDL is chosen based on the smallest value of Schwarz criterion and Hannan-Quinn criterion. After comparing the values we obtain: ARDL (1, 1, 1, 1). We then estimate two panel methods the pooled mean group and mean group. As the p-value of the Hausman test is statically insignificant, the long-run PMG estimator is more appropriate. The error correction term (ECT) is negative and significant at the level of 1%, meaning that there is an evidence of cointegration relationship between variables, so it validates the changes quickness of the factors for assemblage to equilibrium.

Based on the findings of the PMG estimator, the coefficient of renewable energy consumption is positive and significant at the level of 10%, suggesting that a rise by 1 unit in this series can increase the elasticity of the adjusted net saving by 0.053 in the long-run. We can say that the 17 OECD countries are aiming to diversify their energy systems and according to this result these nations will have the necessary technology in the future, which makes the renewable energy an important part in the mitigation of the depletion of natural resources and preserving it for the future generation. This outcome is in line with the studies (Behboudi et al., 2017; You, 2011) and it confirms the objective number 7 of sustainable development (affordable and clean energy). The introduction of such energy can be beneficial for the country and it can enhance the economic level. It will also provide more sustainable energy and may satisfy the energy demand for the future generation in several sectors

The coefficient of gross fixed capital formation is positive and statically accepted at the level of 1%, so an increase by 1 unit in this variable can upsurge the elasticity of the adjusted net saving by 0.89. This outcome displays that such countries are making assets and financial support to increase their national productivity and the achievement of sustainable development goals. However, the series of labour force is positive and insignificant.

4.2.4. The Panel Granger Causality

The panel Granger causality displays that there is bidirectional causality (feedback hypothesis) at the level of 1% between renewable energy consumption and the adjusted net savings, and between gross fixed capital formation and the adjusted net savings. Also, there are four unidirectional causalities (one-way relationship) at the level of 1%; the first causality is from labour force to the adjusted net savings, the second one-way relationship is from gross fixed capital formation to renewable energy consumption, the third causality is from labour force to renewable energy consumption and the fourth relationship is from labour force to gross fixed capital formation.

These findings describe that the renewable energy represents one of the supports for the adoption of sustainable development goals, as is playing a key role in the recognition of sustainable development goals, giving an added-value to the economic sector by satisfying the increasing energy demand, mitigating the effect of pollution and the surplus release of greenhouse gases and also improving the level of well-being of the population.

5. Conclusion

The renewable energy is growing fast around the world and according to expectations; it will occupy a leading position in the overall share of energy consumption (REN21, 2013). (IRENA, 2016) confirmed that the renewable energy does not deplete over a lifetime and they are sustainable sources of energy. Consequently, fast depletion of energy resources, energy scarcity, increasing cost of energy and environmental pollution are the reasons behind the increasing use of renewable energy resources in order to protect societies from the greenhouse effect, destruction of the Ozone layer and air pollution which cause acid rain and smog.

In this paper, we made a model based on two main variables the renewable energy consumption and the factor of sustainable development (adjusted net saving). We found with the random fixed-effect panel that the renewables has a significant and negative contribution to the adjusted net saving in the short-run. However, in the long-term with the panel ARDL model, we showed that the renewable energy consumption has a positive sign and it participates to rise the level of the adjusted net saving. Also, the panel Granger causality shows that there is an evidence of feedback hypothesis amongst renewable energy consumption and the adjusted net savings.

The mission of the Organisation for Economic Co-operation and Development (OECD) is to promote policies that will improve the economic and the social welfare around the world. Therefore, the findings from this research indicate that the 17 countries are still moving together towards achieving a change in their energy consumption process to meet their energy demand. Also, they need to shift their strategy toward the renewable energy for the adoption of the term of sustainable development which opens up other prospects, and it can lead to a common goal that offers a forum where we can combine efforts, share experiences and seek solutions to problems in order to understand what is driving the right economic, social and environmental change.

Notification

In this study, the rules of publication ethics and research ethics were followed. The study was subjected to plagiarism control.

Appendix

Table 2: The First Panel Model

Variables \ Models	Pooled Model	Panel Model With Individual Random-Effect	Panel Model With Individual And Temporal Random-Effect
Intercept	…	-2.451***	-2.470***
LNREC	-0.096***	-0.088***	-0.089***
LNGFCF	1.009***	1.188***	1.184***
LNLF	1.921***	0.546	0.2414
R^2 (Weighted stat)	0.848	0.678	0.659
R^2 (Unweighted stat)	…	0.827	0.827
F statistic	…	332.519***	304.259***
F probability	…	0	0

Source: Done on EViews 10.

Note: *, **, *,** denotes that we can't accept the null hypothesis; but rather we accept the alternative hypothesis at the level of 10%, 5%, and 1%.

Table 3: The Random-Effect Coefficients Estimated from both Individual Random-Effect Panel Model (2nd Model) and Individual and Temporal Random-Effect Panel Model (3rd model)

Countries	2nd Model	3rd Model
	Individual	Individual
Mexico	0.110	0.100
Brazil	-0.327	-0.332
Chile	0.334	0.329
Denmark	0.066	0.078
France	-0.370	-0.371
Germany	-0.164	-0.157
Netherland	0.289	0.298
Norway	0.383	0.394
Spain	-0.388	-0.387
Sweden	0.230	0.242
Switzerland	-0.002	-0.012
Turkey	-0.197	-0.217
South Africa	-0.805	-0.824
Australia	-0.834	-0.828
China	0.637	0.642
India	0.977	0.956
South Korea	0.061	0.064

Source: Done on EViews 10.

Table 4: The Random-Effect Coefficients Estimated from the Individual and Temporal Random-Effect Panel Model (3rd Model)

Period	Coefficient
1990	-0.028
1991	-0.017
1992	-0.032
1993	-0.015
1994	-0.007
1995	0.009
1996	-0.001
1997	-0.001
1998	-0.007
1999	-0.027
2000	0.009
2001	-0.001
2002	0.013
2003	0.010
2004	0.023
2005	0.018
2006	0.031
2007	0.022
2008	0.003
2009	-0.014
2010	0.007
2011	0.005
2012	-0.002
2013	-0.005
2014	-0.002
2015	0.004
2016	-0.003
2017	0.007

Source: Done on EViews 10.

Table 5: Horizontal Cross-Section Dependency Tests

ANS	Coefficient	P-value
REC	-0.089	0
LF	2.056	0
GFCF	0.985	0
Constant	0.324	0.430
R^2	0.848	
F-test	880.826	
Breusch-Pagan LM	654.109	0
Pesaran scaled LM	31.415	0
Pesaran CD	6.71	0

Source: Done on EViews 10.

Table 6: Pesaran 2007 Panel Unit Root Test

Variables	Specification without trend		Specification with trend		Result
	Zt-bar statistic	p-value	Zt-bar statistic	p-value	
ANS	-5.379***	0	-3.417***	0	I(0)
D_ANS	-15.225***	0	-13.419***	0	
REC	1.761	0.961	0.990	0.839	I(1)
D_REC	-9.459***	0	-9.349***	0	
GFCF	-3.492***	0	-1.352*	0.088	I(0)
D_GFCF	-12.317***	0	-10.563***	0	
LF	1.854	0.968	3.592	1	I(1)
D_LF	-9.823***	0	-10.192***	0	

Source: Done on Stata 15.1
Notes: ***, **, *, denote that we accept the alternative hypothesis (significance) at the level of 1%, 5% and 10%.

Table 7: Pedroni Cointegration Test

	Methods	Within Dimension On Pooled Statistic			Between Dimension On Individual Data		
		Tests	Statistic	Prob	Tests	Statistic	Prob
Panel model with trend and intercept	Pedroni (1999)	Panel v-stat	-0.24	0.59	Group p-stat	1.14	0.87
		Panel rho-stat	-1.92**	0.02	Group pp- stat	-4.68***	0
		Panel PP-stat	-7.71***	0	Group ADF- stat	-4.04***	0
		Panel v-stat	-3.80***	0			
	Pedroni (2004)	Panel v-stat	-2.26	0.98			
		Panel rho-stat	-0.23	0.40			
		Panel PP-stat	-4.49***	0			
		Panel v-stat	-4.76***	0			
Panel model with only intercept	Pedroni (1999)	Panel v-stat	2.09**	0.018	Group p-stat	-0.11	0.45
		Panel rho-stat	-2.19**	0.013	Group pp- stat	-3.75***	0
		Panel PP-stat	-5.64***	0	Group ADF- stat	-4.54***	0
		Panel v-stat	-5.28***	0			
	Pedroni (2004)	Panel v-stat	0.11	0.45			
		Panel rho-stat	-1.62*	0.051			
		Panel PP-stat	-4.01***	0			
		Panel v-stat	-4.42***	0			
Panel model without trend and intercept	Pedroni (1999)	Panel v-stat	3.25***	0	Group p-stat	-0.93	0.17
		Panel rho-stat	-2.99***	0	Group pp- stat	-4.53***	0
		Panel PP-stat	-6.20***	0	Group ADF- stat	-5.32***	0
		Panel v-stat	-6.10***	0			
	Pedroni (2004)	Panel v-stat	1.10	0.13			
		Panel rho-stat	-2.24**	0.012			
		Panel PP-stat	-4.05***	0			
		Panel v-stat	-4.32***	0			

Source: Done on EViews 10
Notes: ***, **, *, denote that we accept the alternative hypothesis (significance) at the level of 1%, 5% and 10%.

Table 8: Empirical Result of PMG and MG

D(LNANS)	PMG			MG		
	Long run equation					
	Coefficient	**z-stat**	**Prob**	**Coefficient**	**z-stat**	**Prob**
REC	0.053*	1.881	0.06	0.211**	2.11	0.03
GFCF	0.892***	11.737	0	1.557***	6.58	0
LF	0.359	0.636	0.52	0.223	0.09	0.93
	Short-run equation					
ECT	-0.372***	-6.890	0	-0.579***	10.6	0
D(REC)	-0.0581	-0.503	0.61	-0.392	-1.35	0.17
D(GFCF)	1.050***	8.448	0	1.030***	6.30	0
D(LF)	-0.384	-0.239	0.81	-4.052**	-2.04	0.04
C	0.076	1.357	0.17	3.10*	1.79	0.07
Hausman MG test	1.38	0.711				

Source: Done on Stata 15.1

Notes: ***, **, *, denote that we accept the alternative hypothesis (significance) at the level of 1%, 5% and 10%.

Table 9: Panel Granger Causality

Null Hypothesis:	**F-Statistic**	**Prob.**
REC does not Granger Cause ANS	9.33***	0.0024
ANS does not Granger Cause REC	11.43***	0.0008
LF does not Granger Cause ANS	8.411***	0.0039
ANS does not Granger Cause LF	0.487	0.4854
GFCF does not Granger Cause ANS	17.18***	4.E-05
ANS does not Granger Cause GFCF	21.86***	4.E-06
LF does not Granger Cause REC	11.77***	0.0007
REC does not Granger Cause LF	0.765	0.3821
GFCF does not Granger Cause REC	14.77***	0.0001
REC does not Granger Cause GFCF	0.734	0.3919
GFCF does not Granger Cause LF	0.178	0.6726
LF does not Granger Cause GFCF	8.03***	0.0048

Source: Done on Eviews 10

Note: ***, **, *, denote that we accept the alternative hypothesis (significance) at the level of 1%, 5% and 10%.

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