Causality between energy, carbon, and economic growth: empirical evidence from the European Union

Janda, Karel and Torkhani, Marouan

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Causality between energy, carbon, and economic growth: empirical evidence from the European Union[#]

Karel Janda[*] – Marouan Torkhani[**]

Abstract. This paper examines the relationship between energy consumption and economic growth and between energy consumption and greenhouse emissions for the EU countries, using time series data from 1996 to 2012 within a multivariate framework for 26 EU countries. The energy sources considered are oil consumption, natural gas consumptions, and renewable energies including biomass as a distinct part. Unit Root Tests, cointegration test, Pairwise Granger causality tests, and Error Correction Model are employed to find out the type of the causal relationship. We find out that there is in the short run, a positive unidirectional causal relationship running from oil consumption to economic growth. There is also a positive bidirectional causal relationship between renewable energies and economic growth and between greenhouse emissions and economic growth. However, there is also an unexpected negative bidirectional causal relationship between biomass consumption and gas consumption. From the greenhouse emissions perspective, we can see in the short run, a negative bidirectional causal relationship between greenhouse emissions and renewable energies, and a positive unidirectional causal relationship running from both oil consumption and biomass consumption to greenhouse emissions.

Key words: Economic growth, energy consumption, oil consumption, natural gas, renewable energies, biomass

JEL classification: Q28, O40, Q42, Q43

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[*] Karel Janda; Department of Banking and Insurance, University of Economics, Prague, W. Churchilla 4, 13067 Praha 3, Czech Republic and Institute of Economic Studies, Charles University, Opletalova 26,11000 Praha 1, Czech Republic, E-mail: Karel-Janda@seznam.cz

[**] Marouan Torkhani; Institute of Economic Studies, Charles University, Opletalova 26,11000 Praha 1, Czech Republic, E-mail: marotorkhani@seznam.cz

1-Introduction:

This paper is a follow up to Chang (2010), where he was able to prove Granger causality between energy consumption and economic growth at first plan and between energy consumption and carbon emissions at the second plan. The main base for this paper is going to be the panel Granger causality, using first the Pairwise granger causality, and then using the Error Correction Model based on Engle and Granger's two steps method. The data will cover almost all the European Union except two countries for a period from 1996 to 2012.

The data can be found in the Eurostat web pages where is gathered most of European statistics. The variables will be as following, Gross Domestic Product, Greenhouse emissions, biomass consumption, oil consumption, natural gas consumption, renewable energies consumption, and dirty energies consumption as the sum of all the energies with greenhouse emissions.

Annual data from 1996 to 2012 were collected to determine the relationship between total energy consumption and economic growth in EU countries members. We excluded Malta and Cyprus during the estimates. Cyprus has no gas consumption according to the data. In addition, in the Eurostat sources are missing value for the oil consumption for the last eight years. Moreover, Malta because it seems that most of the data are missing for the oil consumption and gas, in addition the biomass and renewable energies consumption is very low in comparison to those from the other countries.

All forms of Energies will be quantified in thousand TOE (tonnes of oil equivalent).

The greenhouse emissions are quantified in thousands of tonnes CO_2 equivalent.

The Gross Domestic Product is at market price which means current price at million of Euro.

2-Data Description

Gross Domestic Product:

By definition, the GDP is the sum of the added gross value and is one of the best indicators to measure the size of the economy, its performance, and health. The GDP can help to measure the economic growth it is why it is used here to measure the impact of the energies consumption on the economic growth.

We can see from figure 2.1 that the total of the GDP for the 28 EU countries members increases through the time with a slight decline between 2008 and 2010, which could be explained by the economic crisis.

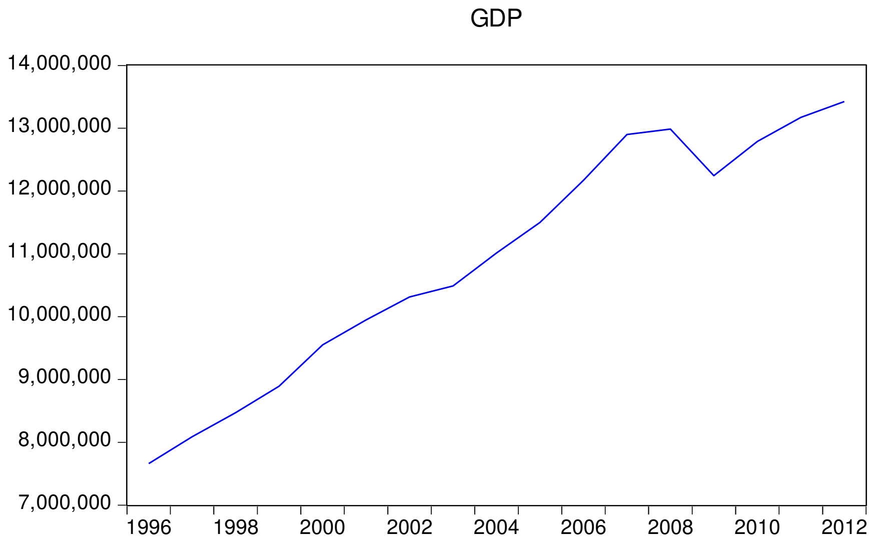

Figure 2.1: Total GDP at current price (Euro) for the 28 EU members

Source: own computations.

Oil consumption:

Oil could be considered by some as one as the most important resources for most of the countries. It is used as an intermediate for production, as carburant for transportations, for heat, for electricity production and multiple other sectors. From figure 2.2, we can see a decline of the oil consumption, especially after 2008. This could be due to alternative resources consumption increases and to the decline of production due to the crisis.

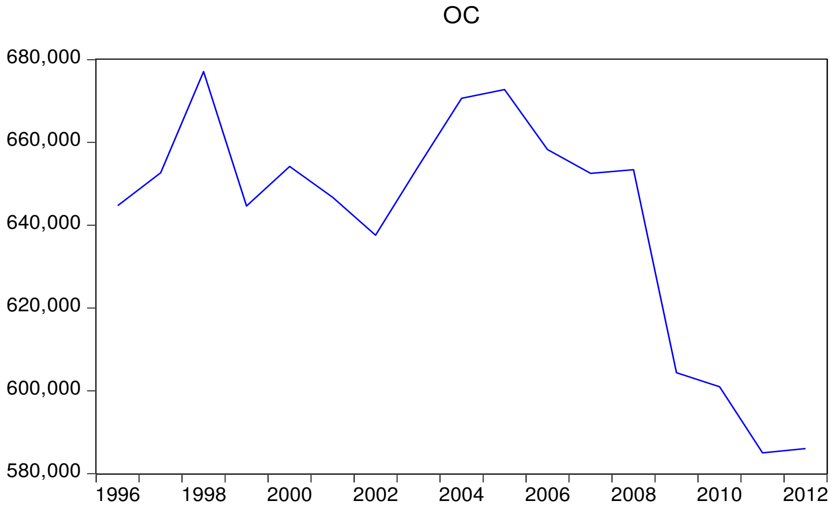

Figure 2.2: Total Gross oil consumption thousand of tonne for the 28 EU members

Source: own computations.

Natural gas consumption:

Like the oil, the natural gas is one of most important raw material, it intervene in most economic sectors, for electricity production and is used by almost all households for heat cooking and other daily uses. From figure 2.3, we can see a sharp increase of the natural gas consumption between 1996 and 2005, then since 2008 a decline with an increase in 2010 then another decrease. The decrease as for oil consumption could be explained by several factor one of them is the economic slowdown and the substitutable energies.

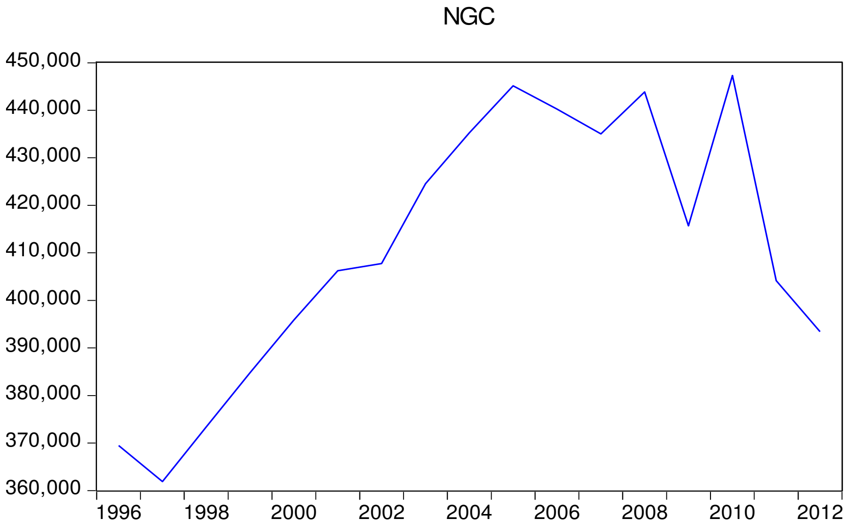

Figure 2.3: Total Gross natural gas consumption thousand of tonne oil equivalents for the 28 EU members

Source: own computations.

Biomass and waste:

Biomass and waste have multiple sources. While it was in the 90s, it was negligible, as it was representing barely 15 percent of the natural gas consumption in 1996 to reach 32 percent in 2012 as we can see in figure 2.4. The main sources of biomass in our data can be listed as following, Solid bio fuels like wood, or charcoal, biogas, biodiesel, bio gasoline, municipal waste and others as it is defined as a biological material convertible to energy. It is considered as a renewable energy and is put in the batch with the others renewable energies but due to its importance. However, in our data, it has been extracted from the renewable energies. As it is considered as renewable energy with greenhouse emissions and was taken apart in the model, and is representing 64 percent of the renewable energies in the EU in 2013.

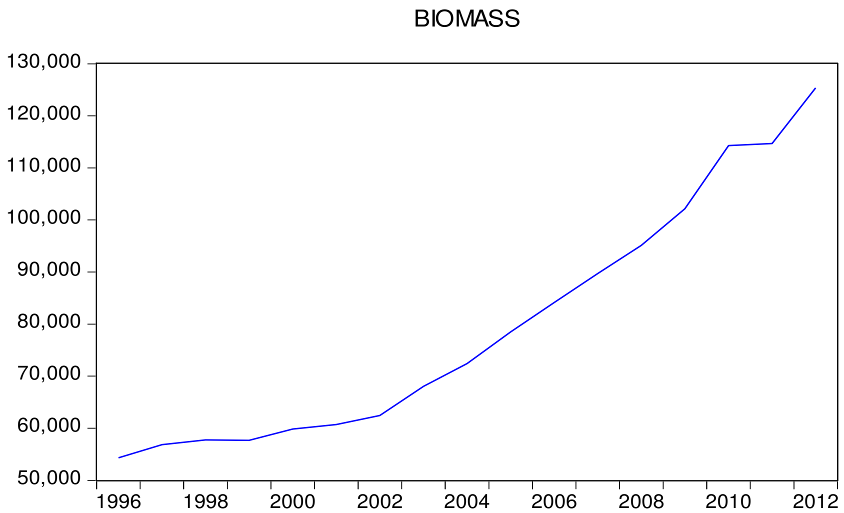

Figure 2.4: Total Gross biomass consumption, thousand of tonne oil equivalent for the 28 EU members

Source: own computations.

Renewable energies

Renewable energies raise many debates, mainly due to the part appellation, which is renewable. In other words, it leads to an inexhaustible source of energy and to a healthier environment and ecology than with the consumption of fossil energies. One of the main restrictions to the development of the renewable energies is the cost due to a high initial capital investment and the difficulties to compete with other kind of energies due to a pricing restriction. Nevertheless, the renewable energies importance and consumption, increases s other time as we can see in figure 2.5 and 2.6. In our case the renewable energies is a combination of several renewable energies. The main components are Hydropower, solar (thermal, photovoltaic and concentrated), wind power.

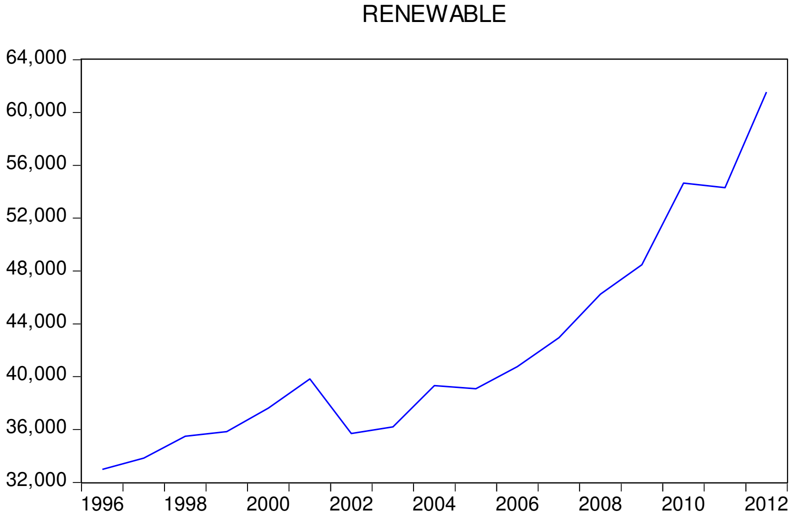

Figure 2.5: Total Gross renewable energies consumption, thousand of tonne oil equivalent for the 28 EU members

Source: own computations.

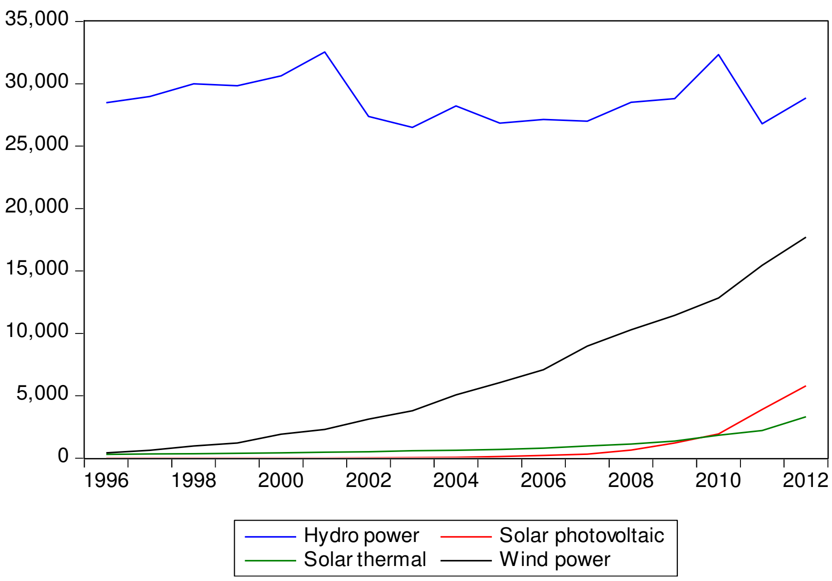

Figure 2.6: Total Gross consumption of the renewable energies variable component thousand of tonne oil equivalent for the 28 EU members

Source: own computations.

Greenhouse emissions:

Greenhouse emissions are the emission of greenhouse gases, by definition, Greenhouse gas are any gas whose absorption the solar radiation and responsible for the greenhouse effect, we can list them as following CO_2 , methane, ozone, water vapour ,fluorocarbons and other green houses. These emissions are harmful to the environment as greenhouse gases contribute to the amount of heat energy released at the Earth's surface and in the lower atmosphere.

As we can see from figure 2.7, the greenhouse emissions decreased other time since 1996, especially since 2006. It can be due to as was stated in the Eurostat to that, "*The European Commission has set out several energy strategies for a more secure, sustainable and low-carbon economy. Aside from combating climate change through a reduction in greenhouse gas emissions.*" *(Eurostat, 2015)*

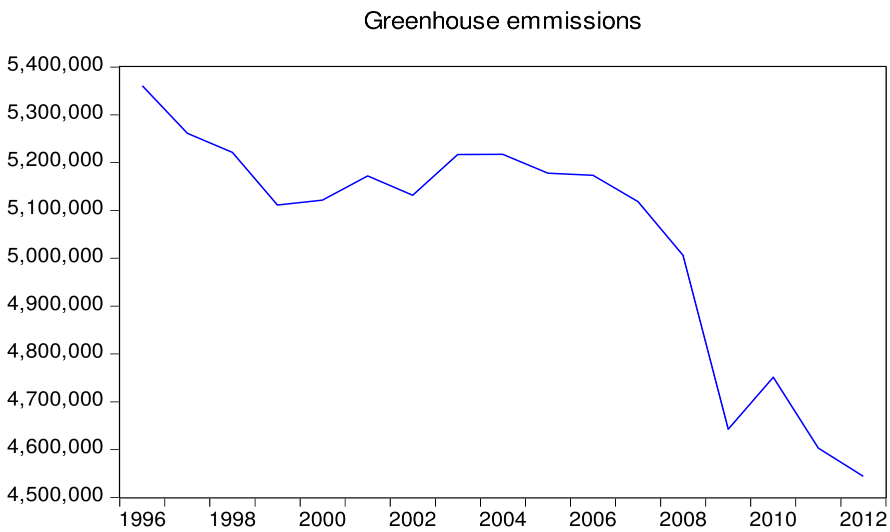

Figure 2.7: Total greenhouse emissions, thousands of tonnes oil equivalents for the 28 EU members

Source: own computations.

Dirty energies:

Dirty energies in this paper are those with greenhouse emissions. In other term, it is the sum of these kinds of energies. Here in this paper, they will be oil consumption, natural gas consumption, and biomass consumption.

Despite the biomass are considered as renewable energies, in this paper, it will be considered as a dirty energy as its consumption produce greenhouse emissions.

3 – Model

We investigate the following two hypotheses:

1. Hypothesis 1: There is a Granger causal effect between energies consumption and economic growth.
2. Hypothesis 2: There is a Granger causal effect between energies consumption and greenhouse emissions.

The energy consumption term used in these hypotheses are defines as fossil energies (Oil consumption+ Natural Gas consumption) + renewable energies consumption (biomass and waste + Hydropower + solar photovoltaic + solar thermal + wind power). We can also classification biomass and waste as dirty energies next to the fossil one.

The Principal Component of the methodology will be as following and will be explained in more detail below: Stationary Test, Co-integration Test, Granger causality tests (1969), and Error Correction Model. The Error Correction Model will be performed in two models. The first model consists in a model with six variables (GDP, BIO, NGC, OC, GE, and RE). The second one consists in a model with four variables where the variable, where DIRT replace all the variables which have a greenhouse emissions.

3.1- Unit root test

To do the stationarity Test, Augmented Dickey-Fuller test is going to be used in order to check the stationary of each variables. This test is necessary to build a time series in order to conduct the cointegration test and the Granger causality tests.

The One of the tests will be augmented Dickey-Fuller test, whose null hypothesis is that variable series is non-stationary and has a Unit Root Test. The null hypothesis is rejected if the test is significant.

Like in Shaari et al. (2012), the equation of the ADF test will be as following:

$$\Delta\lambda_1 = \alpha_1 + \alpha_2 + \Phi\lambda_{t-1} + \beta_i \Sigma_{i=1}^{m} \Delta\lambda X_{t-i} + \varepsilon_t \text{ (1)}$$

Where the λ is the variable of interest, ε_t is the white noise residual, Δ is the differences operator, and t the time trend. The test will be conducted on each of the series for each variable.

Additionally to this test there will be conducted several more Unit Root Tests for further precision, as another Fisher-type known as Fisher-PP test, Breitung (2000) , Levin, Lin and Chu (2002) and Im Pesaran and Shin Test (2003).

3.2-Co-integration Test

Co-integration Test: as in Apergis, N., & Payne, J. E. (2012), it will be used to examine the long-run relationship between all variables. In order to confirm further the evidence in support of long-run equilibrium relationship between energy consumption and economic growth, in our paper two test will be conducted , the first one will be Pedroni (1999) cointegration test and the second one is Kao (1999) cointegration test, both of them are Engle-Granger based, two-step (residual-based) cointegration tests. The Fisher test is a combined Johansen test.

3.2.1-Pedroni cointegration test

Proposed by Pedroni in 1999, it employs four panel statistics and three group panel statistics in other words it is four within-dimension based tests and three between-dimension based tests in order to test the null hypothesis of no cointegration against the alternative hypothesis of cointegration.

$H0: \rho i = 0$

The equation representing the test is as following:

$$Yit = \alpha i + \gamma it + \sum_{j=1}^{m} \beta jiXjit + \varepsilon it = 1 \text{ with } t = 1, \dots, N \; i = 1, \dots, N \quad (2)$$

In our case for the first model, the Pedroni cointegration test will be represented by the following equations:

$$LGDP_{it} = \alpha_{1i} + \gamma_{1it} + \beta_{11}\, LGE_{it} + \beta_{12}\, LBIO_{it} + \beta_{13}\, LOC_{it} + \beta_{14}\, LNGC_{it} + \beta_{15}\, LRE_{it} + \varepsilon_{1it} \quad (3)$$

$$LGE_{it} = \alpha_{2i} + \gamma_{2it} + \beta_{21}\, LGDP_{it} + \beta_{22}\, LBIO_{it} + \beta_{23}\, LOCit + \beta_{24}\, LNGCit + \beta_{25}\, LREit + \varepsilon_{2it} \quad (4)$$

$LBIO_{it} = \alpha_{3i} + \gamma_{3it} + \beta_{31}\, LGE_{it} + \beta_{32}\, LGDP_{it} + \beta_{33}\, LOC_{it} + \beta_{34}\, LNGC_{it} + \beta 35\, LRE_{it} + \varepsilon_{3it}$ (5)

$LOC_{it} = \alpha_{4i} + \gamma_{4it} + \beta_{41}\, LGE_{it} + \beta_{42}\, LGDP_{it} + \beta_{43}\, LBIO_{it} + \beta_{44}\, LNGC_{it} + \beta_{45}\, LRE_{it} + \varepsilon_{4it}$ (6)

$LNGC_{it} = \alpha_{5i} + \gamma 5_{it} + \beta_{51}\, LGEit + \beta_{52}\, LBIO_{it} + \beta_{53}\, LOC_{it} + \beta_{54}\, LGDP_{it} + \beta_{55}\, LRE_{it} + \varepsilon_{5it}$ (7)

$LRE_{it} = \alpha_{6i} + \gamma_{6it} + \beta_{61}\, LGE_{it} + \beta_{62}\, LBIO_{it} + \beta_{63}\, LOC_{it} + \beta_{64}\, LNGC_{it} + \beta_{65}\, LGDP_{it} + \varepsilon_{6it}$ (8)

For the second model, the equations will be as following:

$LGDP_{it}= \alpha_{1i} + \gamma_{1it} + \beta_{11}\, LGE_{it} + \beta_{12}\, LDIRT_{it} + \beta_{13}\, LRE_{it} + \varepsilon_{1it}$ (9)

$LGE_{it} = \alpha_{2i}+ \gamma_{2it} + \beta_{21}\, NGDP_{it} + \beta_{22}\, LDIRT_{t} + \beta_{23}\, LREit + \varepsilon_{2it}$ (10)

$LDIRT_{it} = \alpha_{3i} + \gamma_{3it} + \beta_{31}\, LGE_{it} + \beta_{32}\, LGDP_{it} + \beta_{33}\, LRE_{it} + \varepsilon_{3it}$ (11)

$LRE_{it} = \alpha_{4i} + \gamma_{4it} + \beta_{41}\, LGE_{it} + \beta_{42}\, LGDP_{it} + \beta_{43}\, LDIRT_{it} +\varepsilon_{4it}$ (12)

3.2.2-Kao Cointegration Test

Proposed by Kao in 1999 Kao's panel tests have higher power than Pedroni tests when a small-T number of observations are included in a homogeneous panel. As shown in a study by Guettirez (2003).

This is how the system of cointegration should look like:

$$Yit = \alpha i + \beta Xit + eit = 1 \text{ where } t = 1, \ldots, N \; i = 1, \ldots, N \quad (13)$$

$$\text{With } Y_{it} = Y_{it-1} + u_{it} \quad (14)$$

$$\text{And } X_{it} = X_{it-1} + \varepsilon_{it} \quad (15)$$

3.3- Granger causality tests

As the cointegration test does not catch the direction, Pairwise Granger causality tests model will be used to measure the causal effect between energy and Gross Domestic Product as in Shaari et al. (2012). The Granger causality tests is testing the relationship between the

variables two by two, by definition X causes Y if and only if the past values of X help to predict the changes of Y. While, Y causes X if and only if the past values of Y help to predict the changes of X. Pairwise Granger causality tests will be conducted in this part.
From there the equations for the Granger causality will be looking as following:

$$Y_i = \gamma_0 + \Sigma_{z=1}^{p} \gamma_z Y_{t-z} + \Sigma_{i=1}^{q} \lambda_i X_{t-1} + \mu_t \ (16)$$
$$X_i = \varphi_0 + \Sigma_{z=1}^{p} \sigma_z X_{t-z} + \Sigma_{i=1}^{q} \psi_i Y_{t-1} + \varepsilon_t \ (17)$$

As example, we can take two variables like the LGDP and the oil consumption the equation will look like following:

$$LGDP_i = \gamma_0 + \Sigma_{z=1}^{p} \gamma_z LGDP_{t-z} + \Sigma_{i=1}^{q} \lambda_i LOC_{t-1} + \mu_t (17)$$
$$LOC_i = \varphi_0 + \Sigma_{z=1}^{p} \sigma_z LOC_{t-z} + \Sigma_{i=1}^{q} \psi_i LGDP_{t-1} + \varepsilon_t \ (18)$$

The Lag order will be chosen according to a VAR Lag Order Selection Criteria for system equation model with LBIO LGDP LGE LNGC LOC LRE as variables.
The Pairwise Granger causality will be applied only to the first model in order to pre-check the relationship between the variables.

3.4- Error Correction Model

When Panel cointegration exists, the panel based ECM model can be conducted. This model is based on two steps Engle and Granger procedure between the logarithm of six variables (GDP, Greenhouse emissions, biomass consumption, oil consumption, natural gas consumption, and renewable energies consumption) first. Then between four variables (GDP, Greenhouse emissions, Dirty energies consumption and renewable energies consumption), the Error Correction Model, or shortly ECM will be used in order to obtain the coefficients in the short-run.

As the OLS estimator is biased and inconsistent estimator when applied to cointegrated panel a Fully Modified OLS using the grouped method will be used without trend and constant. Like for Apergis, N., & Payne, J. E. (2012) the Fully Modified OLS will be used as well to determine the long-run equilibrium relationship.

Pedroni (2000) used a Fully Modified OLS to obtain the long run coefficient and concluded that the group mean estimator is shown to behave well even in relatively small samples under a variety of scenarios.

The Fully Modified OLS will be used as well, in order to obtain the residuals, which will be used as error correction term (ECT) in order to include them into the Error Correction Model with Eagle-Granger causality using the first differenced GMM(generalized method of moments) for a consistent and efficient parameter estimates. Arellano (1995) developed this procedure. IT is supposed to be appropriate for a large number of observations and to short samples.

The Error Correction Model will give the short run relationship. It is represented by the following equations for the variable LGDP, LBIO, LGE, LOC, LNGC, and LRE:

$$\Delta LGDP = \gamma_{1i} + \Sigma_{z=1}^{p} \gamma_{11iz} \Delta LGDP_{it-z} + \Sigma_{z=1}^{p} \gamma_{12iz} \Delta LBio_{it-z}$$
$$+ \Sigma_{z=1}^{p} \gamma_{13iz} \Delta LGE_{it-z} + \Sigma_{z=1}^{p} \gamma_{14iz} \Delta LOC_{it-z}$$
$$+ \Sigma_{z=1}^{p} \gamma_{15iz} \Delta LNGC_{it-z} + \Sigma_{z=1}^{p} \gamma_{16iz} \Delta LRE_{it-z} + \tau_1 \, ECT_{it-1} + \mu_{1t} \quad (19)$$

$$\Delta LBio = \gamma_{2i} + \Sigma_{z=1}^{p} \gamma_{21iz} \Delta LGDP_{it-z} + \Sigma_{z=1}^{p} \gamma_{22iz} \Delta LBio_{it-z}$$
$$+ \Sigma_{z=1}^{p} \gamma_{23iz} \Delta LGE_{it-z} + \Sigma_{z=1}^{p} \gamma_{24iz} \Delta LOC_{it-z}$$
$$+ \Sigma_{z=1}^{p} \gamma_{25iz} \Delta LNGC_{it-z} + \Sigma_{z=1}^{p} \gamma_{26iz} \Delta LRE_{it-z} + \tau_2 \, ECT_{it-1} + \mu_{1t} \quad (20)$$

$$\Delta LGE = \gamma_{3i} + \Sigma_{z=1}^{p} \gamma_{31iz} \Delta LGDP_{it-z} + \Sigma_{z=1}^{p} \gamma_{32iz} \Delta LBio_{it-z}$$
$$+ \Sigma_{z=1}^{p} \gamma_{33iz} \Delta LGE_{it-z} + \Sigma_{z=1}^{p} \gamma_{34iz} \Delta LOC_{it-z}$$
$$+ \Sigma_{z=1}^{p} \gamma_{35iz} \Delta LNGC_{it-z} + \Sigma_{z=1}^{p} \gamma_{36iz} \Delta LRE_{it-z} + \tau_3 \, ECT_{it-1} + \mu_{1t} \quad (21)$$

$$\Delta LOC = \gamma_{4i} + \Sigma_{z=1}^{p} \gamma_{41iz} \Delta LGDP_{it-z} + \Sigma_{z=1}^{p} \gamma_{42iz} \Delta LBio_{it-z}$$
$$+ \Sigma_{z=1}^{p} \gamma_{43iz} \Delta LGE_{it-z} + \Sigma_{z=1}^{p} \gamma_{44iz} \Delta LOC_{it-z}$$
$$+ \Sigma_{z=1}^{p} \gamma_{45iz} \Delta LNGC_{it-z} + \Sigma_{z=1}^{p} \gamma_{46iz} \Delta LRE_{it-z} + \tau_4 \, ECT_{it-1} + \mu_{1t} \quad (22)$$

$$\Delta LNGC = \gamma_{5i} + \Sigma_{z=1}^{p} \gamma_{51iz} \Delta LGDP_{it-z} + \Sigma_{z=1}^{p} \gamma_{52iz} \Delta LBio_{it-z}$$
$$+ \Sigma_{z=1}^{p} \gamma_{53iz} \Delta LGE_{it-z} + \Sigma_{z=1}^{p} \gamma_{54iz} \Delta LOC_{it-z}$$
$$+ \Sigma_{z=1}^{p} \gamma_{55iz} \Delta LNGC_{it-z} + \Sigma_{z=1}^{p} \gamma_{56iz} \Delta LRE_{it-z} + \tau_5 \, ECT_{it-1} + \mu_{1t} \quad (23)$$

$$\Delta LRE = \gamma_{6i} + \Sigma_{z=1}^{p} \gamma_{61iz} \Delta LGDP_{it-z} + \Sigma_{z=1}^{p} \gamma_{62iz} \Delta LBio_{it-z}$$
$$+\Sigma_{z=1}^{p} \gamma_{63iz} \Delta LGE_{it-z} + \Sigma_{z=1}^{p} \gamma_{64iz} \Delta LOC_{it-z}$$
$$+\Sigma_{z=1}^{p} \gamma_{65iz} \Delta LNGC_{it-z} + \Sigma_{z=1}^{p} \gamma_{66iz} \Delta LRE_{it-z} + \tau_6 \, ECT_{it-1} + \mu_{1t} \quad (24)$$

The second Error Correction Model is represented by the following equations for the variable LGDP, LGE, LDIRT, and LRE:

$$\Delta LGDP = \gamma_{1i} + \Sigma_{z=1}^{p} \gamma_{11iz} \Delta LGDP_{it-z} + \Sigma_{z=1}^{p} \gamma_{12iz} \Delta LDIRT_{it-z}$$
$$+\Sigma_{z=1}^{p} \gamma_{13iz} \Delta LGE_{it-z} + \Sigma_{z=1}^{p} \gamma_{14iz} \Delta LRE_{it-z} + \tau_1 \, ECT_{it-1} + \mu_{1t} \quad (25)$$

$$\Delta LDIRT = \gamma_{2i} + \Sigma_{z=1}^{p} \gamma_{21iz} \Delta LGDP_{it-z} + \Sigma_{z=1}^{p} \gamma_{22iz} \Delta LDIRT_{it-z}$$
$$+\Sigma_{z=1}^{p} \gamma_{23iz} \Delta LGE_{it-z} + \Sigma_{z=1}^{p} \gamma_{24iz} \Delta LRE_{it-z} + \tau_2 \, ECT_{it-1} + \mu_{1t} \quad (26)$$

$$\Delta LGE = \gamma_{3i} + \Sigma_{z=1}^{p} \gamma_{31iz} \Delta LGDP_{it-z} + \Sigma_{z=1}^{p} \gamma_{32iz} \Delta LDIRT_{it-z}$$
$$+\Sigma_{z=1}^{p} \gamma_{33iz} \Delta LGE_{it-z} + \Sigma_{z=1}^{p} \gamma_{34iz} \Delta LRE_{it-z} + \tau_3 \, ECT_{it-1} + \mu_{1t} \quad (27)$$

$$\Delta LRE = \gamma_{4i} + \Sigma_{z=1}^{p} \gamma_{41iz} \Delta LGDP_{it-z} + \Sigma_{z=1}^{p} \gamma_{42iz} \Delta DIRT_{it-z}$$
$$+\Sigma_{z=1}^{p} \gamma_{43iz} \Delta LGE_{it-z} + \Sigma_{z=1}^{p} \gamma_{44iz} \Delta LRE_{it-z} + \tau_4 \, ECT_{it-1} + \mu_{1t} \quad (28)$$

4- Results of empirical model estimations:

4.1-UNIT ROOT TEST:

The result from the Unit Root Tests performed (Breitung (2000), Levin, Lin and Chu (2002) and Im Pesaran, Shin Test (2003), fisher-ADF and Fisher-PP), with individual effect, individual effects, and individual linear trends, and with none of the effects are listed in the Tables below. It will represent all the seven variables (GDP, Greenhouse emissions, Biomass consumption, oil consumption, natural gas consumption, renewable energies consumption and dirty energies), first at level then at first difference.

The table 4.1 represents the summary of the Unit Root Test performed on the LOC at level. All the statistics from the test performed with individual effects, seems to reject the null hypothesis about the non-stationarity of the variable with 5% of significance. For the individual effects and linear trends, except for Breitung (2000), evidences seem to support the stationarity as well. In other words, it means the majority of the test supports the stationarity of LOC while those performed without effects and trends seems to reject it.

The table 4.2 represents the summary of the Unit Root Test performed on the LOC. At first difference, all the statistics from the test whether performed with individual effects, individual effects and linear trends or none seems to reject the null hypothesis about the non stationarity of the variable with 5% of significance, from there we can say that the LOC at first difference seems to be stationary.

The table 4.3 represents the summary of the Unit Root Test performed on the LNGC at level. All the statistics from the test performed with individual effects reject the null hypothesis of non-stationarity at 5% of significance, while individual effects and linear trends only Fisher-PP and, Lin, and Chu reject the null hypothesis. Additionally we can see that without individual effects and linear trends, all the three test confirm the non-stationarity.

The table 4.4 represents the summary of the Unit Root Test performed on the LNGC. At first difference, all the statistics from the test whether performed with individual effects, individual effects and linear trends or none seems to reject the null hypothesis about the non stationarity of the variable with 5% of significance, from there we can say that the LNGC at first difference seems to be stationary.

The table 4.5 represents the summary of the Unit Root Test performed on the LRE at level. Half of the statistics from individual effects are rejecting the null hypothesis at 5%. While dealing with individual effects and trend, except Breitung t-stat, all the variables seems to reject the null hypothesis at 5%. While those without effect or trend seem to show that, the variables are non-stationary.

The table 4.6 represents the summary of the Unit Root Test performed on the LRE at first difference. All the statistics from the test, whether performed with individual effects, individual effects and linear trends or none seems to reject the null hypothesis about the non-stationarity of the variable with 5% of significance. From there we can say that the LRE at first difference seems to be stationary.

The table 4.7 represents the summary of the Unit Root Test performed on the LGE at level. All the results from the Unit Root Tests at level from the individual effects part, seems to prove that we cannot reject the null hypothesis about non-stationarity of variable, as all of the results are insignificant at 5%. In addition, the results from Unit Root Test for the individual effect and linear trend part seem to confirm as well the null hypothesis, as out of five outputs, only one is rejecting the non-stationarity of LGE at 10%. However, in the one without individual effects and linear trend, seems to reject the null hypothesis at 5% of significance for all the three tests.

The table 4.8 represent the summary of the Unit Root Test performed on the LGE at first difference. All the statistics from the test, whether performed with individual effects, individual effects and linear trends or none seems to reject the null hypothesis about the non-stationarity of the variable with 5% of significance. From there we can say that the LGE at first difference seems to be stationary.

The table 4.9 represents the summary of the Unit Root Test performed on the LGDP at level. All the results from the Unit Root Tests at level conducted with the individual effects are rejecting the null hypothesis about non-stationarity of variable at 5% of significance. In the other hand, the results coming from Unit Root Test for the individual effect and linear trend part and the ones from without individual effects and linear trend, seems to confirm the null hypothesis of non-stationarity of LGDP at level, as all of them are insignificant at 5%.

The table 4.10 represent the summary of the Unit Root Test performed on the LGDP at first difference. All the statistics from the test, whether performed with individual effects, individual effects and linear trends or none seems to reject the null hypothesis about the non-stationarity of the variable with 5% of significance. From there we can say that the LGDP at first difference seems to be stationary.

The table 4.11 represent the summary of the Unit Root Test performed on the LBIO at Level. All the statistics from the test, whether performed with individual effects, individual effects and linear trends or none show that we cannot reject the null hypothesis about the non-stationarity of the variable with 5% of significance. From there we can say that the LBIO at Level seems to be non-stationary.

The table 4.12 represent the summary of the Unit Root Test performed on the LBIO at first difference. All the statistics from the test, whether performed with individual effects, individual effects and linear trends or none seems to reject the null hypothesis about the non-stationarity of the variable with 5% of significance. From there we can say that the LBIO at first difference seems to be stationary.

The table 4.13 represents the summary of the Unit Root Test performed on the LDIRT at level. Three of the statistics from individual effects are rejecting the null hypothesis at 5%. While dealing with individual effects and trend, except Breitung t-stat and Im, Pesaran and Shin W-stat, all the variable seems to reject the null hypothesis at 5%. While those without effect or trend seem to show that, the variables are non-stationary.

The table 4.14 represents the summary of the Unit Root Test performed on the LDIRT at first difference. All the statistics from the test, whether performed with individual effects, individual effects and linear trends or none seems to reject the null hypothesis about the non-stationarity of the variable with 5% of significance. From there we can say that the LDIRT at first difference seems to be stationary.

From this part, we can conclude that all the variables at first difference are stationary. However, we cannot make the same affirmation toward them at level, as in certain case the test seems to reject the stationarity and in other to confirm it, at best we can just assume the stationarity of some of them.

4.2-Co-integration Test

In this part as explained in the methodology part, we will use two type of cointegration test first Pedroni (1999) and Kao (1999) to see the cointegration relationship between the six variables of the first model, then with the four variables, from the second model, each time with a different dependent variable.

We start with the first model reviewing the results. Table 4.15 gives results from Pedroni cointegration test with LGDP dependent variable. Based on no deterministic trend for both common and individual coefficient, all the eleven outputs seems to be insignificant whether at 5% or 10% , from there, it seems that we cannot reject the null hypothesis of no cointegration relationship.

Table 4.16 gives results from Pedroni cointegration test with LGDP dependent variable. Based on deterministic intercept and trend, five outputs from common coefficients out of eight reject the null hypothesis of non-cointegration, while two out of three from the output from individual coefficient reject it. This gives eight out of eleven outputs confirming the cointegration relationship between the variables at 5% of significance.

Table 4.17 gives results from Pedroni cointegration test with LGDP dependent variable. Based on no Deterministic intercept or trend, only one output from common coefficients out of eight reject the null hypothesis of non-cointegration. While the outputs from individual coefficient rejects it. From here, it seems that there is no cointegration.

Given the LGDP as the dependent variable, the results from the Kao residual cointegration test on the six variables as shown in table 4.18 seem to suggest that there is a cointegration relationship between the variables at 5 % of significance as we can reject the null hypothesis of no cointegration.

Table 4.19 gives results from Pedroni Cointegration test with no Deterministic trend, with LOC as the dependent variable. Four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration, while two out of three from the output from individual coefficient reject it, which give in total six out of eleven. This seems to confirm the cointegration relationship between the variables at 5% of significance.

Table 4.20 gives results from Pedroni cointegration test with LOC as the dependent variable. Based on deterministic intercept and trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration, while two out of three from the output from individual coefficient reject it, which give six out of eleven, which seems to confirm the cointegration relationship between the variables at 5% of significance.

Table 4.21 gives results from Pedroni cointegration test with LOC as the dependent variable. Based on no Deterministic intercept or trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration, while two out of three from the output from individual coefficient reject it, which gives in total six out of eleven, which seems to confirm the cointegration relationship between the variables at 5% of significance.

Given the LGE as the dependent variable, Table 4.22, shows the result from the Kao residual cointegration test on the six variables (LGDP, LBIO, LNGC, LOC, LGE, and LRE) seems to suggest that there is a cointegration relationship between the variables at 5 % of significance.

Table 4.23 gives results from Pedroni cointegration test with LNGC as the dependent variable. Based on no deterministic trend, three outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. This gives in total five out of eleven at 5%. From here, we cannot affirm the cointegration of the variables.

Table 4.24 gives results from Pedroni cointegration test with LNGC as the dependent variable. Based on deterministic intercept and trend, five outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. This gives in total seven out of eleven at 5%. From here, it seems to confirm the cointegration relationship between the variables at 5% of significance.

Table 4.25 gives results from Pedroni cointegration test with LNGC as the dependent variable. Based on no Deterministic intercept or trend, four outputs from common coefficients out of eight, seems reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance, which give in total six out of eleven at 5%. It seems to confirm the cointegration relationship between the variables at 5% of significance.

Given the LNGC as the dependent variable, the result from the Kao residual cointegration test as seen in table 4.26, seems to suggest that there is a cointegration relationship between the variables at 5 % of significance.

Table 4.27 gives results from Pedroni cointegration test with LRE as the dependent variable. Based on no deterministic trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. This is giving in total six out of eleven at 5%. From there, it seems to confirm the cointegration relationship between the variables at 5% of significance.

Table 4.28 gives results from Pedroni cointegration test with LRE as the dependent variable. Based on deterministic intercept and trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. In total six out of eleven reject the null hypothesis at 5%. It seems to confirm the cointegration relationship between the variables at 5% of significance.

Table 4.29 gives results from Pedroni cointegration test with LRE as the dependent variable. Based on no Deterministic intercept or trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. This gives in total six out of eleven at 5%, which seems to confirm the cointegration relationship between the variables at 5% of significance.

Given the LRE as the dependent variable, the result from the Kao residual cointegration test from table 4.30, seems to suggest that there is no cointegration relationship between the variables.

Table 4.31 gives results from Pedroni cointegration test with LBIO as the dependent variable. Based on no deterministic trend, only one output from common coefficients out of eight reject the null hypothesis of non-cointegration at 10% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance, which give three outputs out of eleven rejecting the non-cointegration relationship. It seems that the variables are not cointegrated.

Table 4.32 gives results from Pedroni cointegration test with LBIO as the dependent variable. Based on deterministic intercept and trend, only two out of eleven outputs from individual coefficient reject the null hypothesis at 10% of significance.

Table 4.33 gives results from Pedroni cointegration test with LBIO as the dependent variable. Based on no Deterministic intercept or trend, one output from common coefficients out of eight reject the null hypothesis of non-cointegration at 10% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. It seems that there is no cointegration. At least the table 4.34, with the results from Kao residual tests seems to suggest that there is a cointegration relationship between the variables at 5 % of significance.

Table 4.35 gives results from Pedroni cointegration test with LGE as the dependent variable. Based on no deterministic trend, one output from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance, which give three out of eleven at 5% of significance rejecting the non-cointegration relationship.

Table 4.36 gives results from Pedroni cointegration test with LGE as the dependent variable. Based on deterministic intercept and trend, two outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. This gives in total, four out of eleven outputs rejecting the non-cointegration relationship at 5% of significance.

Table 4.37 gives results from Pedroni cointegration test with LGE as the dependent variable. Based on no Deterministic intercept or trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance, which give in total six out of eleven at 5% of significance rejecting the non-cointegration relationship.

Given the LGE as the dependent variable, the result from the Kao residual cointegration test on the six variables (LGDP, LBIO, LNGC, LOC, LGE, and LRE), seems to suggest that there is a cointegration relationship between the variables at 5 % of significance as we can see in Table 4.38.

From here, as we can see that most of the tests reject the non-cointegration of the variable, we can affirm a cointegration relationship linking all the six variables.

From there we check the cointegration in the second model between the four variables. Table 4.39 gives results from Pedroni cointegration test with LGDP as the dependent variable. Based on no deterministic trend, one output from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While one out of three from the output from individual coefficient reject it at 5% of significance and another at 10%.

Table 4.40 gives results from Pedroni cointegration test with LGDP as the dependent variable. Based on deterministic intercept and trend, two outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance, and one at 10%.

Table 4.41 gives results from Pedroni cointegration test with LGDP as the dependent variable. Based on no Deterministic intercept or trend, one output out of three from the output from individual coefficient reject it at 5% of significance, which give in total six out of eleven at 5% of significance rejecting the non-cointegration relationship.

Given the LGDP as the dependent variable, the result from the Kao residual cointegration test on the four variables seems to show a cointegration relationship at 5 % of significance from the probability of the ADF outcome as we can see in table 4.42. The Kao residual test is the only one, which seems to show a cointegration relationship between the variables.

Table 4.43 gives results from Pedroni cointegration test with LDIRT as the dependent variable. Based on no deterministic trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. This gives in total six out of eleven at 5%. From there, it seems to confirm the cointegration relationship between the variables at 5% of significance.

Table 4.44 gives results from Pedroni cointegration test with LDIRT as the dependent variable. Based on deterministic intercept and trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. In total six out of eleven reject the null hypothesis at 5%. It seems to confirm the cointegration relationship between the variables at 5% of significance.

Table 4.45 gives results from Pedroni cointegration test with LDIRT as the dependent variable. Based on no Deterministic intercept or trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. This gives in total six out of eleven at 5%, which seems to confirm the cointegration relationship between the variables at 5% of significance.

Given the LDIRT as the dependent variable, the result from the Kao residual cointegration test from table 4.46, seems to confirm that there is cointegration relationship between the variables.

Table 4.47 gives results from Pedroni cointegration test with LGE as the dependent variable. Based on no deterministic trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. This gives in total six out of eleven at 5%. From there, it seems to confirm the cointegration relationship between the variables at 5% of significance.

Table 4.48 gives results from Pedroni cointegration test with LGE as the dependent variable. Based on deterministic intercept and trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. In total six out of eleven reject the null hypothesis at 5%. It seems to confirm the cointegration relationship between the variables at 5% of significance.

Table 4.49 gives results from Pedroni cointegration test with LGE as the dependent variable. Based on no Deterministic intercept or trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. This gives in total six out of eleven at 5%, which seems to confirm the cointegration relationship between the variables at 5% of significance.

Given the LGE as the dependent variable, the result from the Kao residual cointegration test from Table 4.50, seems to confirm that there is cointegration relationship between the variables.

Table 4.51 gives results from Pedroni cointegration test with LRE as the dependent variable. Based on no deterministic trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. This gives in total six out of eleven at 5%. From there, it seems to confirm the cointegration relationship between the variables at 5% of significance.

Table 4.52 gives results from Pedroni cointegration test with LRE as the dependent variable. Based on deterministic intercept and trend, four outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. While two out of three from the output from individual coefficient reject it at 5% of significance. In total six out of eleven reject the null hypothesis at 5%. It seems to confirm the cointegration relationship between the variables at 5% of significance.

Table 4.53 gives results from Pedroni cointegration test with LRE as the dependent variable. Based on no Deterministic intercept or trend, three outputs from common coefficients out of eight reject the null hypothesis of non-cointegration at 5% of significance. Moreover, one output at 10%. While two out of three from the output from individual coefficient reject it at 5% of significance. This gives in total five out of eleven at 5%, and one at 10%. From here, we can say that there is a cointegration relationship between the variables at 10% of significance.

Given the LRE as the dependent variable, the result from the Kao residual cointegration test from Table 4.54, it seems that there is no cointegration relationship between the variables.

From this section, we can conclude that most of the tests suggest that there is a cointegration relationship between all the variables, whether for the first model or the second one. Hence, we can continue our research.

4.3-Granger causality tests:

In order to choose the optimal Lag Order in the Pairwise Granger causality tests, a VAR Lag Order Selection Criteria for system equation model has been made. The results are as shown in table 4.55; suggest that the optimal Lag is Lag 3, according to Final prediction error and Akaike information criterion.

Table 4.55: VAR Lag Order Selection Criteria for system equation model with LBIO LGDP LGE LNGC LOC LRE as variables.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1156.715	NA	0.008885	12.30387	12.40678	12.34556
1	1407.709	4938.891	2.13e-14	-14.45194	-13.73156*	-14.16010
2	1469.696	115.4467	1.62e-14	-14.72694	-13.38908	-14.18494*
3	1525.637	100.6351	1.32e-14*	-14.93796*	-12.98262	-14.14580
4	1550.693	43.48371	1.49e-14	-14.82215	-12.24933	-13.77984
5	1587.323	61.24436	1.49e-14	-14.82882	-11.63853	-13.53636
6	1610.617	37.46688	1.73e-14	-14.69436	-10.88659	-13.15174
7	1657.190	71.95438	1.57e-14	-14.80625	-10.38100	-13.01347
8	1694.882	55.83999*	1.58e-14	-14.82415	-9.781433	-12.78122

With LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

Table 4.56: The results from Panel Granger causality tests between LGDP, LBIO, LNGC, LOC, LGE, and LRE.

Pairwise Granger causality tests

Sample: 1996 2012
Lags: 3

Null Hypothesis:	Obs	F-Statistic	P-Value
LBIO does not Granger Cause LGDP	348	0.18696	0.9052
LGDP does not Granger Cause LBIO		6.76165	0.0002
LGE does not Granger Cause LGDP	348	8.06473	3.E-05
LGDP does not Granger Cause LGE		2.76029	0.0422
LNGC does not Granger Cause LGDP	347	4.28722	0.0055
LGDP does not Granger Cause LNGC		9.13955	8.E-06
LOC does not Granger Cause LGDP	302	6.74397	0.0002
LGDP does not Granger Cause LOC		2.59827	0.0525

LRE does not Granger Cause LGDP	348	0.53911	0.6558
LGDP does not Granger Cause LRE		10.2368	2.E-06
LGE does not Granger Cause LBIO	364	7.14086	0.0001
LBIO does not Granger Cause LGE		4.28384	0.0055
LNGC does not Granger Cause LBIO	363	6.99901	0.0001
LBIO does not Granger Cause LNGC		2.12790	0.0964
LOC does not Granger Cause LBIO	310	4.91097	0.0024
LBIO does not Granger Cause LOC		0.14933	0.9301
LRE does not Granger Cause LBIO	364	1.68908	0.1690
LBIO does not Granger Cause LRE		9.31939	6.E-06
LNGC does not Granger Cause LGE	363	0.91349	0.4345
LGE does not Granger Cause LNGC		8.77707	1.E-05
LOC does not Granger Cause LGE	310	0.79301	0.4986
LGE does not Granger Cause LOC		1.29515	0.2762
LRE does not Granger Cause LGE	364	0.41584	0.7417
LGE does not Granger Cause LRE		8.52927	2.E-05
LOC does not Granger Cause LNGC	309	5.77240	0.0008
LNGC does not Granger Cause LOC		0.25572	0.8572
LRE does not Granger Cause LNGC	363	1.58130	0.1936
LNGC does not Granger Cause LRE		6.43666	0.0003
LRE does not Granger Cause LOC	310	1.24836	0.2923
LOC does not Granger Cause LRE		5.28656	0.0014

Source: own computations.

From Table 4.56 we can see the Granger causality relationship between our six variables. We will start by checking the relationship between economic growth and the other variables. As we can see there is a unidirectional Granger causality relationship running from economic growth to biomass at 1 % of significance. The relationship between economic growth and greenhouse emissions seems to be bidirectional at 5 % of significance. The same bidirectional relationship can be observed between economic growth and natural gas consumption and between economic growth and oil consumption at 1% and 5% of significance. Additionally, between economic growth and renewable energies, we can see that economic growth does Granger cause renewable energies.

The next variable to check in priority is the greenhouse emissions. From the P-values, we can say that greenhouse emissions does Granger cause the natural gas consumption and at 1 % of significance. In addition, we can see a bidirectional Granger causality relationship between biomass consumption and greenhouse emissions 1% of significance. Additionally, we can see a unidirectional Granger causality running from greenhouse emissions to renewable energies and at 1 % of significance.

After checking the greenhouse emissions and the economic growth, we check the relation linking the renewable energies to the other variables. We see a unidirectional causal relationship running from oil consumption to renewable energies at 1 % of significance. Same unidirectional causal relationship is running from natural gas consumption to renewable energies at 1 % of significance. Exactly the same relationship is running from biomass consumption, economic growth, and greenhouse emissions to renewable energies.

Now we have just three last relationships to verify. The one, which is between oil consumption and biomass, the one which is between oil consumption and natural gas consumption, and the one which is between biomass and natural gas consumption.

4.4-Error Correction Model:

4.4.1-Fully Modified OLS

As we found that the variables are cointegrated, a based ECM model can be conducted.

The first part of the ECM (Error Correction Model) is to extract the Error Correction Term (ECT) from the Fully Modified OLS in order to be able to proceed to the next step and create a panel causality tests. The Fully Modified ordinary least square estimators generate consistent estimator of the parameter β. In addition, it controls for the likely endogenity of the regressor and serial correlation. Pedroni (2000) used a Fully Modified OLS to obtain the long run coefficient and concluded that the group mean estimator is behaving well, even in relatively small samples under a variety of scenarios. As in our case, the sample period (17 years) seems to be too short; we can use Fully Modified OLS to catch the co-movement among the variables toward each other. Hence, we will check it with LGDP and LGE as dependent, as they are those with the higher interest in this study.

Table 4.57: Results of Fully Modified OLS for LGDP as dependent variable and LBIO, LNGC, LOC, LGE and LRE as independent variables.

Dependent Variable: LGDP
Method: Panel Fully Modified Least Squares (FMOLS)
Panel method: Grouped estimation
Long-run covariance estimates (Bartlett kernel, Newey-West fixed bandwidth)

Variable	Coefficient	Std. Error	t-Statistic	P-values
LNGC	0.120071	0.105722	1.135723	0.2569
LOC	0.167512	0.078690	2.128748	0.0340
LBIO	0.570694	0.047701	11.96395	0.0000
LRE	0.113702	0.040343	2.818405	0.0051
LGE	0.369940	0.117162	3.157506	0.0017

R-squared	0.754215	Mean dependent var	12.27059
Adjusted R-squared	0.748415	S.D. dependent var	1.379516
S.E. of regression	0.691941	Sum squared resid	162.3073
Long-run variance	0.005594		

Source: own computations.

The results from the Fully Modified Panel Ordinary Least Squares (Fully Modified OLS), where Logarithm of Gross Domestic Product (LGDP) is dependent variable, are listed in table 4.57. The linear regressions indicate that all the variables except the natural gas consumption have a positive significant impact on economic growth. This supports the hypothesis of the positive impact of the energy, and explains the positive impact of the greenhouse emissions. According to the results, an increase by 1% of the oil consumption, biomass consumption, renewable energies consumption and greenhouse emissions, increase the economic growth respectively by 0.17%, 0.57%, 0.11%, 0.37%. The results could be interpreted as long run causality.

The second Fully Modified OLS was added in order to have a look in the long run on the impact of the other variables on the greenhouse emissions, especially as it would be interesting if we find out that the renewable has a negative impact.

Table 4.58: Results of Fully Modified OLS for LGE as dependent variable and LBIO, LNGC, LOC, LGDP and LRE as independent variables.

Dependent Variable: LGE
Method: Panel Fully Modified Least Squares (FMOLS)
Panel method: Grouped estimation

Variable	Coefficient	Std. Error	t-Statistic	P-values
LGDP	0.031522	0.030647	1.028523	0.3044

LRE	-0.065418	0.013943	-4.691938	0.0000
LOC	0.656149	0.025090	26.15185	0.0000
LNGC	0.520525	0.027740	18.76473	0.0000
LBIO	0.072646	0.033523	2.167025	0.0309

R-squared	0.647747	Mean dependent var	11.81013
Adjusted R-squared	0.639410	S.D. dependent var	1.012788
S.E. of regression	0.608170	Sum squared resid	125.0165
Long-run variance	0.001113		

Source: own computations.

Table 4.58 shows the results from the Fully modified OLS, with the greenhouse emissions as dependent variable. As we can see all the variables seems to be significant at 5% except the gross domestic product. Oil consumption, natural gas consumption and biomass consumption have a positive impact on the greenhouse emissions. As an increase by 1% percent of any of these variables, lead respectively to an increase, by 0.65%, 0.52%, and 0.073% of the greenhouse emissions. Note however, that the biomass impact on the greenhouse emissions is lower than the fossils energies. The renewable energies have a negative impact on the greenhouse emissions, an increase by 1% leads to a decrease by 0.065%. The renewable energies behave as expected.

4.4.2-Panel causality test

After extracting the error correction term, we include them into the model as in the equations from 19 to 28. The results from the Panel Granger causality are listed in table 4.59 and table 4.60 for both models.

Table 4.59: Review of the results extracted from the Error Correction Model for LGDP, LBIO, LNGC, LOC, LGE, and LRE.

Dependent Variable	Type of causality relation ship						
	Short run coefficient						Long run causality
	ΔLGDP	ΔLOC	ΔLNGC	ΔLGE	ΔLRE	ΔLBIO	ECTi(-1)
ΔLGDP		0.114213 (0.0245)	-0.023882 (0. 6473)	1. 060689 (0.0000)	0.068029 (0.0002)	-0.072564 (0.0166)	-0.066168 (0.0275)
ΔLOC	0. 187198 (0. 4849)		-0. 202947 (0. 0380)	0. 292965 (0. 2222)	0. 030786 (0. 1720)	-0. 035813 (0. 7058)	-0.410176 (0.0129)

ΔLNGC	-0.142356 (0.1200)	-0. 071134 (0.0117)		1.185900 (0.0000)	0.004089 (0.5986)	0.181799 (0. 0106)	-0.147875 (0.0000)
ΔLGE	0. 260658 (0. 0020)	0. 058997 (0. 0247)	0. 322657 (0.0000)		-0.053864 (0.0000)	0. 068815 (0.0015)	-0. 099072 (0. 0173)
ΔLRE	0.611700 (0. 0330)	0. 317350 (0. 2754)	-0. 198678 (0. 5604)	-1.031688 (0.0574)		0.140258 (0. 2267)	-0. 439233 (0. 0004)
ΔLBIO	-0.344666 (0.0058)	0.099127 (0.2644)	0.169015 (0.0006)	0.161414 (0.3199)	0.113185 (0.0000)		-0.189709 (0.0057)

Source: own computations.

Table 4.59 represents the collected results from multiple regressions which were ran according to the equations in the error correction part in methodology for all the variables (GDP, Greenhouse emissions , biomass consumption, oil consumption, natural gas consumption and renewable energies consumption), after the collection of the ECT from the Fully Modified OLS .

The results give the individual relationship in the short run. According to table 4.59, when LGDP is the dependent variables, greenhouse emissions, renewable energies, and oil consumption have a significant and positive impact on the GDP; the three of them are significant at 1%. An increase of greenhouse emissions by 1% increases the LGDP 1.06%, while an increase of the renewable energies increases it by 0.068% and an increase of the oil consumption lead to an increase by 0.11% of the economic growth.

In the other hand both biomass consumption have a significant and negative impact on the GDP with a significance of 1%. From the table we see that an increases of the Biomass by 1% lead to a decrease of the GDP by 0.016%. Although the effect seems to be light, the biomass negative impact in the short run can be explained by the high needs to process its production.

In the long run, the ECT coefficient is equal to -0.07, and is significant at 5%. The ECT coefficient represents how fast deviations from the long run equilibrium are eliminated following changes in each variable, in other term the adjustment to the long run equilibrium. The estimated coefficient indicates that about 7 per cent of the disequilibrium is corrected within a year. Moreover, we can say that the economic growth, responds to deviations from long-run equilibrium at 5% level of significance.

The results when LOC is the dependent variable, only natural gas consumption seems to be negative and significant at 5% in the short run. The increase by 1% of the natural gas consumption decreases the one from oil by 0.2%. This result could be due to the possible substitutability of the oil by natural gas.

The ECT coefficient is equal to -0.41, and is significant at 5%, meaning that that about 41% of the disequilibrium is corrected within a year. In addition, we can say that the oil consumption responds to deviations from long-run equilibrium at 5% level of significance.

The results when LNGC is the dependent variable, shows that oil consumption, greenhouse emissions and biomass are statistically significant in the short run. The greenhouse emissions and the biomass are significant, respectively at 1% and 5%. They have a positive impact on the natural gas consumption. With 1% of increases, the LNGC increases respectively by 1.19%, 0.18%. Whereas, oil consumption seems to be significant at 5% and have a negative impact on the natural gas consumption with a decrease of 0.07%, if it increases by 1%.

In the long run, the ECT coefficient is equal to -0.14 seems to be significant at 1%. This is meaning that the adjustment within a year is equal to 14%. Moreover, we can say that the natural gas consumption responds to deviations from long-run equilibrium at 1% level of significance.

When the LGE is taken as the dependent variable, it seems that all the variables are significant in the short run at 1% of significance, except for the oil consumption being significant at 5%. All the variables seem to have a positive impact on the greenhouse emissions except the renewable energies, which was expected. An increase by 1% of Gross Domestic Product, oil consumption, natural gas consumption, and biomass increases the greenhouse emissions respectively by 0.26%, 0.05%, 0.32%, and 0.07%. While an increases of the renewable energies consumption by 1% decrease the greenhouse emissions by 0.05%.

From the ECT we can see that the coefficient is significant at 1% and it is showing that the adjustment within a year is equal to 10%. In addition, we can say that the greenhouse emissions respond to deviations from long-run equilibrium at 1% level of significance.

The next regression take the LRE as dependent variable, from the table we can see that only two variables are significant, gross domestic product at 5% and greenhouse emissions at 10% in the short run. The greenhouse emissions have a negative impact, and the gross domestic product seems to have a positive impact. An increases by 1 % of the greenhouse emissions decrease by -1.03% the renewable energies while, an increases of biomass by 1% lead to an increases by 0.61% of the renewable energies.

In the long run, the ECT coefficient does give a significant result at 1%. The estimated coefficient of -0.43 indicates that about 43 per cent of the disequilibrium is corrected within a year. Moreover, we can say that the renewable energies respond to deviations from long-run equilibrium at 1% level of significance.

The last regression is the one with the LBIO as dependent variable in the short run. From the table we can see that in the in the short run Gross Domestic Product has a negative and significant impact on the biomass consumption at 1% of significance, with an increases of the Gross Domestic Product by 1%, the biomass consumption decrease by 0.34%. Two other variables have a positive impact and are significant at 1%. The two variables are natural gas consumption and renewable energies. The natural gas consumption increase by 1% leads to an increase of the biomass consumption by 0.16%. Moreover, the renewable energies increase by 1% leads to an increase by 0.11% of the biomass consumption.

In the long run the ECT coefficient seems to be significant at 1%. The estimated coefficient of -0.18 indicates that about 18 per cent of the disequilibrium is corrected within a year. Moreover, we can say that the biomass consumption responds to deviations from long-run equilibrium at 1% level of significance.

Table 4.60: Review of the results extracted from the Error Correction Model for LGDP, LDIRT, LGE, and LRE.

Dependent Variable	**Type of causality relation ship**				
	Short run coefficient				**Long run causality**
	ΔLGDP	**ΔLDIRT**	**ΔLRE**	**ΔLGE**	**ECTi(-1)**
ΔLGDP		0.164495 (0.0000)	0.067696 (0.0000)	0.907655 (0.0000)	-0.047386 (0.0000)
ΔLDIRT	0.023353 (0.7726)		0.025139 (0.0015)	0.381554 (0.0000)	-0.611922 (0.0000)
ΔLRE	0.493132 (0.0036)	0.363981 (0.0294)		-1.785538 (0.0000)	-0.192676 (0.0328)
ΔLGE	0.376442 (0.0000)	0.326849 (0.0488)	-0.063735 (0.0004)		-0.206947 (0.1540)

Source: own computations.

Table 4.60 represents the collected results from multiple regressions, which were ran according to the equations from 25 to 28, in the error correction model part. The variables (GDP, Greenhouse emissions, Dirty energies, and renewable energies consumption) are those from the second model. The coefficients of the ECM are estimated by the GMM, after the collection of the Error Correction Term from the Fully Modified OLS.

The given results are the individual relationship in the short run. According to table 4.60, when LGDP is the dependent variables, all the variables seem to be positive and significant at 1%. An increase of the dirty energies by 1% leads to an increase by 0.16% of the economic growth. While an increase by 1% of the renewable energies leads to its increase by 0.07%. In addition, the greenhouse emissions increase the economic growth by 0.91% when increased by 1%.

In the long run, the ECT coefficient seems to be significant at 1%. The estimated coefficient of -0.05 indicates that about 5% per cent of the disequilibrium is corrected within a year. Moreover, we can say that the economic growth responds to deviations from long-run equilibrium at 1% level of significance.

The results when dirty energies is the dependent variable, shows that both renewable energies and greenhouse emissions have a positive and significant impact at 1% in the short run. From the coefficients in the table, we can see that when renewable energies or the greenhouse emissions increase by 1%, it leads to an increase of the dirty energies respectively by 0.025% and 0.38%.

In the long run, the ECT coefficient seems to be significant at 1%. The estimated coefficient of -0.61 indicates that about 62% per cent of the disequilibrium is corrected within a year. In addition, we can say that the dirty energies consumption responds to deviations from long-run equilibrium at 1% level of significance.

When LRE is the dependent variable, the P-values show the all the variables are significant at 1%. The behaving of economic growth, renewable dirty energies, and greenhouse emissions seems logically comprehensible. The economic growth affects positively on the renewable energies. As more economic activities lead to more energetic needs. An increase by 1% of the economic growth leads to an increase by 0.49% of the renewable energies consumption. An increase of the dirty energies by 1% leads to an increase of the renewable energies by 0.36%. However, the decrease by 1% of the greenhouse emissions leads to its decrease by 1.78% probably to the negligible importance of the renewable energies in the energy production.

In the long run, the ECT coefficient does give a significant result at 1%. The estimated coefficient of -0.43 indicates that about 43 per cent of the disequilibrium is corrected within a year. Moreover, we can say that the renewable energies consumption responds to deviations from long-run equilibrium at 1% level of significance.

The last interpretation is the one where the greenhouse emissions are the dependent variable. The P-values shows that the economic growth and renewable energies are significant at 1% while the dirty energies consumption is significant at 5%. It seems logic to see that the economic growth and the dirty energies consumption increase the greenhouse emissions, their increase by 1% leads respectively to increase the emissions by 0.38% and 0.33%. The negative impact of the renewable energies seems as well to be logical, as it is a substitute to the dirty one. It increases by 1% leads to a decrease by 0.06% of the greenhouse emissions.

In the long run, the ECT coefficient seems to be insignificant. In addition, we can say that the greenhouse emissions seem not to be responding to deviations from long-run equilibrium.

4.5-Main results

The empirical results in this paper leads to confirming both null hypotheses. In other terms, most of the observations tend to say that there is a Granger causal effect between energies consumption and economic growth, and that that there is a Granger causal effect between energies consumption and greenhouse emissions for the EU members.

To do so a unit root tests have been conducted and showed that the variables even if in some times was non-stationary at level, was always stationary at first differences. A cointegration tests were conducted as well, and most of them proved that it seems that the variables are cointegrated. Both unit root tests and cointegration tests results, allowed us to proceed to both Pairwise Granger causality tests and Error Correction models.

The Pairwise Granger causality tests, suggest a bidirectional causal relationship between economic growth and the fossil energies (natural gas consumption + oil consumption) and between economic growth and greenhouse emissions, however it suggest just a unidirectional causal relationship running from economic growth to both biomass consumption and renewable energies.

These results seems to show that there is a linkage between economic growth and energies consumption, even if it seems that the renewable energies including the biomass does not affect the economic growth but just the opposite. The second important observation here is that there is as well a linkage between energies consumption and greenhouse emissions, which suggest that affecting one would lead to result on the other.

The next important relationship to denote is that according to the Pairwise Granger causality, there is bidirectional causality between there is a unidirectional causality running from the greenhouse emissions to the natural gas consumption. This is an expected relationship, however unexpected was that there is no linkage between oil consumption and greenhouse emissions and between and that there is just a unidirectional causal relationship running from the greenhouse emissions to both natural gas consumptions and renewable energies.

The results from the Pairwise Granger causality, even if they seem promising for the first hypothesis, are not enough for the second. It seems to reject partly that energies consumption does Granger cause the greenhouse emissions.

Nevertheless, some econometricians argue about the limitations of the Pairwise method for Granger causality. Considering the designation (Pairwise), this method tests two by two the variables, this could lead to misleading results when more than two variables are involved in the relationship. From here, another method was performed on the variables. This method is the Error Correction Model based on Engle-Granger's two-step method.

The Error correction model was made in two steps first using the Fully Modified OLS, then after extracting the Error Correction Term by a Generalized Method of Moments. In the first step, we can catch an idea about how the variable could behave in the long term. Among the most important results, we can say that except the natural gas consumption, it seems that all kind of energies and the greenhouse emissions are influencing positively on the economic growth. Moreover, we can say that all kind of dirty energies are influencing positively on the greenhouse emissions, and only the renewable energies are affecting negatively on it. These results seem to confirm both null hypotheses about the linkage between energies with greenhouse emissions and economic growth.

The second step of the Error correction model gives us the results in the short run. According to this part, in the short run all variables except the natural gas consumption are linked to the economic growth. Almost of them as expected, have a positive causal effect on the economic growth. Only Biomass consumption has a small negative impact on it. This result could be due to the important cost of the production of the biomass. Additionally a second Error Correction model was made to recheck the relationship, it confirmed the results from the first one as the energies whether they are clean (renewable) or with emissions (the sum of biomass, oil, and natural gas consumptions) have a positive impact on the economic growth. We should denote as well that in both cases the greenhouse emissions are influencing positively on the economic growth.

Again, if we look into both representation of the Error corrections model, we can see that all the variables are linked to the greenhouse emissions. In either models, the dirty energies as a sum or separately are affecting positively on it. Only the renewable energies seem to impact negatively on it. Moreover, again the greenhouse emissions seem to impact positively in the short run on the economic growth.

Last important thing is to observe that most of the variable seems to have an influence on each other's. This shows maybe that there are a possible complementarities or substitutability between them, giving perspectives about possible switch from one kind to another.

Here we list the kind of causal relationship between economic growth and other variable and between greenhouse emissions and other variables according to the Error Correction Model:

From table 4.59 it is as following:

A unidirectional causal relationship running from oil consumption to economic growth.

In other words, an increase of oil consumption leads to economic growth.

A bidirectional causal relationship between renewable energies and economic growth.

In other words, an increase of renewable energies leads to economic growth and vice versa.

A bidirectional causal relationship between biomass consumption and economic growth.

In other words, an increase of biomass consumption leads to economic decrease and vice versa.

A bidirectional causal relationship between greenhouse emissions and economic growth.

In other word an increase of greenhouse emissions, lead to economic growth and vice versa.

A bidirectional causal relationship between greenhouse emissions and renewable energies.

In other words, an increase of renewable energies leads to a decrease of greenhouse emissions and vice versa.

A unidirectional causal relationship running from both oil consumption and biomass consumption to greenhouse emissions.

In other words, an increase of oil consumption or biomass, lead to an increase of greenhouse emissions.

From table 4.60 with similar interpretations as following:

A unidirectional causal relationship running from dirty energies to economic growth.

A bidirectional causal relationship between renewable energies and economic growth.

A bidirectional causal relationship between greenhouse emissions and economic growth.

A bidirectional causal relationship between greenhouse emissions and renewable energies.

5-Conclusions

This paper aims to examine the relationship between energy consumption and economic growth and between energy consumptions and greenhouse emissions for EU countries, using an annual panel time series data from 1996–2012 within a multivariate framework for 26 EU countries. The energies are composed from oil consumption, natural gas consumptions, and renewable energies. To do that, several test where used; Unit Root Tests, cointegration test, Pairwise Granger causality tests, and Error Correction Model are employed to find out the type of the causal relationship.

From the results, we can say that the EU countries are energy dependent. We can see clearly that there is Granger causality between the economic growth and the energies consumption. A similar result of causal relationship can was listed in Stern (2010). This could mean that energy conservative policies may harm the economic growth of the EU. Fei, Li, et al (2011), found as well a similar result for China, however according to them, the carbon emissions is becoming a concern due to the pollutions. Another similar result could be found in Chang (2010) as well for China, where the authors see that a change to more clean energies would lead to a decline of the carbon emissions without effecting the economic growth, as evidence he point to that there is a Granger causality running from energy consumption to carbon emissions. A similar result was found in this paper where we can see that oil consumption, biomass Granger causes the greenhouse emissions and we can see a bidirectional causal relationship between the dirty energies and the greenhouse emissions.

The result concerning the renewable energies seems also to be in favours of the switch in the kind of energy use, as there is a bidirectional causal relationship between both renewable energies and economic growth and between renewable energies and greenhouse emissions. The renewable seems to affect positively the economic growth and in addition affect negatively the greenhouse emissions. Rafiq and Alam (2010) provided the same results. However, in the short run it seems that there is a negative bidirectional relationship between biomass and economic growth. This linkage could be due to many reasons; one of them is that a growing needs to the biomass consumption leads to more investment into the infrastructure and system of delivery the supply. According to Payne (2010), the negative impact of energy consumption on economic growth could be due excessive energy consumption in unproductive industries or capacity constraints or an inefficient energy supply.

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Appendix:

Table 4.1: The results of Levin, Lin and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000), Fisher-ADF and Fisher-PP, Panel Unit Root Tests on LOC at level:

	Individual effects			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-3.69112	0.0001	23	344
Im, Pesaran and Shin W-stat	-3.02140	0.0013	23	344
ADF - Fisher Chi-square	109.644	0.0000	23	344
PP - Fisher Chi-square	115.833	0.0000	23	356
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-6.75128	0.0000	23	344
Breitung t-stat	1.99557	0.9770	23	321
Im, Pesaran and Shin W-stat	-4.30992	0.0000	23	312
ADF - Fisher Chi-square	113.418	0.0000	23	312
PP - Fisher Chi-square	126.379	0.0000	23	330
	None			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-1.01503	0.1550	23	331
ADF - Fisher Chi-square	39.9548	0.7223	23	331
PP - Fisher Chi-square	51.0725	0.2811	23	356

Source: own computations.

Table 4.2: The results of Levin, Lin and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000) Fisher-ADF and Fisher-PP, Panel Unit Root Tests on LOC at First difference.

	Individual effects			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-14.6129	0.0000	23	317
Im, Pesaran and Shin W-stat	-14.6764	0.0000	22	314
ADF - Fisher Chi-square	235.971	0.0000	23	317
PP - Fisher Chi-square	335.612	0.0000	23	333
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-9.50578	0.0000	22	318
Breitung t-stat	-3.11386	0.0009	22	290
Im, Pesaran and Shin W-stat	-10.6786	0.0000	22	312
ADF - Fisher Chi-square	177.188	0.0000	22	312

PP - Fisher Chi-square	283.913	0.0000	22	330
	None			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-18.5696	0.0000	23	320
ADF - Fisher Chi-square	343.247	0.0000	23	320
PP - Fisher Chi-square	382.532	0.0000	24	333

Source: own computations.

Table 4.3: The results of Levin, Lin and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000), Fisher-ADF and Fisher-PP, Panel Unit Root Tests on LNGC at level.

	Individual effects			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-8.09094	0.0000	26	401
Im, Pesaran and Shin W-stat	-3.37763	0.0004	26	401
ADF - Fisher Chi-square	106.343	0.0000	26	401
PP - Fisher Chi-square	136.184	0.0000	26	415
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-1.92739	0.0270	26	403
Breitung t-stat	4.39852	1.0000	26	377
Im, Pesaran and Shin W-stat	1.02821	0.8481	26	403
ADF - Fisher Chi-square	65.8792	0.0934	26	403
PP - Fisher Chi-square	85.0794	0.0026	26	415
	None			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	1.46901	0.9291	26	404
ADF - Fisher Chi-square	28.4323	0.9968	26	404
PP - Fisher Chi-square	28.5114	0.9967	26	415

Source: own computations.

Table 4.4: The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000), Fisher-ADF test and Fisher-PP test Panel Unit Root Tests on LNGC at First difference.

	Individual effects			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-15.2783	0.0000	26	382
Im, Pesaran and Shin W-stat	-15.3926	0.0000	26	382
ADF - Fisher Chi-square	285.368	0.0000	26	382
PP - Fisher Chi-square	318.588	0.0000	26	389
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-15.3247	0.0000	26	375
Breitung t-stat	-4.23529	0.0000	26	349

-Im, Pesaran and Shin W-stat	-14.7594	0.0000	26	375
ADF - Fisher Chi-square	252.303	0.0000	26	375
PP - Fisher Chi-square	327.269	0.0000	26	389
	None			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-17.9694	0.0000	26	379
ADF - Fisher Chi-square	372.404	0.0000	26	379
PP - Fisher Chi-square	433.059	0.0000	26	389

Source: own computations.

Table 4.5: The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000), Fisher-ADF test and Fisher-PP test Panel Unit Root Tests on LRE at level.

	Individual effects			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	0.84305	0.8004	26	400
Im, Pesaran and Shin W-stat	2.44539	0.9928	26	400
ADF - Fisher Chi-square	72.7806	0.0301	26	400
PP - Fisher Chi-square	96.7408	0.0002	26	416
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-3.88689	0.0001	26	409
Breitung t-stat	3.20138	0.9993	26	383
Im, Pesaran and Shin W-stat	-2.27758	0.0114	26	409
ADF - Fisher Chi-square	90.9591	0.0007	26	409
PP - Fisher Chi-square	109.336	0.0000	26	416
	None			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	6.09304	1.0000	26	402
ADF - Fisher Chi-square	7.93635	1.0000	26	402
PP - Fisher Chi-square	7.02398	1.0000	26	416

Source: own computations.

Table 4.6: The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000), Fisher-ADF test and Fisher-PP test Panel Unit Root Tests on LRE at First difference.

	Individual effects			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-15.5212	0.0000	26	377
Im, Pesaran and Shin W-stat	-14.7131	0.0000	26	377

ADF - Fisher Chi-square	281.072	0.0000	26	377
PP - Fisher Chi-square	411.774	0.0000	26	390
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-14.6763	0.0000	26	375
Breitung t-stat	-6.76961	0.0000	26	349
Im, Pesaran and Shin W-stat	-12.6049	0.0000	26	375
ADF - Fisher Chi-square	225.024	0.0000	26	375
PP - Fisher Chi-square	367.838	0.0000	26	390
	None			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-14.1510	0.0000	26	376
ADF - Fisher Chi-square	341.709	0.0000	26	376
PP - Fisher Chi-square	413.479	0.0000	26	390

Source: own computations.

Table 4.7: The results of Levin, Lin and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000), Fisher-ADF test and Fisher-PP test, Panel Unit Root Tests on LGE at level

	Individual effects			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	1.49184	0.9321	26	394
Im, Pesaran and Shin W-stat	1.61340	0.09467	26	394
ADF - Fisher Chi-square	54.3912	0.3863	26	394
PP - Fisher Chi-square	57.5347	0.2778	26	416
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-1.54911	0.0607	26	407
Breitung t-stat	5.95107	1.0000	26	381
Im, Pesaran and Shin W-stat	1.75748	0.9606	26	407
ADF - Fisher Chi-square	50.9702	0.5144	26	407
PP - Fisher Chi-square	63.6505	0.1290	26	416
	None			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-7.19502	0.0000	26	398
ADF - Fisher Chi-square	109.770	0.0000	26	398
PP - Fisher Chi-square	120.617	0.0000	26	416

Source: own computations.

Table 4.8: The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000), Fisher-ADF test and Fisher-PP test Panel Unit Root Tests on LGE at First difference.

	Individual effects

Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-14.2709	0.0000	26	380
Im, Pesaran and Shin W-stat	-13.1105	0.0000	26	380
ADF - Fisher Chi-square	247.824	0.0000	26	380
PP - Fisher Chi-square	294.659	0.0000	26	390
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-16.5631	0.0000	26	383
Breitung t-stat	-9.18790	0.0000	26	357
Im, Pesaran and Shin W-stat	-13.8052	0.0000	26	383
ADF - Fisher Chi-square	234.258	0.0000	26	383
PP - Fisher Chi-square	288.003	0.0000	26	390
	None			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-14.7570	0.0000	26	375
ADF - Fisher Chi-square	287.293	0.0000	26	375
PP - Fisher Chi-square	368.072	0.0000	26	390

Source: own computations.

Table 4.9: The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000), Fisher-ADF test and Fisher-PP test Panel Unit Root Tests on LGDP at level.

	Individual effects			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-8.49237	0.0000	26	386
Im, Pesaran and Shin W-stat	-1.88349	0.0298	26	386
ADF - Fisher Chi-square	77.9133	0.0115	26	386
PP - Fisher Chi-square	101.546	0.0000	26	400
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	1.93894	0.9737	26	389
Breitung t-stat	6.67005	1.0000	26	363
Im, Pesaran and Shin W-stat	4.30110	1.0000	26	389
ADF - Fisher Chi-square	33.5736	0.9779	26	389
PP - Fisher Chi-square	31.2701	0.9899	26	400
	None			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	13.7470	1.0000	26	379
ADF - Fisher Chi-square	5.18556	1.0000	26	379
PP - Fisher Chi-square	0.23617	1.0000	26	400

Source: own computations.

Table 4.10: The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000), Fisher-ADF test and Fisher-PP test Panel Unit Root Tests on LGDP at First difference.

	Individual effects			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-8.16328	0.0000	26	364
Im, Pesaran and Shin W-stat	-5.70223	0.0000	26	364
ADF - Fisher Chi-square	128.185	0.0000	26	364
PP - Fisher Chi-square	157.222	0.0000	26	374
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-11.1440	0.0000	26	364
Breitung t-stat	-5.74707	0.0000	26	338
Im, Pesaran and Shin W-stat	-5.14771	0.0000	26	364
ADF - Fisher Chi-square	120.501	0.0000	26	364
PP - Fisher Chi-square	162.302	0.0000	26	374
	None			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-8.26062	0.0000	26	371
ADF - Fisher Chi-square	145.241	0.0000	26	371
PP - Fisher Chi-square	142.743	0.0000	26	374

Source: own computations.

Table 4.11: The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000), Fisher-ADF test and Fisher-PP test Panel Unit Root Tests on LBIO at Level.

	Individual effects			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	2.53217	0.943	26	399
Im, Pesaran and Shin W-stat	6.47931	1.0000	26	399
ADF - Fisher Chi-square	19.6619	1.0000	26	399
PP - Fisher Chi-square	17.4256	1.0000	26	416
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-1.42357	0.0773	26	404
Breitung t-stat	2.65738	0.9961	26	378
Im, Pesaran and Shin W-stat	0.36355	0.6419	26	404
ADF - Fisher Chi-square	45.2557	0.7344	26	404
PP - Fisher Chi-square	40.1465	0.8845	26	416
	None			
Method	statistic	P-values	Cross-sections	Obs.

Levin, Lin & Chu	12.9936	1.0000	26	405
ADF - Fisher Chi-square	186.171	1.0000	26	405
PP - Fisher Chi-square	264.761	1.0000	26	416

Source: own computations.

Table 4.12: The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000), Fisher-ADF test and Fisher-PP test Panel Unit Root Tests on LBIO at First difference.

	Individual effects			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-13.4045	0.0000	26	383
Im, Pesaran and Shin W-stat	-11.2749	0.0000	26	383
ADF - Fisher Chi-square	216.836	0.0000	26	383
PP - Fisher Chi-square	261.609	0.0000	26	390
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-10.0429	0.0000	26	379
Breitung t-stat	-3.88828	0.0001	26	353
Im, Pesaran and Shin W-stat	-8.15316	0.0000	26	379
ADF - Fisher Chi-square	164.367	0.0000	26	379
PP - Fisher Chi-square	250.190	0.0000	26	390
	None			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-9.09207	0.0000	26	374
ADF - Fisher Chi-square	186.171	0.0000	26	374
PP - Fisher Chi-square	264.761	0.0000	26	390

Source: own computations.

Table 4.13: The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000), Fisher-ADF test and Fisher-PP test Panel Unit Root Tests on LDIRT at Level.

	Individual effects			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-3.05230	0.0011	23	343
Im, Pesaran and Shin W-stat	-1.48626	0.0686	23	343
ADF - Fisher Chi-square	74.3517	0.0051	23	343
PP - Fisher Chi-square	73.6270	0.0060	23	356
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.

Levin, Lin & Chu	-3.88044	0.0001	23	343
Breitung t-stat	1.13763	0.8724	23	320
Im, Pesaran and Shin W-stat	-1.06802	0.1428	23	343
ADF - Fisher Chi-square	67.8283	0.0198	23	343
PP - Fisher Chi-square	73.8943	0.0056	23	356
	None			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	2.61058	0.9955	23	344
ADF - Fisher Chi-square	24.5140	0.9961	23	344
PP - Fisher Chi-square	27.9027	0.9839	23	356

Source: own computations.

Table 4.14: The results of Levin, Lin, and Chu (2002), Im, Pesaran and Shin Test (2003), Breitung (2000), Fisher-ADF test and Fisher-PP test Panel Unit Root Tests on LDIRT at First difference .

	Individual effects			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-15.7878	0.0000	23	326
Im, Pesaran and Shin W-stat	-16.1390	0.0000	22	323
ADF - Fisher Chi-square	74.3517	0.0000	23	326
PP - Fisher Chi-square	73.6270	0.0000	23	333
	Individual effects, individual linear trends			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-13.6757	0.0000	22	321
Breitung t-stat	-7.08082	0.0000	22	299
Im, Pesaran and Shin W-stat	-15.3009	0.0000	22	321
ADF - Fisher Chi-square	263.210	0.0000	22	321
PP - Fisher Chi-square	319.258	0.0000	22	330
	None			
Method	statistic	P-values	Cross-sections	Obs.
Levin, Lin & Chu	-19.4395	0.0000	23	324
ADF - Fisher Chi-square	356.906	0.0000	23	324
PP - Fisher Chi-square	397.270	0.0000	23	333

Source: own computations.

Table 4.15: The results of Pedroni residual cointegration test with No deterministic trend for LGDP, LBIO, LNGC, LOC and LRE with LGDP is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-2.015955	0.9781	-1.473327	0.9297

Panel rho-Statistic	3.504043	0.9998	3.705448	0.9999
Panel PP-Statistic	0.032531	0.5130	0.219307	0.5868
Panel ADF-Statistic	-0.444967	0.3282	-0.685309	0.2466
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	5.675321	1.0000		
Group PP-Statistic	-0.446089	0.3278		
Group ADF-Statistic	-1.247964	0.1060		

Source: own computations.

Table 4.16: The results of Pedroni residual cointegration test with Deterministic intercept and trend for LGDP, LBIO, LNGC, LOC, LGE, and LRE with LGDP is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	14.85946	0.0000	7.908286	0.0000
Panel rho-Statistic	4.528311	1.0000	4.891382	1.0000
Panel PP-Statistic	-1.728311	0.0424	-1.089903	0.1379
Panel ADF-Statistic	-2.309640	0.0105	-1.663685	0.0481
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	6.086340	1.0000		
Group PP-Statistic	-7.844932	0.0000		
Group ADF-Statistic	-3.673268	0.0001		

Source: own computations.

Table 4.17: The results of Pedroni residual cointegration test with no Deterministic intercept or trend for LGDP, LBIO, LNGC, LOC, LGE, and LRE with LGDP is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-2.017340	0.9782	-2.595030	0.9953
Panel rho-Statistic	2.622110	0.9956	2.902760	0.9982
Panel PP-Statistic	-1.002812	0.1580	-1.139407	0.1273
Panel ADF-Statistic	-1.119867	0.1314	-1.811203	0.0351
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	5.038532	1.0000		
Group PP-Statistic	-0.453112	0.3252		
Group ADF-Statistic	-1.227155	0.1099		

Source: own computations.

Table 4.18 The results of Kao residual cointegration test for LGDP, LBIO, LNGC, LOC, LGE and LRE with LGDP is taken as dependent variable.

	t-Statistic	P-values
ADF	-2.167713	0.0151
Residual variance	0.005834	
HAC variance	0.009570	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	P-values
RESID(-1)	-0.139465	0.021927	-6.360330	0.0000
R-squared	0.076752	Mean dependent var	--	0.015549
Adjusted R-squared	0.076762	S.D. dependent var	-	0.088179
S.E. of regression	0.084727	Akaike info criterion	-	-2.095883
Sum squared resid	2.483829	Schwarz criterion	-	-2.084789
Log likelihood	364.6356	Hannan-Quinn criter.	-	-2.091466
Durbin-Watson stat	1.432358		-	

Source: own computations.

Table 4.19: The results of Pedroni residual cointegration test with no Deterministic trend for LGDP, LBIO, LNGC, LOC, LGE and LRE with LOC is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-1.899637	0.9713	-3.295556	0.9995
Panel rho-Statistic	2.718114	0.9967	2.792888	0.9974
Panel PP-Statistic	-6.135147	0.0000	-7.901293	0.0000
Panel ADF-Statistic	-6.151486	0.0000	-7.448689	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	4.465968	1.0000		
Group PP-Statistic	-8.866641	0.0000		
Group ADF-Statistic	-6.477371	0.0000		

Source: own computations.

Table 4.20: The results of Pedroni residual cointegration test with Deterministic intercept and trend for LGDP, LBIO, LNGC, LOC, LGE, and LRE with LOC is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-3.073173	0.9989	-5.091281	1.0000
Panel rho-Statistic	3.864737	1.0000	4.312271	1.0000
Panel PP-Statistic	-6.033173	0.0000	-10.53458	0.0000
Panel ADF-Statistic	-3.905244	0.0000	-5.743995	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	5.867390	1.0000		
Group PP-Statistic	-13.59066	0.0000		
Group ADF-Statistic	-5.085908	0.0000		

Source: own computations.

Table 4.21: The results of Pedroni residual cointegration test with no Deterministic intercept or trend for LGDP, LBIO, LNGC, LOC, LGE, and LRE with LOC is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-1.327924	0.9079	-2.910074	0.9982
Panel rho-Statistic	1.732926	0.9584	1.199128	0.8848

Panel PP-Statistic	-5.609610	0.0000	-4.997964	0.0000
Panel ADF-Statistic	-5.756036	0.0000	-5.019127	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	3.623259	0.9999		
Group PP-Statistic	-6.582221	0.0000		
Group ADF-Statistic	-4.905712	0.0000		

Source: own computations.

Table 4.22: The results of Kao residual cointegration test for LGDP, LBIO, LNGC, LOC, LGE and LRE with LOC is taken as dependent variable.

Kao residual cointegration test

	t-Statistic	P-values
ADF	-3.844941	0.0001
Residual variance	0.023304	
HAC variance	0.026169	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	P-values
RESID(-1)	-0.497642	0.054848	-9.073133	0.0000
R-squared	0.190528	Mean dependent var	--	-0.004842
Adjusted R-squared	0.190528	S.D. dependent var	-	0.106722
S.E. of regression	0.096019	Akaike info criterion	-	-1.845673
Sum squared resid	3.189969	Schwarz criterion	-	-1.834580
Log likelihood	321.2242	Hannan-Quinn criter.	-	-1.841256
Durbin-Watson stat	1.784987		-	

Source: own computations.

Table 4.23: The results of Pedroni residual cointegration test with no Deterministic trend for LGDP, LBIO, LNGC, LOC, LGE and LRE with LNGC is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-1.260395	0.8962	-1.922884	0.9728
Panel rho-Statistic	3.711965	0.1261	3.833121	0.9999
Panel PP-Statistic	-1.144913	0.1261	-1.889084	0.0294
Panel ADF-Statistic	-2.875050	0.0020	-2.989500	0.0014
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	5.947534	1.0000		
Group PP-Statistic	-4.086156	0.0000		
Group ADF-Statistic	-4.723422	0.0000		

Source: own computations.

Table 4.24: The results of Pedroni residual cointegration test with Deterministic intercept and trend for LGDP, LBIO, LNGC, LOC, LGE, and LRE with LNGC is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	3.283289	0.0005	-2.561524	0.9948
Panel rho-Statistic	3.940001	1.0000	4.978903	1.0000
Panel PP-Statistic	-2.801939	0.0025	-2.808092	0.0025
Panel ADF-Statistic	-3.065047	0.0011	-4.31582	0.0000

Alternative hypothesis: individual AR coefs. (between-dimension)		
Group rho-Statistic	6.860727	1.0000
Group PP-Statistic	-6.124611	0.0000
Group ADF-Statistic	-5.772825	0.0000

Source: own computations.

Table 4.25: The results of Pedroni residual cointegration test with no Deterministic intercept or trend for LGDP, LBIO, LNGC, LOC, LGE, and LRE with LNGC is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-1.308268	0.9046	-2.178440	0.9853
Panel rho-Statistic	2.456682	0.9930	2.150143	0.9842
Panel PP-Statistic	-3.832674	0.0001	-3.559834	0.0002
Panel ADF-Statistic	-4.551350	0.0000	-4.933035	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	4.612764	1.0000		
Group PP-Statistic	-3.738627	0.0001		
Group ADF-Statistic	-6.380995	0.0000		

Source: own computations.

Table 4.26: The results of Kao residual cointegration test for LGDP, LBIO, LNGC, LOC, LGE and LRE with LNGC is taken as dependent variable.

Kao residual cointegration test

	t-Statistic	P-values
ADF	-15.79116	0.0000
Residual variance	0.028174	
HAC variance	0.044551	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	P-values
RESID(-1)	-0.414653	0.020494	-20.23330	0.0000
R-squared	0.536598	Mean dependent var	--	0.019040
Adjusted R-squared	0.536598	S.D. dependent var	-	0.176300
S.E. of regression	0.120013	Akaike info criterion	-	-1.399548
Sum squared resid	4.983520	Schwarz criterion	-	-1.388454
Log likelihood	243.8215	Hannan-Quinn criter.	-	-1.395131
Durbin-Watson stat	0.857946		-	

Source: own computations.

Table 4.27: The results of Pedroni residual cointegration test with no Deterministic trend for LGDP, LBIO, LNGC, LOC, LGE and LRE with LRE is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-0.522364	0.6993	-2.517790	0.9941
Panel rho-Statistic	3.237660	0.9994	3.053453	0.9989
Panel PP-Statistic	-4.188126	0.0000	-6.885363	0.0000
Panel ADF-Statistic	-4.089936	0.0000	-5.591512	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				

Group rho-Statistic	5.098851	1.0000
Group PP-Statistic	-11.38436	0.0000
Group ADF-Statistic	-5.756557	0.0000

Source: own computations.

Table 4.28: The results of Pedroni residual cointegration test with Deterministic intercept and trend for LGDP, LBIO, LNGC, LOC, LGE, and LRE with LRE is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-1.574726	0.9423	-3.273726	0.9995
Panel rho-Statistic	4.007706	1.0000	3.931707	1.0000
Panel PP-Statistic	-5.517501	0.0000	-10.29371	0.0000
Panel ADF-Statistic	-4.725598	0.0000	-7.432897	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	5.637526	1.0000		
Group PP-Statistic	-14.73290	0.0000		
Group ADF-Statistic	-7.595234	0.0000		

Source: own computations.

Table 4.29: The results of Pedroni residual cointegration test with no Deterministic intercept or trend for LGDP, LBIO, LNGC, LOC, LGE, and LRE with LRE is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-0.697360	0.7572	-2.589301	0.9952
Panel rho-Statistic	3.073089	0.9989	2.467980	0.9932
Panel PP-Statistic	-2.079116	0.0188	-3.401554	0.0003
Panel ADF-Statistic	-2.776045	0.0028	-4.017901	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	4.752463	1.0000		
Group PP-Statistic	-7.084777	0.0000		
Group ADF-Statistic	-4.573712	0.0000		

Source: own computations.

Table 4.30: The results of Kao residual cointegration test for LGDP, LBIO, LNGC, LOC, LGE and LRE with LRE is taken as dependent variable.

Kao residual cointegration test

	t-Statistic	P-values
ADF	-1.128027	0.1297
Residual variance	0.032024	
HAC variance	0.027999	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	P-values
RESID(-1)	-0.237157	0.036256	-6.541241	0.0000
R-squared	0.109516	Mean dependent var	--	0.004650
Adjusted R-squared	0.109516	S.D. dependent var	-	0.189289

S.E. of regression	0.178624	Akaike info criterion	-	-0.604192
Sum squared resid	11.03964	Schwarz criterion	-	-0.593099
Log likelihood	105.8273	Hannan-Quinn criter.	-	-0.599775
Durbin-Watson stat	2.055495		-	

Source: own computations.

Table 4.31: The results of Pedroni residual cointegration test with no Deterministic trend for LGDP, LBIO, LNGC, LOC, LGE and LRE with LBIO is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-1.162654	0.8775	-1.141006	0.8731
Panel rho-Statistic	4.076505	1.0000	4.239996	1.0000
Panel PP-Statistic	1.279088	0.8996	0.808010	0.7905
Panel ADF-Statistic	-0.000834	0.4997	-1.316398	0.0940
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	5.671668	1.0000		
Group PP-Statistic	-8.410526	0.0253		
Group ADF-Statistic	-3.374525	0.0235		

Source: own computations.

Table 4.32: The results of Pedroni residual cointegration test with Deterministic intercept and trend for LGDP, LBIO, LNGC, LOC, LGE, and LRE with LBIO is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-3.183427	0.5774	-1.416546	0.9217
Panel rho-Statistic	4.831416	1.0000	5.456858	1.0000
Panel PP-Statistic	-1.856913	0.9590	0.716261	0.7631
Panel ADF-Statistic	-3.243545	0.8101	-0.712183	0.2382
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	6.742524	1.0000		
Group PP-Statistic	-1.585830	0.0564		
Group ADF-Statistic	-2.042741	0.0205		

Source: own computations.

Table 4.33: The results of Pedroni residual cointegration test with no Deterministic intercept or trend for LGDP, LBIO, LNGC, LOC, LGE, and LRE with LBIO is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-0.492273	0.6887	-0.994825	0.8401
Panel rho-Statistic	2.396476	0.9917	2.520988	0.9941
Panel PP-Statistic	-0.888668	0.1871	-1.088652	0.1382
Panel ADF-Statistic	-1.240893	0.1073	-1.402419	0.0804

Alternative hypothesis: individual AR coefs. (between-dimension)		
Group rho-Statistic	4.812838	1.0000
Group PP-Statistic	-3.325826	0.0004
Group ADF-Statistic	-1.676473	0.0468

Source: own computations.

Table 4.34: The results of Kao residual cointegration test for LGDP, LBIO, LNGC, LOC, LGE and LRE with LBIO is taken as dependent variable.

Kao residual cointegration test

	t-Statistic	P-values
ADF	-2.347426	0.0095
Residual variance	0.016460	
HAC variance	0.016896	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	P-values
RESID(-1)	-0.222478	0.032264	-6.895605	0.0000
R-squared	0.120745	Mean dependent var	--	0.001358
Adjusted R-squared	0.120745	S.D. dependent var	-	0.145403
S.E. of regression	0.136343	Akaike info criterion	-	-1.144414
Sum squared resid	6.431899	Schwarz criterion	-	-1.133321
Log likelihood	199.5559	Hannan-Quinn criter.	-	-1.139997
Durbin-Watson stat	2.009961		-	

Source: own computations.

Table 4.35: The results of Pedroni residual cointegration test with no Deterministic trend for LGDP, LBIO, LNGC, LOC, LGE, and LRE, with LGE is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-2.102598	0.9822	-2.290073	0.9890
Panel rho-Statistic	3.944425	1.0000	3.952348	1.0000
Panel PP-Statistic	-0.404362	0.3430	-0.757724	0.2243
Panel ADF-Statistic	-1.196916	0.1157	-2.113219	0.0173
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	5.869814	1.0000		
Group PP-Statistic	-4.027074	0.0000		
Group ADF-Statistic	-2.518708	0.0059		

Source: own computations.

Table 4.36: The results of Pedroni residual cointegration test with Deterministic intercept and trend for LGDP, LBIO, LNGC, LOC, LGE, and LRE with, LGE is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-1.880594	0.9700	-2.587619	0.9952
Panel rho-Statistic	5.192904	1.0000	5.239509	1.0000
Panel PP-Statistic	-1.183991	0.1182	-2.315078	0.0103
Panel ADF-Statistic	-1.101203	0.1354	-2.385860	0.0085
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	6.015993	1.0000		
Group PP-Statistic	-7.626852	0.0000		

Group ADF-Statistic	-4.168071	0.0000

Source: own computations

Table 4.37 : The results of Pedroni residual cointegration test with no Deterministic intercept or trend for LGDP, LBIO, LNGC, LOC, LGE and LRE with , LGE is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-4.450385	1.0000	-4.532891	1.0000
Panel rho-Statistic	2.450598	0.9929	2.078133	0.9812
Panel PP-Statistic	-3.656120	0.0001	-4.871293	0.0000
Panel ADF-Statistic	-4.339391	0.0000	-5.351504	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	4.602674	1.0000		
Group PP-Statistic	-6.264654	0.0000		
Group ADF-Statistic	-4.448205	0.0000		

Source: own computations.

Table 4.38: The results of Kao residual cointegration test for LGDP, LBIO, LNGC, LOC, LGE and LRE with LGE is taken as dependent variable.

Kao residual cointegration test

	t-Statistic	P-values
ADF	-3.551590	0.0002
Residual variance	0.001642	
HAC variance	0.001679	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	P-values
RESID(-1)	-0.327699	0.039299	-8.338520	0.0000
R-squared	0.160664	Mean dependent var	--	-0.003768
Adjusted R-squared	0.160664	S.D. dependent var	-	0.042172
S.E. of regression	0.038636	Akaike info criterion	-	-3.666388
Sum squared resid	0.516487	Schwarz criterion	-	-3.655295
Log likelihood	637.1184	Hannan-Quinn criter.	-	-3.661971
Durbin-Watson stat	1.923567		-	

Source: own computations.

Table 4.39: The results of Pedroni residual cointegration test with no Deterministic trend for LGDP, LDIRT, LGE and LRE with , LGDP is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-2.864105	0.9979	-1.453182	0.9269
Panel rho-Statistic	2.556045	0.9947	1.405421	0.9201
Panel PP-Statistic	0.728273	0.7668	-0.757724	0.1077
Panel ADF-Statistic	0.101870	0.5406	-1.824359	0.0340
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	3.011651	0.9987		
Group PP-Statistic	-1.499177	0.0669		
Group ADF-Statistic	-2.343143	0.0096		

Source: own computations.

Table 4.40: The results of Pedroni residual cointegration test with Deterministic intercept and trend for LGDP, LDIRT, LGE and LRE with , LGDP is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	18.21140	0.0000	12.97762	0.0000
Panel rho-Statistic	3.149088	0.9992	3.321332	0.9969
Panel PP-Statistic	0.227568	0.5900	0.272006	0.6072
Panel ADF-Statistic	-1.708619	0.0438	-1.481944	0.0692
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	5.139662	1.0000		
Group PP-Statistic	0.706703	0.7601		
Group ADF-Statistic	-1.065657	0.1433		

Source: own computations

Table 4.41 : The results of Pedroni residual cointegration test with no Deterministic intercept or trend for LGDP, LDIRT, LGE and LRE with , LGDP is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-2.140952	0.9839	-1.561154	0.9408
Panel rho-Statistic	2.255663	0.9880	1.528806	0.9812
Panel PP-Statistic	0.741347	0.7708	-0.338188	0.3676
Panel ADF-Statistic	0.286489	0.6127	-0.700462	0.2418
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	3.291518	0.9995		
Group PP-Statistic	-0.63449	0.2613		
Group ADF-Statistic	-2.343865	0.0095		

Source: own computations.

Table 4.42: The results of Kao residual cointegration test for LGDP, LDIRT, LGE and LRE with LGDP is taken as dependent variable.

Kao residual cointegration test

	t-Statistic	P-values
ADF	-2.135071	0.0164
Residual variance	0.006286	
HAC variance	0.010415	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	P-values
RESID(-1)	-0.147035	0.021979	-6.689861	0.0000
R-squared	0.063057	Mean dependent var	--	0.025083
Adjusted R-squared	0.063057	S.D. dependent var	-	0.104495
S.E. of regression	0.101147	Akaike info criterion	-	-1.741615
Sum squared resid	3.550054	Schwarz criterion	-	-1.730546
Log likelihood	304.0411	Hannan-Quinn criter.	-	-1.737208
Durbin-Watson stat	1.576930		-	

Source: own computations.

Table 4.43: The results of Pedroni residual cointegration test with no Deterministic trend for LGDP, LDIRT, LGE and LRE with , LDIRT is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-0.293638	0.6155	0.154716	0.4385
Panel rho-Statistic	-0.316184	0.3759	-0.219533	0.4131
Panel PP-Statistic	-7.695074	0.0000	-5.214636	0.0000
Panel ADF-Statistic	-7.693839	0.0000	-5.529199	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	1.589041	0.9440		
Group PP-Statistic	-6.859728	0.0000		
Group ADF-Statistic	-6.026679	0.0000		

Source: own computations.

Table 4.44: The results of Pedroni residual cointegration test with Deterministic intercept and trend for LGDP, LDIRT, LGE and LRE with , LDIRT is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-2.719255	0.9967	-2.078505	0.9812
Panel rho-Statistic	1.528723	0.9368	1.801571	0.9642
Panel PP-Statistic	-8.663270	0.0000	-5.585669	0.0000
Panel ADF-Statistic	-9.203561	0.0000	-5.838459	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	3.265770	0.9995		
Group PP-Statistic	-8.728446	0.0000		
Group ADF-Statistic	-6.450447	0.0000		

Source: own computations

Table 4.45 : The results of Pedroni residual cointegration test with no Deterministic intercept or trend for LGDP, LDIRT, LGE and LRE with , LDIRT is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-0.418158	0.6621	0.396429	0.3459
Panel rho-Statistic	0.125179	0.4502	-0.495352	0.3102
Panel PP-Statistic	-5.472373	0.0000	-3.602841	0.0002
Panel ADF-Statistic	-5.512715	0.0000	-3.935332	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	1.449668	0.9264		
Group PP-Statistic	-4.934190	0.0000		
Group ADF-Statistic	-5.512715	0.0000		

Source: own computations.

Table 4.46: The results of Kao residual cointegration test for LGDP, LDIRT, LGE and LRE with LDIRT is taken as dependent variable.

Kao residual cointegration test

	t-Statistic	P-values
ADF	-3.400150	0.0003
Residual variance	0.004095	
HAC variance	0.003785	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	P-values
RESID(-1)	-0.382465	0.042105	-9.083707	0.0000
R-squared	0.191904	Mean dependent var	--	0.000898
Adjusted R-squared	0.191904	S.D. dependent var	-	0.056352
S.E. of regression	0.050657	Akaike info criterion	-	-3.124618
Sum squared resid	0.890440	Schwarz criterion	-	-3.113549
Log likelihood	544.6836	Hannan-Quinn criter.	-	-3.120211
Durbin-Watson stat	2.036500		-	

Source: own computations.

Table 4.47: The results of Pedroni residual cointegration test with no Deterministic trend for LGDP, LDIRT, LGE and LRE with , LGE is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-0.383149	0.6492	-0.146337	0.5582
Panel rho-Statistic	0.841557	0.8000	-0.722121	0.7649
Panel PP-Statistic	-2.327910	0.0100	-2.849109	0.0022
Panel ADF-Statistic	-2.674965	0.0037	-3.379601	0.0004
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	2.701792	0.9966		
Group PP-Statistic	-6.829100	0.0000		
Group ADF-Statistic	-4.109099	0.0000		

Source: own computations.

Table 4.48: The results of Pedroni residual cointegration test with Deterministic intercept and trend for LGDP, LDIRT, LGE and LRE with , LGE is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-0.490867	0.6882	-0.749834	0.7733
Panel rho-Statistic	3.288601	0.9995	3.059188	0.9989
Panel PP-Statistic	-2.260433	0.0119	-2.605207	0.0046
Panel ADF-Statistic	-2.790413	0.0026	-2.745518	0.0030
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	4.567421	1.0000		
Group PP-Statistic	-6.907867	0.0000		
Group ADF-Statistic	-3.15374	0.0008		

Source: own computations

Table 4.49 : The results of Pedroni residual cointegration test with no Deterministic intercept or trend for LGDP, LDIRT, LGE and LRE with , LGE is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-2.536395	0.9944	-3.021524	0.9987
Panel rho-Statistic	-0.547470	0.2920	-0.809536	0.2091
Panel PP-Statistic	-5.472373	0.0001	-3.514981	0.0002
Panel ADF-Statistic	-4.287425	0.0000	-3.994674	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	1.438154	0.9248		
Group PP-Statistic	-3.903606	0.0000		
Group ADF-Statistic	-4.925149	0.0000		

Source: own computations.

Table 4.50: The results of Kao residual cointegration test for LGDP, LDIRT, LGE and LRE with LGE is taken as dependent variable.

Kao residual cointegration test

	t-Statistic	P-values
ADF	-2.614354	0.0045
Residual variance	0.001733	
HAC variance	0.001709	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	P-values
RESID(-1)	-0.300639	0.038572	-7.794282	0.0000
R-squared	0.142340	Mean dependent var	--	-0.003685
Adjusted R-squared	0.142340	S.D. dependent var	-	0.041744
S.E. of regression	0.038659	Akaike info criterion	-	-3.665202
Sum squared resid	0.518599	Schwarz criterion	-	-3.654132
Log likelihood	638.7451	Hannan-Quinn criter.	-	-3.660795
Durbin-Watson stat	1.886618		-	

Source: own computations.

Table 4.51: The results of Pedroni residual cointegration test with no Deterministic trend for LGDP, LDIRT, LGE and LRE with , LRE is taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	0.275478	0.3915	-1.383950	0.9168
Panel rho-Statistic	-0.050537	0.4798	0.254102	0.6003
Panel PP-Statistic	-5.289614	0.0000	-6.280551	0.0000
Panel ADF-Statistic	-5.034033	0.0000	-6.040366	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	1.924165	0.9728		
Group PP-Statistic	-10.22843	0.0000		
Group ADF-Statistic	-6.549645	0.0000		

Source: own computations.

Table 4.52 The results of Pedroni residual cointegration test with Deterministic intercept and trend for LGDP, LDIRT, LGE and LRE with , LRE taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-1.442295	0.9254	-3.676872	0.9999
Panel rho-Statistic	1.349621	0.9114	1.933307	0.9734
Panel PP-Statistic	-6.496748	0.0000	-8.343774	0.0000
Panel ADF-Statistic	-7.088757	0.0000	-7.795035	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	3.243534	0.9994		
Group PP-Statistic	-10.45557	0.0000		
Group ADF-Statistic	-7.793399	0.0000		

Source: own computations

Table 4.53 : The results of Pedroni residual cointegration test with no Deterministic intercept or trend for LGDP, LDIRT, LGE and LRE with , LRE taken as dependent variable.

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	P-values	Weighted Statistic	P-values
Panel v-Statistic	-0.549912	0.7088	-1.723434	0.9576
Panel rho-Statistic	-1.526397	0.7723	0.626595	0.7345
Panel PP-Statistic	-1.526397	0.0635	-2.068804	0.0193
Panel ADF-Statistic	-1.748655	0.0402	-3.316602	0.0005
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	2.512537	0.9940		
Group PP-Statistic	-3.218850	0.0006		
Group ADF-Statistic	-3.830641	0.0000		

Source: own computations.

Table 4.54: The results of Kao residual cointegration test for LGDP, LDIRT, LGE and LRE with LRE taken as dependent variable.

Kao residual cointegration test

	t-Statistic	P-values
ADF	0.106225	0.4577
Residual variance	0.032083	
HAC variance	0.028204	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	P-values
RESID(-1)	-0.202112	0.035261	-5.731970	0.0000
R-squared	0.084896	Mean dependent var	--	0.008103
Adjusted R-squared	0.084896	S.D. dependent var	-	0.193955
S.E. of regression	0.185540	Akaike info criterion	-	-0.528225
Sum squared resid	11.94549	Schwarz criterion	-	-0.517155
Log likelihood	92.91107	Hannan-Quinn criter.	-	-0.523818
Durbin-Watson stat	2.122167		-	

Source: own computations.