JOURNAL OF ECONOMIC DEVELOPMENT 89
Volume 42, Number 3, September 2017

A ROBUST ANALYSIS OF THE RELATIONSHIP BETWEEN NATURAL DISASTERS, ELECTRICITY AND ECONOMIC GROWTH IN 41 COUNTRIES

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In this paper, our objective is to investigate the relationship between natural disasters (droughts, floods, earthquakes, and storms), electricity and other variables macroeconomic for 41 countries over the period 1990–2014. The Panel data and Granger causality-VECM used in this paper over the period 1990–2014. The analysis finds that, the impact of natural disasters is negative and stronger on developing than on developed countries. Second, the test of causality shows that both in short term and long term there is a unidirectional relationship running from disaster measures to electricity consumption. In the long term, we note the existence of a unidirectional causal relationship ranging from disaster measures to GDP per capita.

Keywords: Natural Disaster, Economic Growth, Electricity Consumption, Panel Data, Granger Causality-VECM
JEL Classification: Q54, O16, Q4, C23, C22

1. INTRODUCTION

Natural disasters are now better known. They are well investigated and mapped both locally and global scale. Natural disasters are liable to cause serious economic and social disruption. The immediate damage is decrease production, expenditures and the number of hours worked. According to the data reported by EM-DAT, Americas suffered in 2014 from 76 natural disasters and the damage reached US$ 25.8 billion. On the other side, Africa suffered from 39 natural disasters, a number far below its 2004-2013 annual average. According to EM-DAT (2014), the damages from natural disasters in European countries represent approximately US$ 7.8 billion.

The occurrence of natural disasters such as earthquakes, hurricanes, tornadoes, floods, storms and volcanic eruptions have negative effects on the electrical system operation. The earthquakes that have hit several countries such as China, Italy, Japan and the United States have severe impact economic, environmental and human. In addition, they destroyed their power system equipment.

The response of the authorities has led in practice by the implementation of prevention and risk management systems evolving since the 1980s, resulting in an abundance of tools and acronyms that thwarts their ownership all players. In the period immediately following the event, reconstruction efforts are offset these losses and, paradoxically, create a net stimulatory effect on economic growth. To achieve this objective, it is necessary to measure or estimate economic costs of such disasters. In this sense, many studies have examined the debate in a macro-economic perspective by exploring how disasters affect real GDP per capita.

In general, economic effects due to disasters can be classified into two categories: direct damage and indirect damage. The main findings shown that the direct effects of natural disasters depend on the level of development of the affected countries (Kahn, 2005).Most empirical studies have shown that natural disasters have a negative indirect damage in short-term, such as effects on economic growth (Noy, 2009; Fomby et al., 2013). Although long-term studies are still relatively rare and yet failed to provide consistent results (Skidmore and Toya, 2002; Noy and Nualsri, 2007; Jaramillo, 2009.).

The contribution of this article is to assess the effects of natural disaster on economic growth, physical capital, labor and electricity. Furthermore, our study of literature suggests that few studies have examined the impact of natural disaster on the electricity. For this purpose, we use a Panel data and Granger causality-VECM model, including four types of disasters (earthquakes, storms, floods and droughts) in about 41 countries over the period 1990 to 2014.

The sections of this paper presented as follows. The literature review section presents a brief literature review. The data section details the data used in the empirical part. The descriptive statistics and correlation matrix section summarizes the key statistics and correlation of the total variables. The model specification section describes the econometric method. The estimation methods and empirical results section discusses the empirical findings. Finally, conclusion and policy implications section.

2. REVIEW OF THE RELEVANT LITERATURE

2.1. Natural Disaster and Economic Growth

There is a considerable attention in literature about the impact of natural disaster on economic growth. For instance, Albala-Bertrand (1993) investigated the effects of natural disaster on the economy and society in developing countries. He concluded that in reality disasters do not represent a problem for development. Benson (1997a, b, and c), Benson and Clay (1998, 2001) evaluated the impact of natural disasters on economic growth in some countries such as Fiji, Vietnam, Philippines, and Dominica. The findings showed that disasters shocks have a severe negative short-run economic consequence, with increase of property, and worsening inequalities. Using a cross-section of 89 developed and developing countries over 1960-1990, Skidmore and Toya (2002) investigated the effects of disaster risk on economic growth and another macroeconomic variable in the long run. They detected a positive relationship between natural disaster and economic growth. These authors showed that the frequency of climatic disasters have a positive significant effects on total factor productivity (TFP), and human capital accumulation. In another paper, Caselli and Malhotra (2004) based their analysis on Solow model and used a dataset of 172 countries for events between 1975 and 1996. Their result showed that natural disaster has a negative significant impact on economic growth.

Furthermore, Loayza and et al. (2009) examined the impact of disaster risk by type and economic sector for a group of 94 developed and developing countries for the period 1961–2005. They showed that natural disaster impact is very severe in developing countries than developed countries. Similarly, Cavallo and Noy (2010) founded that the economic growth decreases following the catastrophic events. Sawada et al. (2011) used a panel data model of 189 countries between 1968 and 200. They showed that natural disasters generate a negative impact on economic costs. Baker and Bloom (2013) used a cross-country panel data to investigate the causal relationship between extreme weather events and growth. The results of the empirical study show natural disaster having a neutral or positive effect on GDP growth. Berlemann and Wenzel (2015) found that the drought has a negative impact on long-term economic growth in developed and developing countries. Jeroen (2016) suggested that impact of natural disasters on economic growth is different depending on the degree of financial development and the quality of the political institutions.

2.2. Natural Disaster and Electricity Consumption

Electricity is an essential factor for economic development in all countries of the world. Electricity consumption increases with technological progress and industrialization. The increase in production is synonymous with improved quality of life and wealth creation. However, the components of the electricity power networks directly affected by natural disasters such as earthquakes, hurricanes, floods, tornadoes and typhoons. In some extreme cases, power outages lasted a few days or even weeks.

Some research focuses on the link between natural disasters and electricity. For example, Chang et al. (2007) studied the problem of disruption of electrical systems after extreme events. In addition, they proposed strategic approaches to mitigate future electric power outages. According to Oral and Dönmez (2010) found that earthquake have a negative effect on the Turkish Power System.

2.3. Other Macroeconomic Impacts of Disasters

Skidmore and Toya (2002) employed a cross-section of developed and developing countries between 1960 and 1990. They showed that after natural disaster, an increase in the risk of capital destruction leads to an increase in investments in human capital. By using a neoclassical growth model, Caselli and Malhotra (2004) investigated the losses of growth rate after natural disaster. Their result indicated that there is relationship between losses of labor and capital stock and economic growth. A recent study by Noy (2008) has investigated the macroeconomic impact of natural disasters in developed and developing countries over 1970 and 2003, using the regression analysis. The findings showed that capital losses affected by disaster events. In another study, Cuaresma and Hlouskova (2008) showed that natural disasters stimulate the use of new technologies and provide the ability to recover the capital stock. Hallegatte and Dumas (2009) found that there is a negative relationship between natural disaster and capital. However, after disaster, capital losses can be compensated and replaced using recent technologies, which have higher productivities. Leiter et al. (2009) analyzed the relationship between floods, capital stock, employment, and productivity. These authors showed that the impact of flood on physical capital accumulation depends on the percentage of intangible assets in the production process. In addition, they concluded that positive capital and employment effects do not necessarily lead to higher productivity in the short-run. Fomby et al. (2013) employed vector auto regressions (VARX), applied to a panel of cross-country and time-series data, and found that severe earthquakes have a negative impact on capital stock and labor force.

3. DATA

3.1. Natural Disasters (Definition and Measurement)

A natural disaster is a phenomenon that is dangerously in a defined space and time. She is able to cause a disruption of the functioning of the economic, social and environmental. These impacts can generate impacts not only on a short-term basis but also long-term. Natural disasters classified into three categories: geophysical, hydro-meteorological and biological disasters.

The number of natural disasters increasing significantly. Among these phenomena, hydrological disasters, including floods, increased slightly compared to 2012. The number of victims from hydrological disasters decreased by 70.2% compared to their decade's annual average. Meteorological disasters (storms) represented in 2013 approximately 32.1% of the total disaster (CRED, 2013).

In our study, we use data from EM-DAT database (It contains information on people killed, made homeless, the event name, the location, the day, month and year in which the disaster starts and ends) and we focus on four types of disasters: Geophysical; earthquakes, Hydro meteorological; storms and floods, and Climatologically; droughts.

We follow the approach of Noy (2009) to construct the measurement of the disasters that is the sum of total of people killed; the sum of total of people affected and cost of economic damage. The cost measure of disasters (DM) calculated as follows:

$$\text{Total population affected}_{i,t} = \left[\sum_{j=1}^{N}\left(\frac{\text{Total population affected}_{i,j,t}}{\text{Total population}_{i,t}}\right)\right], \quad (1)$$

$$\text{Total population killed}_{i,t} = \left[\sum_{j=1}^{N}\left(\frac{\text{Total population killed}_{i,j,t}}{\text{Total population}_{i,t}}\right)\right], \quad (2)$$

$$\text{Economic damage}_{i,t} = \left[\sum_{j=1}^{N}\left(\frac{\text{Damage}_{i,j,t}}{\text{Total GDP}_{i,t}}\right)\right], \quad (3)$$

where, i denotes the country, j corresponds to the natural disaster and $t = 1, \ldots, N$ corresponds to the year. Natural events that occur in January potentially have a bigger effect on the macro-economy, than an event that occurred in December of the same year. We follow the approach Noy (2009), we use the following rates: $(12 - \text{month})/12$ to correct the time of the event. The disaster measures (DMS) calculated as following:

$$DMS = DM\,\frac{(12-\text{month})}{12}.$$

Table 1. Natural Disaster Categories, Definition, and Types

Disaster Subgroup	Definition	Disaster Main Type
Geophysical	Events originating from solid earth	Earthquake, Volcanic, Mass Movement (dry)
Hydrometeorological	Natural processes or phenomena of Hydrological or Meteorological	Flood, Storm, Mass movement (wet)
Climatological	A hazard caused by long-lived, meso- to macro-scale atmospheric processes ranging from intra-seasonal to multi-decadal climate variability.	Drought, Wildfire

3.2. Data Sources Other Variables

We use three dependent variables obtained from World Bank: GDP per capita, labor input, physical capital stock and electricity consumption. The selected countries are: (i) The European countries: United Kingdom, Turkey, Sweden, Romania, Czech Republic, Portugal, Netherlands, Norway, Malta, Italy, Ireland, Greece, France, Finland, Denmark, Austria, and Cyprus. (ii) The African countries: South Africa, Algeria, Egypt, Gabon, Kenya, Mauritius, Morocco, Togo, Tunisia, and Zimbabwe. (iii) The American countries: Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Ecuador, United States, Guatemala, Honduras, Mexico, Paraguay, Peru, Salvador, Trinidad and Tobago, Uruguay, and Venezuela.

4. DESCRIPTIVE STATISTICS AND CORRELATION MATRIX

4.1. Descriptive Statistics

Table 2. Major Statistics of the 41 Sample Countries

		LNGDP	LNK	LNL	LNEC	DMS
Together of the sample	Mean	8.8308	23.7884	15.7089	7.6793	19.5781
	Median	8.6579	23.9570	15.6438	7.7284	0.8354
	Maximum	11.1432	28.7448	18.8972	10.1499	2293.522
	Minimum	5.7675	18.631	12.6738	4.2354	0.0000
	Std.Dev.	1.4022	1.9108	1.277153	1.2713	128.4061
	Skewness	-0.1615	0.0187	0.055133	-0.2764	13.8100
	Kurtosis	2.0048	2.7552	2.9310	2.6725	215.5710
	Jarque-Bera	46.7593	2.6195	0.7224	17.6377	19.6241
	Probability	0.0000	0.2698	0.6968	0.0001	0.0000
	Sum	9051.621	24383.19	16101.70	7871.286	20067.59
	SumSq.Dev.	2013.493	3738.790	1670.268	1655.127	168.8383
	Observations	1025	1025	1025	1025	1025
European countries	Mean	10.1503	8.6812	16.5561	24.8841	15.5716
	Median	10.3620	8.6713	1.7988	24.7764	15.3987
	Maximum	11.1432	10.1499	1869.422	26.9925	17.3118
	Minimum	7.9936	6.8598	8.86E-10	21.5166	12.6738
	Std.Dev.	0.7188	0.6923	103.8705	1.2131	1.1438
	Skewness	-1.3910	0.1257	15.7429	-0.4004	-0.2611
	Kurtosis	4.2477	3.0051	274.2728	3.4137	2.6647
	Jarque-Bera	145.2660	0.9892	11.6531	12.6977	6.0196
	Probability	0.0000	0.6097	0.0000	0.0017	0.0493
	Sum	3806.379	3255.483	6208.563	9331.557	5839.368
	SumSq.Dev.	193.2656	179.2753	403.5118	550.4589	489.3329
American countries	Mean	8.4574	23.5211	15.8902	7.4105	27.5931
	Median	8.4125	23.2164	15.7663	7.3515	0.0145
	Maximum	10.7451	28.7448	18.8972	9.7547	2293.522
	Minimum	6.7169	20.3664	13.0277	4.7341	0.0000
	Std.Dev.	0.9790	2.0454	1.4398	1.0699	172.9310
	Skewness	0.6458	0.7598	0.2904	0.5548	10.5297
	Kurtosis	3.0434	2.8379	2.4875	2.8766	125.2411
	Jarque-Bera	29.5836	41.3605	10.6269	22.0764	27.2467
	Probability	0.0000	0.0000	0.0049	0.0000	0.0000
	Sum	3594.411	9996.487	6753.349	3149.499	11727.07
	SumSq.Dev.	406.4427	1773.879	879.0253	485.3773	126.7977
	Observations	425	425	425	425	425
African countries	Mean	7.3370	22.4673	15.5955	6.5169	9.4753
	Median	7.4592	22.9204	15.9778	6.6838	1.9881
	Maximum	8.8701	24.9734	17.2031	8.5293	152.6215
	Minimum	5.7675	18.6312	13.0027	4.2354	3.58E-07
	Std.Dev.	0.9438	1.5543	1.1139	1.1166	22.6828
	Skewness	-0.1306	-0.6680	-0.9277	-0.2383	3.5943
	Kurtosis	1.5987	2.5625	2.9877	2.4436	17.1171
	Jarque-Bera	19.0484	18.5282	32.2804	5.0319	2352.850
	Probability	0.0000	0.0000	0.0000	0.0807	0.0000
	Sum	1650.832	5055.145	3508.988	1466.304	2131.960
	SumSq.Dev.	199.5374	541.1581	277.9776	279.2850	115250.7
	Observations	225	225	225	225	225

Source: Author's calculations.

Table 2 summarizes the key statistics relating to the four groups of countries. There are the averages of European countries, American countries and African countries and the average of the whole sample and their respective standard deviations.

These tables highlight three findings. First, the average of per capita GDP of European countries (10.50) is higher than the average of 41 countries (8.830) and those of the Americas (8.457) and African countries (7.337).The average of electricity of African countries (6.516) is less than the average of the American countries (7.410) and those of the 41 countries (7.679) and European countries (24.884). The American region appears as the most disadvantaged of all groups with the means of the DMS (27.593), values that are well below the average of other countries (the entire sample (19.5781), European countries (15.5717) and African countries (9.4754))

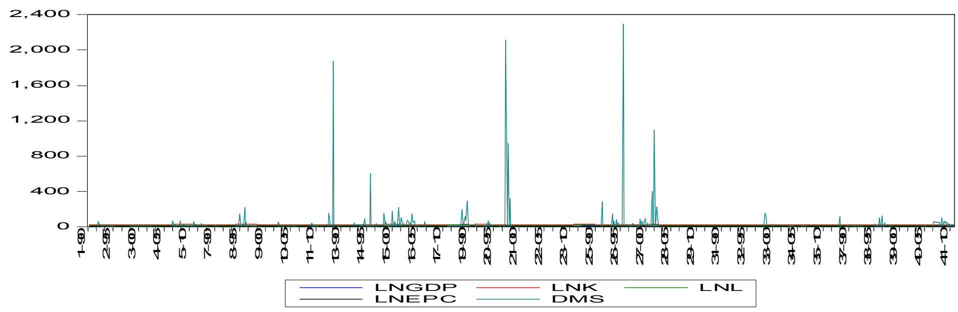

Figure.1. Together of the Sample

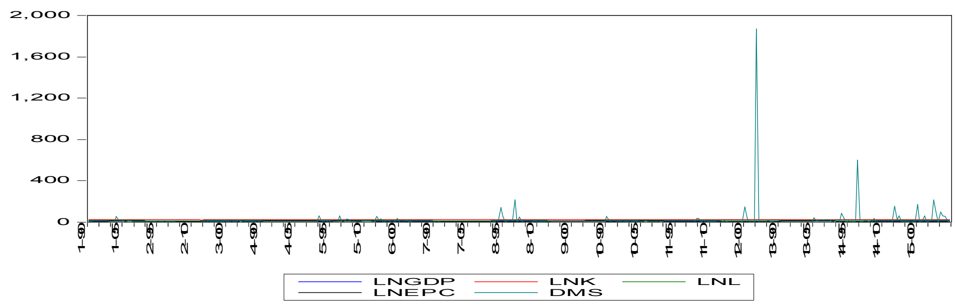

Figure 2. European Countries

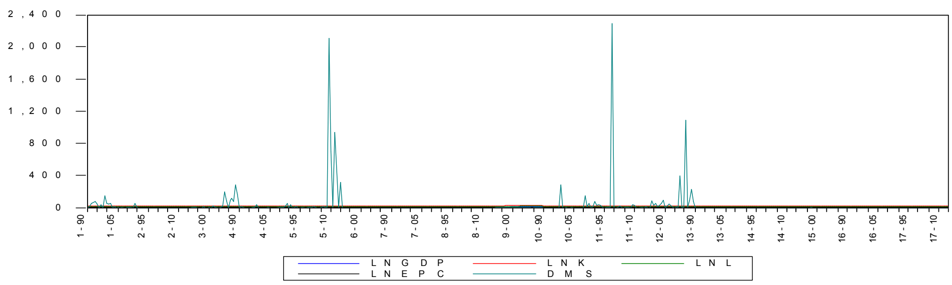

Figure 3. American Countries

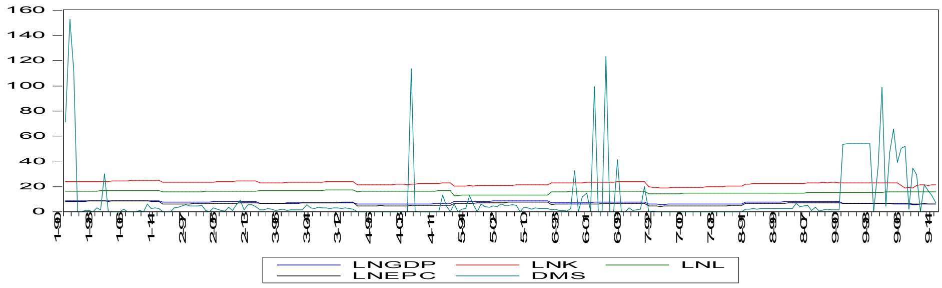

Figure 4. African Countries

4.2. Correlation Analysis of the Total Variables

As regards the entire sample, Table 3 allows to establish a positive correlation between GDP per capita and all other variables. The degree of correlation is important between GDP per capita, electricity consumption, and capital. It is relatively low between GDP per capita, labor, and DMS. The variable of DMS has a positive correlation to all other variables with all the countries in the sample. This may be related to the high heterogeneity between different regions on the one hand and on the other hand, countries them.

5. MODEL SPECIFICATION

Our main aim here is to examine the impact of natural disasters, labor input, physical capital stock and electricity consumption on GDP per capita, for a panel of 41 countries over the period 1990–2014. Based on the findings of previous studies the baseline model is expressed as follows:

$$GDP = f(L, K, EC, DMS). \quad (4)$$

The logarithmic transformation of Eq. (4) can be given as follows:

$$lnGDP_t = \alpha_0 + \alpha_1 lnK_t + \alpha_2 L_t + \alpha_3 EC_t + \alpha_4 DMS_t + \varepsilon_t. \quad (5)$$

Since our empirical analysis involves a panel of countries, Eq. (5) can be written in a panel data form as:

$$lnGDP_{it} = \alpha_0 + \alpha_{1i} lnK_{it} + \alpha_{2i} L_{it} + \alpha_{3i} EC_{it} + \alpha_4 DMS_t + \varepsilon_{it}, \quad (6)$$

where ln denotes the natural logarithm, the subscript $i = 1, \ldots, N$ denotes the country and $t = 1, \cdots, T$ refers to the time period. GDP: Per capita real gross domestic product. L: Labor input k: physical capital stock. EC: Electricity Consumption, DMS: disaster measures. We use a dynamic panel model; Eq. (6) takes the following form:

$$lnGDP_{it} = \alpha_0 lnGDP_{it-1} + \sum_{j=1}^{3} \beta_j X_{it} + \mu_{it} + \varepsilon_{it},\ i = 1 \dots, N,\ t = 1, \dots, T, \quad (7)$$

where $i = 1, \cdots, N$ denotes the country and $t = 1, \cdots, T$ denotes the time period; $lnGDP_{it-1}$ represents the log of lagged dependant variables of economic growth ($lnGDP_{it-1}$).

6. ESTIMATION METHODS AND EMPIRICAL RESULTS

6.1. The Test Unit Roots on the Panel Data

Proposed by Dickey and Fuller (1979) to test the unit root of the autoregressive process, the notion of unit root remains since then inescapable in the analysis of long-term process involving the use of two static series. The unit root test on the panel data proposed by Levin and Lin (1992), aims to answer the issue taking into account the forms of heterogeneity based on the assumption of the existence of specific constants to each individual than the fixed effects model individual works to take into account.

There are three generations of unit root tests. The first test generation based on the independence of individuals, she comes from Levin and Lin (1992, 1993). The second generation is that which admits the hypothesis inter-individual dependence; she is outcome the analysis of Bai and Ng (2002), Pesaran (2003). Finally, a third category was envisaged by O'Connell (1998) and Chang (2002, 2004) to introduce an analysis where it is possible to consider a structural break.

Levin and Lin (1992 and 1993), Harris and Tzavalis (1999) and Levin, Lin and Chu (2002) adopt the homogeneous specification of the autoregressive root while Im Pesaran and Shin (1997) and Henin, Jolivaldt and Nguyen (2001) use heterogeneous specifications of the autoregressive root and sequential tests. They sign up into the category of first generation tests. However, second generation tests are those based on factor models of Choi (2001), Bai and Ng (2002), and Moon and Perron (2004) for a more general approach.

There is different tests in-law of the stationary panel data. Levin et al. (2002) represent a stationarity test at the based the test of Augmented Dickey Fuller with homogeneity in the dynamics of autoregressive coefficients for all panel units. Mandala and Wu (1999) combine the p-value of unit root test of individual at using Fischer-ADF and Fischer-PP tests. On the other panel test are Im et al. (2003) which are different from the test Levin et al. (2002) at the base of homogeneity. The tests that we use in this research are the tests of Im et al. (2003), Levin et al. (2002) and Fischer-ADF.

The results are shown in Table 4. We notice that the variables are stationary at the first difference we can hope that there are long-term relationships between the variables.

6.2. Results of Pedroni Panel Cointegration Tests

The results of the tests of cointegration of Pedroni presented in Tables 5. Pedroni (2004) developed seven tests of cointegration applicable to panel data. The four first concerns the intra-individual dimension while the last three concern the inter-individual dimension. Regarding intra-individual dimension, Pedroni perfected nonparametric statistics that take into account the serial autocorrelation problems. The first test is the ratio of the parametric variance, the second statistics rho of Philips and of Pedroni, the third t statistic of Philips and of Pedroni, and the fourth, the ADF Statistics of Hariris and Sollis (2003). The tests of inter-individual dimension wear meanwhile them, on the both nonparametric statistics of Philips and Pedroni - rho and t-statistics while the third is, meanwhile, the ADF Statistics of Hariris and Sollis (2003). In general, the test Pedroni returns to formulate the following model of economic growth:

$$LogGDP_{it} = a_i + \acute{a}_i K_{it} + \acute{a}_i L_{it} + \acute{a}_i EC_{it} + \acute{a}_i DMS_{it} + \acute{a}_{it}, \quad (8)$$

where $i = 1, \ldots, 41;\ t = 1, \ldots, 25$ and the individual fixed effects. The null hypothesis of no cointegration given by the equation: $\acute{a}_{it} = \tilde{n}_i \tilde{n}_{it-1} + v_{it}$ or $\tilde{n}_i$ represents the autoregressive coefficient residues of i country. The null hypothesis of not cointegrated of the intra-individual dimension is given by: $H_0: \check{n}_i = 1;\ H_1: \tilde{n}_i < \tilde{n} < 1$. Similarly, the null hypothesis of inter-individual dimension is given by: $H_0: \check{n}_i = 1;\ H_1: \tilde{n}_i < \tilde{n} < 1$.

Pedroni shows that these statistics distributed according to standard normal centered-reduced. This leads for all N and T, to reject the null hypothesis for any $\tilde{n}_i$ value above the critical value from the table of the normal distribution of Pedroni at threshold of 5%. The objective here is to use these statistics of Pedroni to test if the five variables ($LnGDP$, LnK, LnL, $LnECT$, and $LnDMS$) are cointegrated them through 41 countries over the period 1990-2014 and estimate the long-term relationship between GDP per capita and the 4 other variables in order to highlight how electricity she has a durable relationship with GDP per capita.

Table 5 gives the values of $\tilde{n}$ for the 7 tests of Pedroni. We Noted that the largely positive values of v statistics of intra-individual dimension led to reject the null hypothesis while for the five other statistics, the rejection of the null hypothesis is not conditioned by negative values widely regarded statistics. Every seven statistics are significant at the 1% and 5% level, so the null hypothesis of non co-integration is rejected. Meaning that there is a long-run relationship between the variables.

Table 4. Unit Root Tests on Panel Variables

		European countries		American countries		African countries		Together of the sample	
		Individual effects	Individual effects and trends	Individual effects	Individual effects and trends	Individual effects	Individual effects and trends	Individual effects	Individual effects and trends
LLC	GDP	-4.7429 (0.0000)*	1.2495 (0.8943)	-0.1248 (0.4503)	0.5087 (0.6945)	-1.0668 (0.1430)	-0.4175 (0.3381)	-3.3016 (0.0005)*	1.0125 (0.8444)
	$D(GDP)$	-4.8629 (0.0000)*	-5.3177 (0.0000)*	-7.4550 (0.0000)*	-6.4589 (0.0000)*	-4.0946 (0.0000)*	-3.1857 (0.0007)*	-9.4819 (0.0000)*	-8.8217 (0.0000)*
	K	-2.4691 (0.0068)*	0.9749 (0.8352)	-0.8967 (0.1849)	-1.7231 (0.0424)**	1.0210 (0.8464)	-0.1323 (0.4473)	-1.2151 (0.1121)	-0.4946 (0.3104)
	$D(K)$	-6.1919 (0.0000)*	-5.7604 (0.0000)*	-7.8638 (0.0000)*	-5.245 (0.0011)*	-4.6032 (0.0021)*	-3.5861 (0.0002)*	-10.721 (0.0000)*	-9.1203 (0.0000)*
	L	-3.1668 (0.0166)**	-1.4308 (0.0759)	-4.1306 (0.0001)*	-0.7814 (0.2173)	-2.6850 (0.0036)**	-2.0709 (0.0192)	-4.3078 (0.0000)	-2.5271 (0.0057)
	$D(L)$	-4.9679 (0.0000)*	-5.1289 (0.0000)*	-5.0320 (0.0000)*	-4.1778 (0.0000)*	-2.8569 (0.0000)*	-2.7031 (0.0000)*	-7.2327 (0.0000)*	-6.7676 (0.0000)*
	EC	2.6080 (0.9954)	22.3981 (0.8976)	-1.7991 (0.0360)	7.2875 (1.0000)	-3.1283 (0.0009)*	1.6750 (0.9530)	-1.6978 (0.5448)	20.4515 (1.0000)
	$D(EC)$	31.742 (0.0000)*	45.846 (0.0000)*	4.8479 (0.0000)*	9.6374 (0.0000)*	-4.2888 (0.0000)*	-4.5275 (0.0000)*	22.592 (0.0000)*	32.5943 (0.0000)*
	DMS	-5.5614 (0.0000)*	-5.2704 (0.0000)*	-6.4822 (0.0000)*	-5.6703 (0.0000)*	-8.3255 (0.0000)*	-5.8088 (0.0000)*	-11.784 (0.0000)*	-9.6786 (0.0000)*
	$D(DMS)$	-16.172 (0.0000)*	-14.010(0.0000)*	-14.193 (0.0000)*	-10.5998 (0.0000)*	-11.5218 (0.0000)*	-9.0355 (0.0000)*	-24.4010 (0.0000)*	-19.6823 (0.0000)*
IPS	GDP	-0.6619 (0.2540)	4.0487 (1.0000)	4.6814 (1.0000)	0.9733 (0.8348)	2.3881 (0.9915)	-0.6206 (0.2674)	3.7330 (0.9999)	2.7848 (0.9973)
	$D(GDP)$	-4.7131 (0.0000)*	-4.6984 (0.0000)*	-6.9174 (0.0000)*	-4.8843 (0.0000)*	-4.8396 (0.0000)*	-3.3056 (0.0005)*	-9.5725 (0.0000)*	-7.5358 (0.0000)*
	K	-0.0562 (0.4776)	0.7288 (0.7670)	2.1915 (0.9858)	-1.4832 (0.0690)	3.2248 (0.9994)	-0.9772 (0.1642)	2.8880 (0.9981)	-0.9721 (0.1655)
	$D(K)$	-6.1521 (0.0000)*	-4.5062 (0.0000)*	-8.6782 (0.0000)*	-6.5552 (0.0000)*	-5.1141 (0.0000)*	-3.1344 (0.0009)*	-11.7053 (0.0000)*	-8.4153 (0.0000)*
	L	2.4391 (0.9926)	0.2840 (0.6118)	-0.3745 (0.3540)	1.2152 (0.8879)	0.8904 (0.8134)	-1.2450 (0.1065)	1.6513 (0.9507)	0.3709 (0.6447)
	$D(L)$	-4.8295 (0.0000)*	-4.0253 (0.0000)*	-5.6344 (0.0000)*	-4.8296 (0.0000)*	-3.3032 (0.0005)*	-2.1217 (0.0000)*	-8.0969 (0.0000)*	-6.5387 (0.0000)*
	EC	-1.6786 (0.0466)**	4.2286 (1.0000)	1.3498 (0.9115)	-0.3187 (0.3750)	0.7230 (0.7652)	1.4979 (0.9329)	0.1925 (0.5764)	3.0543 (0.9989)
	$D(EC)$	-7.6128 (0.0000)*	-8.0332 (0.0000)*	-9.9890 (0.0000)*	-8.3530 (0.0000)*	-5.2598 (0.0000)*	-4.3687 (0.0000)*	-13.5012 (0.0000)*	-12.2845 (0.0000)*
	DMS	-6.6177 (0.0000)*	-6.1385 (0.0000)*	-6.6143 (0.0000)*	-5.6139 (0.0000)*	-7.1347 (0.0000)*	-5.8089 (0.0000)*	-11.6047 (0.0000)*	-10.0495 (0.0000)*
	$D(DMS)$	-18.0644 (0.0000)*	-16.1225 (0.0000)*	-18.5207 (0.0000)*	-16.1351 (0.0000)*	-15.1874 (0.0000)*	-13.8416 (0.0000)*	-29.9679 (0.0000)*	-26.6266 (0.0000)*
ADF	GDP	30.4890 (0.4408)	11.4052 (0.9991)	13.4450 (0.9994)	32.9702 (0.5179)	9.5497 (0.9456)	20.2804 (0.3173)	53.4838 (0.9938)	64.6558 (0.9208)
	$D(GDP)$	74.4514 (0.0000)*	72.4188 (0.0000)*	113.069 (0.0000)*	81.7420 (0.0000)*	58.3721 (0.0000)*	44.1907 (0.0005)*	245.893 (0.0000)*	198.351 (0.0000)*
	K	23.6377 (0.7882)	29.3186 (0.5009)	24.9639 (0.8704)	49.7762 (0.0395)	4.6827 (0.9993)	21.8152 (0.2403)	53.2843 (0.9942)	100.910 (0.0767)
	$D(K)$	95.3831 (0.0000)*	72.1423 (0.0000)*	140.104 (0.0000)*	104.308 (0.0000)*	59.4906 (0.0000)*	38.5896 (0.0000)*	294.977 (0.0000)*	215.040 (0.0000)*
	L	19.9848 (0.9169)	45.2543 (0.0365)	47.6839 (0.0598)	22.4524 (0.9353)	14.7784 (0.6771)	23.6105 (0.1682)	82.4471 (0.4654)	91.3172 (0.2256)
	$D(L)$	75.7161 (0.0000)*	63.3820 (0.0004)*	93.2153 (0.0000)*	81.4540 (0.0000)*	45.9022 (0.0003)*	34.2770 (0.0000)*	214.834 (0.0000)*	179.113 (0.0000)*
	EC	41.5655 (0.0779)	14.3084 (0.9931)	27.1479 (0.7916)	42.3065 (0.1551)	17.3162 (0.5015)	11.2813 (0.8820)	86.0295 (0.3589)	67.8962 (0.8684)
	$D(EC)$	120.889 (0.0000)*	121.413 (0.0000)*	164.453 (0.0000)*	134.070 (0.0000)*	63.3359 (0.0000)*	51.6297 (0.0000)*	348.678 (0.0000)*	307.113 (0.0000)*
	DMS	104.943 (0.0000)	92.8028 (0.0000)	110.080 (0.0000)*	90.5831 (0.0000)*	85.6134 (0.0000)*	67.7659 (0.0000)*	300.636 (0.0000)	251.152 (0.0000)
	$D(DMS)$	285.960 (0.0000)*	262.229 (0.0000)*	308.575 (0.0000)*	246.700 (0.0000)*	186.592 (0.0000)*	160.960 (0.0000)*	781.127 (0.0000)*	669.888 (0.0000)*

Notes: (*) and (**) show that the corresponding null hypothesis can be rejected at 1% and 5% respectively. (D) indicates the first difference operator.

Table 5. Result of Pedroni Cointegration Test

	European countries	American countries	African countries	Together of the sample
	Within-dimension			
Panel v-Statistic	0.0048*	0.0434**	0.0457**	0.0000*
	(-2.5909)	(-1.7121)	(-1.6878)	(-4.3660)
Panel rho-Statistic	0.0000*	0.0002*	0.0095**	0.0000*
	(-8.2929)	(-3.5842)	(-1.4797)	(-8.5198)
Panel PP-Statistic	0.0000*	0.0000*	0.0400**	0.0000*
	(-18.4975)	(-16.8629)	(-1.7511)	(-25.1716)
Panel ADF-Statistic	0.0310**	0.0430**	0.0505**	0.0040*
	(-1.8661)	(-1.3850)	(-1.6400)	(-2.6502)
	Between-dimension			
Group rho-Statistic	0.0350**	0.0082*	0.0362**	0.0000*
	(-0.3853)	(-2.1055)	(-0.3510)	(-2.9477)
Group PP-Statistic	0.0000*	0.0064*	0.0209**	0.0025*
	(-5.9330)	(-2.4874)	(-2.0356)	(-2.8102)
Group ADF-Statistic	0.0004*	0.0077*	0.0118**	0.0058*
	(-3.3655)	(-1.2950)	(-1.1811)	(-2.5247)

Notes: Statistic tests are in parentheses. * and ** represent statistical significance at 1% and 5% level, respectively. The null hypothesis is that the variables are not cointegrated.

6.3. Results of Kao Panel Cointegration Test

The Kao (1999) proposed testing the null hypothesis of no cointegration of Dickey-Fuller and Augmented Dickey-Fuller type, but which assume homogeneous cointegration vectors between the individuals. The results reported in Table 6showed the existence of a panel long-run equilibrium relationship between all variables.

Table 6. Kao (1999)'s Residual Cointegration Test Results (LNGDP as Dependent Variable)

Countries Methods	European countries	American countries	African countries	Together of the sample
ADF	0.0035* (-2.6947)	0.0367** (-1.7905)	0.0018* (-2.9147)	0.0000* (-4.4401)

Note: Statistic tests are in parentheses. * and ** represent statistical significance at 1% and 5% level, respectively.

6.4. Panel Causality Test

Following Apergis and Payne (2010) we estimate the following equation for the Pedroni test:

$$GDP_{it} = \alpha_i + \delta_i t + \beta_i K_{it} + \delta_i L_{it} + \gamma_i EPC_{it} + \rho_i DMS_{it} + e_{it}, \quad (9)$$

where, i keep for each country in the panel, t represents time. The parameters of

α_i and δ_i are for the possibility specific of fixed effect of country and the trend. The ε_{it} is for the estimated residual. To test the null hypothesis of no cointegration $\theta_i = 1$ we make the following unit root: (the test Pedroni)

$$\varepsilon_{it} = \theta_i \varepsilon_{it-1} + w_{it}. \quad (10)$$

Then, the residuals of the Eq. 9 were used to estimate the error term in the following equations:

$$\Delta GDP_{it} = \beta_{10} + \textstyle\sum_{i=1}^{P} \beta_{11i}\, GDP_{it-k} + \sum_{i=1}^{P} \beta_{12i} K_{it-k} + \sum_{i=1}^{P} \beta_{13i} L_{it-k} + \sum_{i=1}^{P} \beta_{14i} EC_{it-k} + \sum_{i=1}^{P} \beta_{15i} DMS_{it-k} + \beta_{16} ECT_{it-1} + \varepsilon_{1it}, \quad (11)$$

$$K_{it} = \beta_{20} + \textstyle\sum_{i=1}^{P} \beta_{21i}\, K_{it-k} + \sum_{i=1}^{P} \beta_{22i} GDP_{it-k} + \sum_{i=1}^{P} \beta_{23i} L_{it-k} + \sum_{i=1}^{P} \beta_{24i} EC_{it-k} + \sum_{i=1}^{P} \beta_{25i} DMS_{it-k} + \beta_{26} ECT_{it-1} + \varepsilon_{2it}, \quad (12)$$

$$L_{it} = \beta_{30} + \textstyle\sum_{i=1}^{P} \beta_{31i}\, L_{it-k} + \sum_{i=1}^{P} \beta_{32i} GDP_{it-k} + \sum_{i=1}^{P} \beta_{33i} K_{it-k} + \sum_{i=1}^{P} \beta_{34i} EC_{it-k} + \sum_{i=1}^{P} \beta_{35i} DMS_{it-k} + \beta_{36} ECT_{it-1} + \varepsilon_{3it}, \quad (13)$$

$$EC_{it} = \beta_{40} + \textstyle\sum_{i=1}^{P} \beta_{41i}\, EC_{it-k} + \sum_{i=1}^{P} \beta_{42i} GDP_{it-k} + \sum_{i=1}^{P} \beta_{43i} K_{it-k} + \sum_{i=1}^{P} \beta_{44i} L_{it-k} + \sum_{i=1}^{P} \beta_{45i} DMS_{it-k} + \beta_{46} ECT_{it-1} + \varepsilon_{4it}, \quad (14)$$

$$DMS_{it} = \beta_{50} + \textstyle\sum_{i=1}^{P} \beta_{51i}\, DMS_{it-k} + \sum_{i=1}^{P} \beta_{52i} GDP_{it-k} + \sum_{i=1}^{P} \beta_{53i} K_{it-k} + \sum_{i=1}^{P} \beta_{54i} L_{it-k} + \sum_{i=1}^{P} \beta_{55i} EC_{it-k} + \beta_{56} ECT_{it-1} + \varepsilon_{5it}, \quad (15)$$

where Δ the first difference operator, GDP is the gross domestic product; K is gross fixed capital formation; L is labor force; ECT is electricity consumption; DMS is the disaster measures. In the co-integration test created by Pedroni (2000) there are seven groups of tests. A group quadruple (panel test) was called in dimension and a triple group (test of the groups) was named between the dimensions.
Table 7 shows the results of equations 1 to 5. The ECT term coefficients show setting the short term to long term. The test of Hausman (1978) shows that we must apply the model fixed effects. For the entire sample, the estimate indicates that electricity consumption has a positive and significant impact on the economic growth in the short term and there is bidirectional causality between GDP and electricity consumption. The estimate also shows that short-term economic growth increases the electricity consumption. This result is consistent with the findings of (Yang, 2000; Asaduzzaman and Billah, 2006; Ahmad and Islam, 2011; Lean and Shahbaz, 2012; Bayar and Alp Özel, 2014; and Hu et al., 2015).

Labor input and physical capital stock have positive and significant impacts as short-term on economic growth. In addition, natural disaster is positively correlated to GDP. We note that physical capital stock and labor have positive and significant effects on electricity consumption are. Always in the short term, the causality test shows that there is a unidirectional relationship from disaster measures to electricity consumption and from natural disaster to GDP. We reveal the existence of a bidirectional relationship between GDP per capita and labor, but a unidirectional relationship from physical capital stock to GDP per capita.

Table 7. Results of the Causality Test in Panel

		The dependent variables The direction of the causations in short-term					
		ΔGDP	ΔK	ΔL	ΔEPC	ΔDMS	ECT
Group	ΔGDP	-----	1.8856 (0.2006)	0.8276 (0.0168)**	3.3750 (0.0533)***	0.9347 (0.3241)	-13.5102 (0.0000)*
	ΔK	3.6217 (0.0072)*	-----	0.2574 (0.0030)*	2.8948 (0.0097)*	0.4513 (0.1263)	-0.0730 (0.3065)
	ΔL	1.6836 (0.0728)***	1.2576 (0.3719)	-----	1.5632 (0.0988)***	1.4686 (0.8195)	-0.8909 (0.3254)
	ΔEPC	0.3786 (0.0067)*	1.7541 (0.0346)**	(0.20228) (0.00291)*	-----	0.4550 (0.1504)	0.0985 (0.3362)
	ΔDMS	1.0528 (0.0000)*	0.9291 (0.0004)*	2.17469 (0.00036)*	-0.0731 (0.0001)*	-----	0.0280 (0.0020)*
European Countries	ΔGDP	-----	3.7219 (0.2908)	0.1910 (0.0481)**	0.6124 (0.1158)	2.2241 (0.3147)	-0.3381 (0.0856)***
	ΔK	0.9893 (0.0281)**	-----	2.02513 (0.0143)**	1.4528 (0.0345)**	1.2670 (0.1154)	-4.5899 (0.0215)**
	ΔL	3.3285 (0.0105)**	4.1945 (0.3243)	-----	0.6625 (0.1291)	0.2594 (0.1432)	-4.4292 (0.2391)
	ΔEPC	0.8235 (0.0067)*	1.6015 (0.0208)**	0.3124 (0.0034)*	-----	0.1420 (0.2785)	-2.8488 (0.0023)*
	ΔDMS	1.7964 (0.0002)*	3.2940 (0.0062)*	2.6784 (0.0001)*	-1.1882 (0.0025)*	-----	-2.4505 (0.0015)*
American Countries	ΔGDP	-----	3.8238 (0.2342)	0.1006 (0.0281)**	1.6904 (0.0885)***	1.2291 (0.3357)	-0.2210 (0.0375)**
	ΔK	1.0395 (0.0165)**	-----	0.4450 (0.0073)*	0.7676 (0.0228)**	0.9397 (0.9338)	-0.7906 (0.2479)
	ΔL	0.9618 (0.1140)	1.0635 (0.4224)	-----	3.6304 (0.0499)**	2.9702 (0.1597)	-0.7179 (0.2724)
	ΔEPC	0.2210 (0.0375)**	1.1750 (0.0469)**	0.5963 (0.0056)	-----	0.8473 (0.2177)	-0.5874 (0.2269)
	ΔDMS	-0.2666 (0.0012)*	0.1446 (0.0035)*	-0.67828 (0.0421)**	-2.70932 (0.0017)*	-----	-0.6290 (0.0007)*
African Countries	ΔGDP	----	3.5873 (0.5943)	1.53695 (0.0242)**	2.8854 (0.1144)	10.844 (0.9968)	-2.1751 (0.0766)***
	ΔK	0.8850 (0.0098)*	-----	0.1243 (0.0030)*	0.6131 (0.0146)**	1.7706 (0.2469)	-0.6866 (0.0721)***
	ΔL	1.0627 (0.2340)	1.7999 0.0560***	----	0.6559 (0.0349)**	1.3109 (0.5425)	-0.7458 (0.0766)***
	ΔEPC	1.1151 (0.0551)***	2.4937 (0.4238)	0.4212 (0.0172)**	----	2.0239 (0.4227)	-0.1114 (0.0749)***
	ΔDMS	-1.3236 (0.0001)*	-0.4082 (0.0009)*	-0.2819 (0.0004)*	-1.1747 (0.0001)*	-----	-0.3729 (0.0030)*

Notes: The probability values are in brackets.* Shows that the variables are significant at the 1% level. ** Shows that the variables are significant at the 5% level. *** Shows that the variables are significant at the 10% level.

Regarding the results of estimation of European countries, the short-term economic growth effect is positive and not significant on the two variables (power consumption, and capital), but has a positive effect and significant on the labor. In contrast, the effects of the consumption of electricity, disaster measures and capital are positive and statistically significant on economic growth. Therefore, the causality test shows that there is a unidirectional relationship running from the disaster measures and capital to economic growth. In addition, there is a bidirectional causality between labor and GDP per capita. In addition, there is a unidirectional relationship from the disaster measures to labor and from the disaster measures to electricity consumption. Besides, the capital has a positive impact on electricity consumption at the 1% level. This meaning that there is a bidirectional causality between capital and electricity consumption. Finally, there is a unidirectional causality from electricity consumption to GDP per capita.

Moreover, for the American countries, estimates of results show that the per capita GDP has a positive and significant impact on the consumption of electricity, and labor, but an effect positive and not significant on capital. In contrast, the disaster measures have affected negatively and significantly on economic growth and on consumption of electricity. Therefore, the causality test shows that there is a bidirectional relationship between GDP per capita and electricity consumption. In addition, there is a unidirectional relationship running from the capital to the GDP, GDP to labor in short-term and disaster measures to GDP per capita. In addition, there is a unidirectional relationship running from the disaster measures to the capital and labor. The results are consistent with the findings of Gourio (2008), Cuaresma et al. (2008) and Hallegatte and Dumas (2009).We note that there is a bidirectional relationship between electricity consumption and capital. Also, a unidirectional relationship from labor to electricity consumption.

Finally, for the African countries, the results indicate that economic growth effect positive and not significant on electricity, and capital, but significant on the labor. In addition, the power consumption affects significantly and positively on GDP per capita and labor. This implies that an increased use of electricity of 1% increases the economic growth, the labor and the disaster measures of 1.1151%, 0.4212%, and 2.0239%, respectively. The effect of electricity is positive on capital but not significant. In addition, the variable of DMS has a negative effect and significant on all variables. This indicates that a 1% increase of this variable decreases GDP per capita, capital, labor and electricity consumption of 1.3236%, 0.4082%, 0.2819%, and 1.1747%, respectively. In total, the short-term causality test shows that there is a unidirectional relationship from electricity consumption to GDP per capita, from disaster measures to GDP per capita, from capital to GDP per capita and from GDP per capita to labor. In addition, these results show that there is a unidirectional relationship from the disaster measures to electricity consumption, from the disaster measures to capital. In addition, there is a unidirectional relationship from disaster measures to labor. Moreover, there is a bidirectional relationship between electricity consumption and labor. Finally, the one-way relationship between capital and electricity consumption is found.

The error-correction coefficients are statistically significant and show the setting the short-term to the long-term. The results of causality test show that there is a unidirectional relationship from the disaster measures to capital and from disaster measures to labor. In addition, there is a unidirectional relationship from the disaster measures to the economic growth and the disaster measures to the electricity consumption for the entire sample in the long-term. Moreover, for the European countries, there is a unidirectional relationship from electricity consumption to economic growth, from capital to labor, and consumption of electricity to labor. A bidirectional relationship between labor and electricity consumption is found. For the American countries, the results indicate that there is a unidirectional relationship from the disaster measures and electricity consumption, the disaster measures and capital, from the disaster measures to labor, from the disaster measures to electricity consumption and from the disaster measures to economic growth. Finally, the direction of causality shows that there is a bidirectional relationship between labor and capital, in the African countries of long-term. To simplify the results, we have summarized in the following figures:

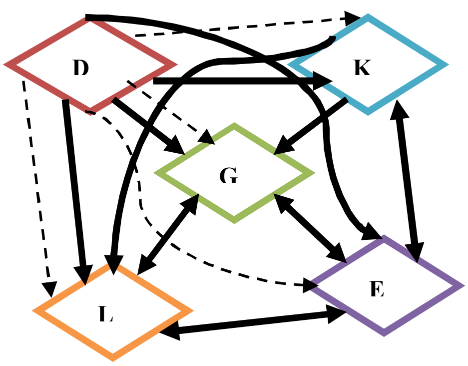

Figure 1. The Entire Sample

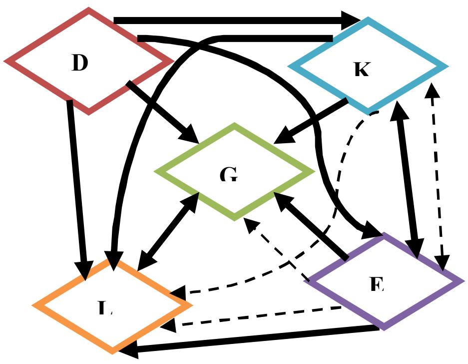

Figure2. European Countries

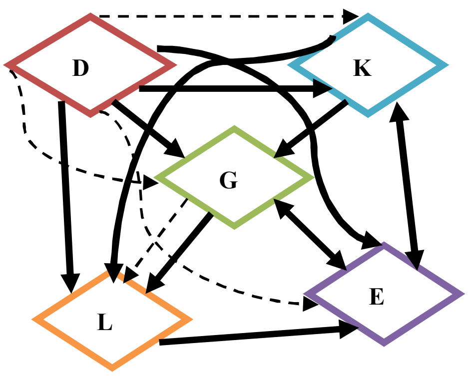

Figure 3. American Countries

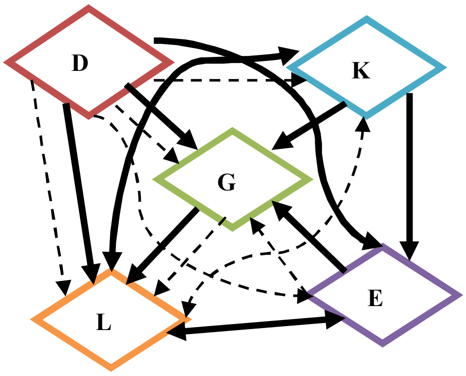

Figure 4. African Countries

Notes: ▬▬ : short-term, - - - - : long-term.

7. CONCLUSION AND POLICY IMPLICATIONS

Given the complex relationship between macroeconomic variable, electricity and natural disasters, we need to investigate the consequences in the short and long term of natural disasters. Based on the literature review conducted, this article discusses seeks relationship causality at long-term and short-term between electricity consumption, economic growth, natural disaster and other variables in 41 countries for the period 1990-2014.

In our study, we found that African countries are facing much greater shock to their macro-economies. These countries are already confronted with the dangers inherent to underdevelopment (aging infrastructure, toxic and hazardous factories, polluted water) are poorly informed and prepared. They are often clueless about these risks and they do not have the means to protect their populations. Does not have technology and sufficient financial resources, help is often unorganized, slow and inefficient, the populations of alert and information systems are non-existent and very suitable means of protection.

Natural disaster that decreases the capital stock and labor force leads to a decrease in the output growth rate. However, this effect is more likely to appear in the long term. There are different ways how natural disasters affect economic growth. According to result of causality, we concluded that an increase in economic growth leads to an increase in electricity consumption and increased electricity consumption increases economic growth. We also noted that there is unidirectional causality from disaster measures to electricity consumption in all the countries in our study. Natural disaster such as earthquake can destroy all types of power system equipment.

These findings have important implications for the disaster relief policies. To reduce the impact of natural disaster, it should develop the knowledge of hazards and risk assessment, invest in prevention and encourage political development. Countries should use their knowledge of the risks and use education to improve safety. Therefore, every individual should know the risk areas that exist in their area. There must also be close collaboration with the media and associations to implement risk education activities.

Therefore, to attenuate the consequences of natural disasters, all countries must implement a prevention plan with sufficient technical and human resources. Finally, it is necessary that countries get ready to act to be most effective against a catastrophe and its consequences. That is to say, to establish an operational emergency plans as well as dedicated funds.

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Received November 27, 2016, Accepted September 4, 2017.