Energy intensity and industrialization in Cameroon

Gael FOKAM[1], Christelle MAPA[2], Mathurin ISSABE[3]

[1,2]*Faculty of Economics and Management, University of Dschang, Dschang, Cameroon*
[3]*PhD in Economics and Management, University of Dschang, Dschang, Cameroon*

Abstract: **This paper assesses the effect of energy intensity on industrialization in Cameroon over the period 1980-2020. The energy sector plays an essential role in economic prosperity and development. Energy consumption is an integral part of the growth process of any economy, whether it is an industrialized or a developing country. We estimate a panel data model using the Econometrics-Autoregressive Distributed Lag (ARDL) method. Our results show that at all levels of estimation of both long-run and short-run co integration tests, energy intensity does not favor the industrialization process in Cameroon. This leaves an important policy implication for Cameroon's stakeholders, namely that they can focus on research and development to encourage investment in the development of new energy sources, increase energy intensity and stimulate economic growth.**

I. INTRODUCTION

Although proto-industrialization is now considered to have occurred before the industrial revolution, the roots of modern industrialization can usually be traced back to the 18th century British Industrial Revolution. In the nineteenth century, a number of European and North American nations were industrialized, followed by southern Europe and Japan in subsequent decades. Several Far Eastern countries, notably those in the aftermath of World War II, became industrialized during the twentieth century.

The term "industrialization" refers to the shift from an agrarian to an industrial civilization, which is accompanied by an increase in per capita income and productivity. Any industrial revolution will necessitate a considerable amount of energy usage. Energy is one of the most heavily planned areas of activity due to its criticality and high capital intensity. Many African countries have significant challenges in obtaining the energy required for economic growth and human well-being (*Revue Synthétique Des Résultats Pays*, 2017).

Over the last five years, the oil and agricultural industries (timber, bananas, cocoa, coffee, cotton, and rubber) have had a significant impact on growth, with revenues representing approximately 50% and 25% of exports, respectively. On the demand side, consumption accounted for roughly 80% of GDP, while investment contributed for only 17%. On the supply side, the primary sector, which is growing in value added, employs 60% of the working population and provides 21% of GDP. However, the low quality and lack of rural infrastructure, financial restrictions connected to production, and the separation of producing areas from consuming centers all impede the sector's expansion. Due to the depletion of some oil wells, the low competitiveness of agro-industries, and the saturation of electrical energy supply capacity, activity in the secondary sector, which accounts for roughly 33% of GDP, is on the decline (*Revue Synthétique Des Résultats Pays*, 2017).

Most writers think that industrialization leads to increased energy consumption because high-value-added industry consumes more energy than traditional agriculture or basic manufacturing. Petroleum refining, primary metals, chemicals, paper, and associated goods, for example, are more energy demanding than agricultural or textile manufacturing (Jones & Sheather, 1991; Samouilidis & Mitropoulos, 1984).

Extractive industries continue to dominate Cameroon's economy, with manufacturing accounting for only 8% of GDP1 compared to 20.5 percent for agriculture, livestock, and fisheries, and 29.5 percent if mining is included. This demonstrates the manufacturing sector's low prominence in the Cameroonian economy. Cameroon thus has a multi-faceted industrialization challenge, despite the fact that some solutions have previously been proposed (*Siècle Avec La Révolution Industrielle Britannique. Des Mouvements d'industrialisation Se Sont Ensuite Succédé Au Cours Du XIX*, 2009). The industrial sector, like the rest of the country, is suffering from an energy shortage. It manifests itself in the form of high-cost electricity and frequent power outages.

Cameroon, on the other hand, has considerable resources that might allow it to become a regional energy exporter in the future (*Revue Synthétique Des Résultats Pays*, 2017). Access to electricity is improving in Cameroon, although it is still limited. In 2015, it was slightly over 50% across the country, but just 22% in rural regions. This poor coverage rate is attributable to two primary factors: generating unit weakness, which is not equal to the level of household and industrial demand, and electrical transmission equipment obsolescence, which results in a technical loss of more than 13% of the energy generated in 2013. As a result, periodic load shedding occurs as consumer demands rise, especially during the dry season. The concessionaire AES-SONEL boosted electricity output from 3,919 GWh in 2004 to 4,821 GWh in 2010. (Solar Gas, n.d.). The Cameroonian government states in its National Development Strategy (NDS) for the period 2020-2030 that it wants to fulfill the national economy's energy needs while also exporting surpluses to neighboring nations by expanding installed electrical energy capacity to 5,000 MW.

II. LITERATURE

The infrastructure network is put in place during the industrialization era to allow mass production and consumption. Although the early build-up of capital stock associated with industrialization may raise energy intensity, a saturation point is ultimately reached when material consumption is oriented more toward the replacement of durable goods than the production of durable products. Manufacturing falls in relation to services in the post-industrial period, and the energy intensity of service-based economies is lower than that of manufacturing-based economies. Second, as technology advances, energy efficiency improves. Third, technical advancement leads to the adoption of less energy-intensive alternative materials. alternative materials with a lower energy consumption (Sadorsky, 2013).

The relationship between economics and energy has always been a fascinating issue that has gotten a lot of attention. The first empirical studies concentrated on causation testing between the economy and energy, but the results were equivocal. Causation is observed to run from GDP to energy use in some situations (Al-Iriani, 2006; Kraft & Kraft, 1978; Ozturk et al., 2010). However, in certain situations, the causal chain flows from energy use to GDP (Apergis & Payne, 2009; C.-C. Lee, 2005; K. Lee & Mathews, 2008; Narayan & Smyth, 2008; Stern, 1993). Furthermore, there are instances where the relationship between energy use and GDP is positive in both directions (Asafu-Adjaye, 2000; C.-C. Lee & Chang, 2008; Mahadevan & Asafu-Adjaye, 2007) or non-causality (Cheng, 1995; Wolde-Rufael, 2006; Yu & Choi, 1985). Because of the varied samples and time intervals, as well as the techniques utilized, the results are typically equivocal.

In the course of economic development, industrialization is a significant occurrence. Many research have been conducted in recent years on the link between industrialization and energy demand and consumption. Many studies demonstrate that as a result of industrialization, energy consumption demand rises. Industrialization is often assessed in empirical models as the value added of industry as a percentage of GDP. This indicator, according to Blanchard, (1992), indicates manufacturing's internal specialization. The evolution of this indicator throughout time reflects the amount of work put into productive reorganization. This statistic is used by certain writers, such as Parikh & Shukla, (1995), as a measure of structural change, and it is predicted that as the percentage of industrial activity in the economy grows, so will the demand for energy. Changes in this ratio over time, according to Blanchard, (1992), may be attributable to structural changes as well as diverging pricing impacts between the two variables utilized to calculate the ratio.

According to Karanfil, (2009), A simple bivariate model does not justify the causation between economic growth and energy use. He proposed that one of the financial variables, such as domestic lending to the private sector, market capitalization, or liquid liabilities, be included in the model. He also claimed that energy use is influenced by interest rates and currency rates through energy costs. In this case, Stern (2000) pointed out the model's absence of important factors. Furthermore, by incorporating the capital stock in the model, Lee and Chang (2008) discovered positive and substantial correlations between energy consumption and economic development for several Asian nations.

For the period 1975-1995, Cole (2006) investigates the link between trade and energy consumption or energy intensity per capita in a panel of 32 industrialized nations. The income elasticities range from -1.1 to -0.1, depending on the regression model parameter. Over the years 1973-1990, Bernardini & Galli (1993) investigated the feasibility of an inverted U-shaped model for energy intensity in a sample of ten Asian economies. Fixed effects and random coefficient estimators are used to estimate panel models. In the fixed effects specification, there is evidence of an inverted U-shaped link between energy intensity and income, but no statistically significant evidence of this association in the random coefficient formulation.

D. W. Jones (1989) investigates the influence of urbanization on energy consumption for a sample of 59 developing nations in 1980. The dependent variable is quantified as energy usage per capita or energy per dollar of GDP, and the regression results are provided for both. Modern energy usage (marketed fossil fuels) and overall energy use are two different categories (which includes traditional fuels like wood and biomass as well as modern fuels). Income, industrial structure, urbanization, and population density are all explanatory variables. Modern energy consumption and total consumption (modern plus traditional) have income elasticities ranging from 0.64 to 1.10. Energy consumption elasticity of industrialization is predicted to be in the range of 0.83 to 1.08. The urbanization elasticities of energy consumption are predicted to range between 0.30 and 0.48 when other factors are held constant. Jones & Sheather, (1991) finds a long-run income elasticity of 0.77, an urbanization elasticity of 0.35, and an industrialization elasticity of 1.35 using a comparable data set for energy intensity as Jones (1989).

Samouilidis & Mitropoulos (1984) stated that long-run elasticities of industrialization on energy intensity between 0.90 and 1.96, and short-run elasticities between 0.17 and 0.46 in various analyses of the Greek economy. To examine the influence of urbanization on energy consumption, Parikh and Shukla (1995) will utilize a data collection that spans the years 1965 to 1987 and includes both developed and developing nations. The income elasticity for total energy consumption models varies from 0.25 to 0.47, whereas the urbanization elasticity ranges from 0.28 to 0.47. They include variables for population density and agriculture's proportion of GDP, in addition to explanatory factors for income and urbanization GDP.

Similarly, Liddle, (2004) shows that urbanization and population density reduce per capita energy use for road transportation. This suggests that personal mobility is less in demand in densely populated and metropolitan areas. For the period 1975-1995, Cole, (2006) investigates the link between trade and energy consumption or energy intensity per capita in a panel of 32 industrialized nations. Depending on the regression model's parameter, income elasticities range from -1.1 to -0.1. While York, (2007) examines the drivers of energy consumption in the European Union from 1960 to 2025 using panel data methodologies. He discovers that income elasticities range from 0.52 to 0.69. Elasticities of urbanization range from 0.29 to 0.56. Population elasticities, which range from 2.56 to 2.75, are significantly higher than income or urbanization elasticities, implying that slower population growth in the European Union will likely play a key role in lowering energy consumption.

Poumanyvong and Kaneko (2010) assess the influence of income, urbanization, industrialization, and population on energy consumption in a sample of 99 countries from 1975 to 2005 using panel data methodologies. They discovered that the influence of urbanization on energy consumption varied by economic class, with low-income people experiencing lower energy consumption and middle- and high-income people experiencing higher energy consumption. The influence of the economy's proportion of industrial activity on energy consumption is favorable, but only statistically significant for low and moderate income groups.

Krey et al. (2012) use integrated assessment models to examine the impact of industrialization on residential energy consumption in China and India. They find that residential energy use is not very sensitive to industrialization, but that energy use is dependent on how labor productivity affects economic growth in the relationship between industrialization and energy consumption. Krey et al. (2012) investigate the influence of industrialization on energy consumption in China and India using a computable general equilibrium model. They discover that industrialization has a minor direct influence on energy consumption, and that much of the impact of industrialization on energy consumption is due to the impact of increasing labor supply on economic development.

III. DATA AND TECHNIQUE OF ESTIMATION

Industrialization is typically quantified in econometric models as a percentage of GDP by industrial value added. This indicator, according to O. J. Blanchard & Summers, (1992), indicates manufacturing's internal specialization. Economic restructuring is measured by the progression of this indicator. However, other writers, such as Parikh and Shukla (1995), utilize this statistic as a structural change indicator. A rise in the percentage of industrial activity in the economy is projected to result in increased energy consumption. Energy usage increases as the economy improves. Explanatory variables include domestic credit, GDP, urbanization, and population density. Regressions are estimated for the dependent variable, energy intensity; of industrialization as the variable of interest; and explanatory variables include domestic credit, GDP, urbanization, and population density.

3.1 Data

The sample utilized is yearly data from the World Development Indicators covering the years 1990 to 2020. (WDI-CD, 2021). Total energy consumption per capita is used to calculate energy intensity (kg of oil equivalent per capita). The proxy for industrialization is industrial value added as a percentage of GDP, while the proxy for urbanization is urban population as a percentage of total population. The private sector receives domestic credit. Economic growth is measured by real GDP per capita.

3.2 The Model

When compared to the linear functional version of the model, the log-linear model gives a superior outcome. As a result, all of the data in the model is converted to natural logarithm. The fundamental energy demand model, according to Sadorsky (2010), is as follows:

$$EC_t = f(IND_t, \sum_{t=1}^{3} VAC_t) \qquad (1)$$

When $\sum_{t=1}^{3} VAC_t$ is taken as the sum of the control variables of urban population, domestic credit to the private sector, and economic growth, equation (1) is obtained.

$$EC_t = f(IND_t, UP_t, DC_t, GDP_t) \qquad (2)$$

With EC denoting logarithmic total energy consumption per capita, IND denoting logarithmic industrial value added as a share of GDP, UP denoting logarithmic urban population as a share of total population, DC denoting logarithmic domestic credit to the private sector as a share of GDP, and GDP denoting logarithmic real GDP per capita.

Urbanization is a key aspect of economic growth that entails several structural changes across the economy and has substantial consequences for energy consumption. Urbanization boosts population and, as a result, economic activity. The demand for energy consumption rises when economic activity rises as a result of urbanization. In the near term, urbanization causes energy consumption in Pacific island countries, according to (Narayan et al. 2011). Energy consumption and urbanization, in the long term, result in gross domestic output.

Industrialization and urbanization, according to Kuznets and Chenery, are the two most important structural changes in social evolution. The "Northam curve," developed by American urban geographer Northam in 1975, is used to describe the basic pattern of urbanization growth as a "S curve." Urbanization has a significant influence on energy consumption, as discussed in the previous assessments. The quantity of money available for investment initiatives is referred to as financial development. A high level of financial development entails a well-developed financial market, which means that banks, stock exchanges, and funds are all available for investment (Minier, 2009; Sadorsky, 2010). The improvement of financial markets may be explained by two primary factors, both of which are linked to investment activity and therefore to economic development.

3.3 Result

To evaluate the long-run equilibrium connection between energy consumption and the industrialization explanatory variable and control variables, we utilize Pesaran et al. (2001) .'s Autoregressive Distributed Lag (ARDL) bounds testing technique. In comparison to other cointegration approaches, ARDL provides a number of benefits. First, regardless of whether the underlying variables are I(0), I(1), or a mix of the two, it may be used (Persan & Pesaran, 1997). Second, the model has a large enough number of delays to represent the data production process in general as well as the specific modeling frameworks. Third, a simple linear transformation may be used to generate the error correction model (ECM) from ARDL, which combines short-term changes with long-term equilibrium without sacrificing long-term information. Fourth, the ARDL approach outperforms the Johensen and Juselius cointegration strategy in terms of small sample characteristics (Pesaran and al., 1999). However, with the ARDL approach, endogeneity is less of a problem since it is not subject to residual correlation. According to Pesaran et al., (1999), the appropriate delays in the ARDL model include the following: The appropriate delays in the ARDL model are corrected by both serial correlation and endogénéity problems. Sixth, the ARDL method is capable of distinguishing between dependent and explanatory factors. The tiny letters in equation (2) indicate that all variables are used in their logarithmic form.

Following D. Jones, (2000), the relationship between the logarithm of energy intensity (e), and the logarithm of industrialization (d) is specified in a compact way as follows:

$$e_{it} = \alpha_i i_{it} + \beta_i u_{it} + \chi_i d_{it} + \delta_i g_{it} + v_i + \varepsilon_{it} \qquad (3)$$

The countries are denoted by the index i (i = 1,...,N) in Equation (3), and the time period is denoted by the index t (t=1,...,T). The effects of the country are included throughout, and this is referred to as random error. Because all of the variables are expressed as natural logarithms, the estimated coefficients can be interpreted as elasticities. A contrast may be made between models with homogeneous pente coefficients $(\alpha_{1i} = \alpha_i, \beta_{1i} = \beta_i, \chi_{1i} = \chi_i, \delta_{1i} = \delta_i)$ as well as models with variable slope coefficients $(\alpha_i, \beta_i, \chi_i, \delta_i)$. These models may be estimated using conventional panel regression approaches such as pooled OLS (POLS) and different fixed-effects specifications (FE) or GMM if the assumption of homogenous slope coefficients is made.

Table 1 : Summary statistics.

	Obs	Mean	Std. Dev.	Min	Max
Logarithms					
Energy/GDP	35	5.978716	0.100795	5.771936	6.092752
Industry	41	3.325029	0.0862	3.155802	3.545056
Urban Pop	41	3.8027	0.167735	3.463264	4.052828
Domestic Credit	39	2.597188	0.523498	1.781506	3.441774
GDP/Pop	41	7.195851	0.150343	6.954943	7.512606
Population Totale	41	16.55041	0.333744	15.96976	17.09439
Energy/GDP	35	396.8257	38.15604	321.159	442.6377
Industry	41	27.90284	2.484832	23.47185	34.64163
Urban Pop	41	45.42917	7.411149	31.921	57.56
Domestic Credit	39	15.38643	8.310095	5.938795	31.24235
GDP/Pop	41	1348.832	206.5498	1048.319	1830.979
Population Total	41	1.63E+07	5311753	8621409	2.65E+07

Source : Autor from stata 17

Mean group (MG) estimators (e.g., Persan & Pesaran, 1997; Pesaran & Smith, 1995) or variations of mean group estimators can be used to estimate models with diverse slope coefficients. Estimating panel models with heterogeneous slope coefficients is a hot topic in econometrics right now (e.g., Coakley et al., 2006; Eberhardt & Teal, 2011).

The link between energy intensity (e) and industrialization (d) in equation (3) may be specified as a dynamic panel data model as follows:

$$\begin{aligned} IND_{it} = {} & \alpha_i IND_{it-1} + \beta_i EC_{it} + \beta_i EC_{it-1} + \chi_i UP_{it} + \chi_i UP_{it-1} + \delta_i DC_{it} + \delta_I DC_{it-1} + \eta_i GDP_{it} \\ & + \eta_i GDP_{it-1} + v_i + \varepsilon_{it} \end{aligned} \qquad (4)$$

For each variable, Equation (4) is an example of an autoregressive distributed lag model (ARDL) of order one. This model is a dynamic adaptation of Jones' original static model (1991). Dynamic models are preferable to static models because they make it easier to calculate both short- and long-run elasticities. ARDL models can also be calculated with either homogeneous or heterogeneous slope coefficients.

The mean group (MG) estimator is used to estimate the models. Pesaran and Smith (1995), Pesaran's common correlated effects estimator (2006). Pesaran (2006)'s estimators, the Common Correlated Effects Mean Group (CCEMG) and the Augmented Mean Group (AMG) (Bond). (AMG) ((Eberhardt & Bond, 2009; Eberhardt & Teal, 2010).

3.4 Granger causality test

Granger provides a sequential technique for evaluating causality between series that begins with a set of preliminary cointegration tests, i.e. a study of the series' stationarity. The Granger causality test is therefore used to stationary (stationary) data. If these stationary series are also cointegrated, a vector error correction/MECM (or error correction model/MCE) will be employed to verify causality (Engle & Granger, 1987; Johansen, 1988), otherwise a VAR in first differences will be utilized for I(1) series.

Consider the following model (5) to evaluate causality between two series "IND and EC" in the sense of Granger :

$$IND_t = \alpha_{01} + \sum_{i=1}^{p} \alpha_{1i}^{1} \Delta IND_{t-i} + \sum_{i=1}^{p} \alpha_{2i}^{1} \Delta EC_{t-i} + \theta_1 W_{t-i} + u_{1t} .... \tag{5.a}$$

$$EC_t = \alpha_{02} + \sum_{i=1}^{p} \alpha_{1i}^{2} \Delta EC_{t-i} + \sum_{i=1}^{p} \alpha_{2i}^{2} \Delta IND_{t-i} + \theta_2 W_{t-i} + u_{2t} .... \tag{5.b}$$

Avec : θ_i : The error correction coefficient is also known as the equilibrium adjustment parameter. Causality tests in the sense of Granger will consist of evaluating the following non-causality null hypotheses (based on Fisher's statistics):

_________ Short-term Granger causality test:

$$IND_0 = \alpha_{2i}^{1} = 0\left(F_c \prec F_t; p-value\ \ F \succ 5\%\right):\ EC_t \text{ does not cause } IND_t \text{ in the short term}$$
$$IND_0 = \alpha_{2i}^{2} = 0\left(F_c \prec F_t; p-value\ \ F \succ 5\%\right):\ IND_t \text{ does not cause } EC_t \text{ in the short term}$$

_________ Long-term Granger causality test:

$$IND_0 = \theta_1 = 0\left(t_c \prec t_t; p-value\ \ t \succ 5\%\right):\ EC_t \text{ does not cause } IND_t \text{ long term}$$
$$IND_0 = \theta_2 = 0\left(t_c \prec t_t; p-value\ \ t \succ 5\%\right):\ IND_t \text{ does not cause } EC_t \text{ long term}$$

_________ Strong Granger causality test (short and long term):

$$IND_0 = \alpha_{2i}^{1} = \theta_1 = 0\left(F_c \prec F_t; p-value\ \ F \succ 5\%\right):\ EC_t \text{ does not cause } IND_t$$
$$IND_0 = \alpha_{2i}^{2} = \theta_2 = 0\left(F_c \prec F_t; p-value\ \ F \succ 5\%\right):\ IND_t \text{ does not cause } EC_t$$
$$F_c = Fisher\ \ calculé;\ F_t = Fisher\ \ tabulate;\ t_c = t \text{ of calculated student } et\ \ t_t = t\ tabulaire.$$

Using the methodology of Dolado et al., (1990), we found that there is no deterministic trend in the time series studied. The results of the Ng & Perron (2001) unit root tests are reported in Table 3. The Ng-Perron test is preferred because the results are more reliable and consistent than the traditional ADF and P-P tests. DeJong et al (1992) and Harris & Sollis (2003) have argued that due to their poor size and power properties, these tests are not reliable for small sample sizes. These tests will over reject the null hypothesis when it is true and accept H0 when it is false.

Table 3: Results of the Ng–Perron unit root test.

Variables	MZa	MZt	MSB	MPT
Level				
lnEC	-1.9059	-0.85148	0.44676	11.4066
lnIND	-7.07854	-1.79368	0.2534	3.76757
lnUP	0.19634	0.08445	0.43011	16.3902
lnDC	-3.13418	-1.10593	0.35286	7.59827
lnGDP	-22.5121	-3.3512	0.14886	1.10133
Lnpt	-1.8649	-0.65246	0.34986	9.7092
1st Difference				
lnEC	-13.376	-2.57197	0.19228	1.88577
lnIND	-19.3167	-2.8419	0.14712	2.17845
lnUP	2.32556	1.4474	0.62239	38.1026
lnDC	-15.8273	-2.80972	0.17752	1.56068
lnGDP	-7.65781	-1.54309	0.20151	4.57027
Lnpt	-20.9139	-3.14835	0.15054	1.46604
2nd Difference				
lnEC	-15.9912	-2.82749	0.17682	1.53269
lnIND	-15.549	-2.77756	0.17863	1.61592
lnUP	-17.225	-2.93471	0.17037	1.42235
lnDC	-16.6436	-2.87769	0.1729	1.49815
lnGDP	-18.8453	-2.93234	0.1556	1.78283
Lnpt	-30.7163	-3.83796	0.12495	1.04398

Source : Autor from Eviews 10

The causality between energy consumption and industrialization can be bidirectional. In order to establish the direction of causality, the Granger causality test was employed and the results are presented in Table 4. The F-statistic and the probability values are constructed under the null hypothesis of no causality.

Table 4: Granger causality test.

Null Hypothesis:	Obs	F-Statistic	Prob.
LNIND does not Granger Cause LNEC	34	0.3496	0.5586
LNEC does not Granger Cause LNIND		0.0002	0.9896

Source : Autor from Eviews 10

Equation (4) is predicted for Cameroon based on quarterly data from 1980 to 2020. To test for the null hypothesis of no cointegration, we must first determine the order of the lags on the initial difference variables. According to Bahmani-Oskooee & Bohl, (2000), the outcomes of this first stage are typically sensitive to the sequence of the VAR.

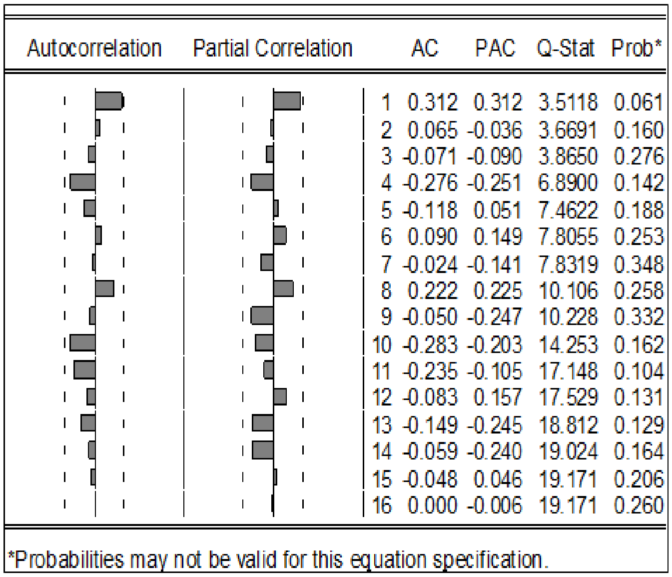
To validate this, we impose 2, 4, 6, 8, and 10 on the initial difference of each variable and compute the F-statistic for the combined significance of the variables' lagged levels. Table 1 displays the computed F-statistic for each lag order, with the crucial values at the bottom of the table. As can be observed, the test result changes depending on the lag order. The computed F-statistic for j = 4 is ambiguous, but it is significant at 90% for j = 6 and at 95% for j = 8 and j = 10. The findings appear to support the existence of a long-run money demand equation (especially when a higher order lag is chosen to formulate the model). These findings should be regarded as preliminary, indicating that while estimating equation (4), we should keep the variables' lagged levels in mind.

Table 5 : Test de diagnostique

Hypothèse du test	**Tests**	**Valeurs**	**Probabilité**
Hétéroscédasticité	Breusch-Pagan-Godfrey	0.51808	0.8785
	Arch-test	3.365969	0.0765
Spécification	Ramsey (Fisher)	0.948309	0.3549

Source : Auteur (nos estimations sur Eviews 10)

The findings shown in Table 5 and Figures (1 and 2) demonstrate the absence of serial correlation, heteroscedasticity, residual normality, and excellent model specification, since the probability associated with the four tests are far above 5%. For all of these tests, the null hypothesis is accepted. As a result, our model has been statistically verified.

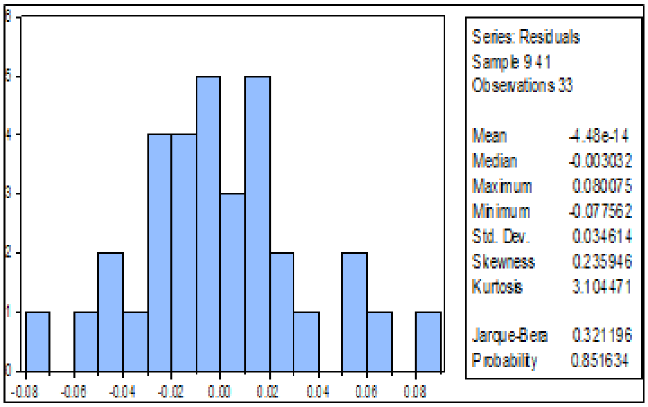


```
Autocorrelation   Partial Correlation      AC     PAC    Q-Stat  Prob*

                                       1   0.312  0.312  3.5118  0.061
                                       2   0.065 -0.036  3.6691  0.160
                                       3  -0.071 -0.090  3.8650  0.276
                                       4  -0.276 -0.251  6.8900  0.142
                                       5  -0.118  0.051  7.4622  0.188
                                       6   0.090  0.149  7.8055  0.253
                                       7  -0.024 -0.141  7.8319  0.348
                                       8   0.222  0.225  10.106  0.258
                                       9  -0.050 -0.247  10.228  0.332
                                      10  -0.283 -0.203  14.253  0.162
                                      11  -0.235 -0.105  17.148  0.104
                                      12  -0.083  0.157  17.529  0.131
                                      13  -0.149 -0.245  18.812  0.129
                                      14  -0.059 -0.240  19.024  0.164
                                      15  -0.048  0.046  19.171  0.206
                                      16   0.000 -0.006  19.171  0.260

*Probabilities may not be valid for this equation specification.
```

Figure 1 : Simple and partial autocorrelation test, or Correlogram



```
Series: Residuals
Sample 9 41
Observations 33

Mean        -4.48e-14
Median      -0.003032
Maximum      0.080075
Minimum     -0.077562
Std. Dev.    0.034614
Skewness     0.235946
Kurtosis     3.104471

Jarque-Bera  0.321196
Probability  0.851634
```

Figure 2 : Jarque Berra normality test

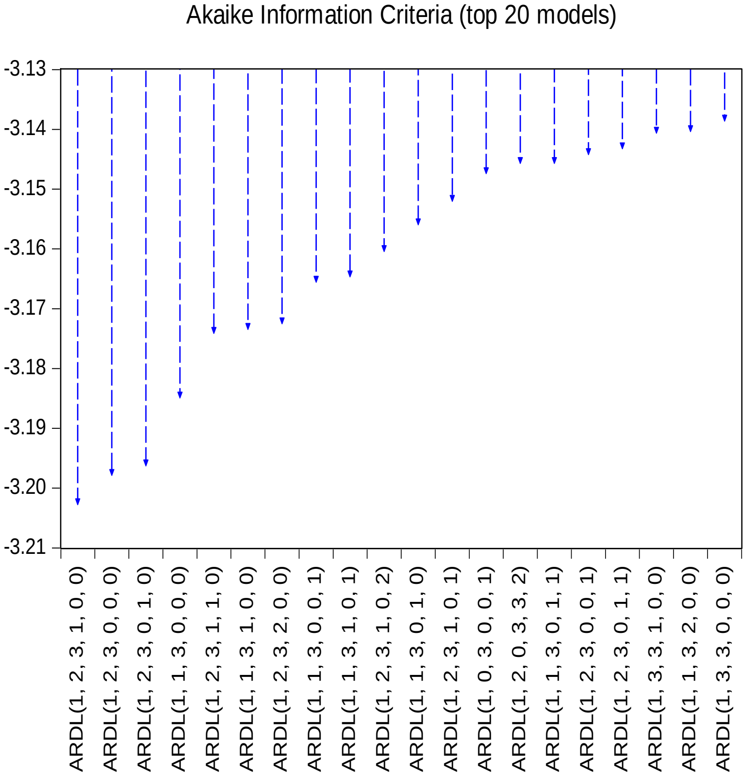


Figure 3 : Valeurs graphiques AIC

Since can be seen, the ARDL model (1,2,3,1,0,0) is the most optimum of the 19 given, as it has the lowest SIC value. Furthermore, in terms of the tests that aid in diagnosing the estimated ARDL model, we observe that there is no autocorrelation of the errors, there is no heteroscedasticity, the errors are normal, and the model has been adequately defined. For all of these tests, the null hypothesis is accepted. As a result, our model has been statistically verified. The projected ARDL (1,2,3,1,0,0) model is internationally good and accounts for 91 percent of Cameroon's industrialization from 1980 to 2020.

We first perform the cointegration test to the bounds (Pesaran et al., 2001). Also, recall that there are two steps to follow to apply the Pesaran cointegration test of Pesaran's cointegration test: ***(i) Determine the optimal lag first (AIC, SIC)***; hence, we will use the Schwarz information criterion (AIC) to select the optimal ARDL model, the one that provides statistically significant results with the least parameters. Below are the estimation results of the optimal ARDL model model selected:

Table 6: Model ARDL(1,2,3,1,0,0)

Dependent Variable: LNIND				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNIND(-1)	-0.161094	0.174193	-0.924802	0.3661
LNEC	-0.519122	0.310081	-1.674149	0.1097
LNEC(-1)	-0.069950	0.407500	-0.171658	0.8654
LNEC(-2)	-0.392207	0.303696	-1.291446	0.2113
LNUP	-18.79136	7.256618	-2.589548	0.0175
LNUP(-1)	16.22422	15.12079	1.072974	0.2961
LNUP(-2)	-2.302033	14.24129	-0.161645	0.8732
LNUP(-3)	19.51763	8.420221	2.317947	0.0312
LNDC	0.010464	0.046131	0.226843	0.8228
LNDC(-1)	0.071307	0.058112	1.227057	0.2340
LNGDP	-0.085735	0.145515	-0.589179	0.5623
LNPT	-7.058067	1.196236	-5.900230	0.0000
C	70.18228	12.44063	5.641376	0.0000
R-squared	0.832973	Mean dependent var		3.343151
Adjusted R-squared	0.732757	S.D. dependent var		0.084696
S.E. of regression	0.043784	Akaike info criterion		-3.131991
Sum squared resid	0.038341	Schwarz criterion		-2.542458
Log likelihood	64.67785	Hannan-Quinn criter.		-2.933631
F-statistic	8.311756	Durbin-Watson stat		2.301424
Prob(F-statistic)	0.000022			
*Note: p-values and any subsequent tests do not account for model selection.				

Source: Author (our estimates on Eviews 10)

(ii) Use Fisher's test to test for cointegration between series.

Table 5 presents the F-values calculated to test the existence of a long-run energy consumption equation under the null hypothesis (i.e., no relationship between regressors). The F-statistics in Table 5 should be compared to the critical bounds provided by (Pesaran et al., 2001) as follows:

$$\text{if } \; Fisher \succ \text{ upper terminal : cointegration exists}$$

$$\text{if } \; Fisher \prec \text{ lower terminal : cointegration does not exist}$$

$$\text{if } \; \text{lower terminal} \prec Fisher \prec \text{ upper terminal : no conclusion.}$$

The outcome of the boundary test is determined by the critical manner in which the sequence of delays is selected, p. As a result, we estimate the conditional model Eq. (4) by imposing a maximum of three lags on the model and selecting the best number of lags using the Schwartz-Bayes criterion (SBC). According to Narayan (2005) and Pesaran et al., (1999), an SBC-based ARDL model outperforms an AIC-based model. As a result, the best lag duration depending on SBC is chosen.

The estimation results are shown in Table 7, which is about cointegration using the ARDL technique. The null hypothesis of no cointegration between the variables can be rejected if the computed F-statistic exceeds the upper critical limit. The null hypothesis of no long-term association cannot be rejected if the computed F-statistic is less than the lower critical limit.

Table 7: Bounds tests for the existence of a long relationship

		1% Critical Bounds		2.5% Critical Bounds		5% Critical Bounds		10% Critical Bounds	
	F-statistics	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
Industrialization led Energy consumption F (1,3)	6.187102[1]	3.06	4.15	2.7	3.73	2.39	3.38	2.08	3
Energy consumption led Industrialization F (1,3)	4.378219	3.06	4.15	2.7	3.73	2.39	3.38	2.08	3

[2] Indicates a rejection of the null hypothesis of no cointegration at 5% level of significance. The lag order is shown within the small brackets beside the F-statistic.

Source: Author (our estimates on Eviews 10)

Table 7 displays the computed F-statistics and the crucial values proposed by Pesaran et al., (2001) at various degrees of significance. At the 5% significance level, the F-statistic is significantly over the crucial threshold. The results of the cointegration test at the limits show the presence of a cointegrating connection between the series under consideration (the value of F-stat is larger than the upper constraint), allowing us to estimate the long-term impacts of *lnind, lnec, lnup, lngdp, and lnpt*. As a result, there is a chance that industrialization and energy use are endogenous. To overcome the endogeneity problem, Ang (2010) recommends re-estimating equation (4) using industrialization as the dependent variable.

When industrialization is a dependent variable and energy consumption does not lead to an increase in industrialization, the computed values of the F-statistics remain below the lower limit of the critical value, implying that there is no long-run connection. First and foremost, consider the connection and causation between variables.

The simple correlation matrix between variables shown below Table (8) shows no relationship between the dependent variable (IND) and the explanatory factors, with the degree of linkage in the first column not reaching 0.50. On the other hand, we suspect that GDP and industrialization are multicollinear. GDP may be able to boost economic industrialization.

Table 8 : Correlations

	IND	EC	UP	DC	GDP	PT
IND	1.0000					
EC	0.3091	1.0000				
UP	-0.3328	-0.8938	1.0000			
DC	0.4215	**0.5204**	-0.7479	1.0000		
GDP	**0.679**	0.3296	-0.4745	**0.7807**	1.0000	
PT	-0.3253	-0.931	**0.9898**	-0.6779	-0.4145	1.0000

Nobs=35

According to the correlation coefficients, energy consumption has the lowest association with industrialization and the largest correlation with urbanization (table 2). Industrialization has the weakest relationships with urbanization, financial development, and GDP per capita. The ARDL cointegration test, however, does not reveal the direction of causation. As a result, we will use the Granger causality test to determine the direction of causation.

Gregory & Hansen, (1996) use the structural break cointegration technique to test the robustness of the cointegration connections between variables. Because of the occurrence of structural breakdowns in a given series, the ARDL's dependability is called into doubt. As a result, we utilized Gregory & Hansen, (1996) structural break cointegration technique to assess both the reliability and robustness of the long-run connection between the variables (see Gregory & Hansen, 1996). Table 6 shows the findings of the Gregory-Hansen cointegration test, which is a residual-based cointegration test that takes into account a single structural break in the series.

As shown in Table 8, the adjustment coefficient or recall force is statistically significant, negative, and has an absolute value between zero and one, implying the existence of an error correction mechanism and, as a result, the existence of a long-term relationship (cointegration) between variables. We also like to mention the following: I In the near run, energy consumption has a less-than-proportional negative influence on industrialization: a 1% increase in energy consumption delays the modernization process by 0.52 percent. These impacts do not reverse over time, which can be explained by Cameroon's lack of energy to encourage industrial progress. (ii) The other control variables did not have the predicted (positive) impact in the short run, which hampered industrial expansion, with the exception of domestic credit, which had a positive influence on industrialization in the short run. In the near run, such paradoxical results would be justified by the country's embryonic and less established economic structures and processes, along with the political instability that do not equip the country with efficient economic strategies. However, the time dimension is a critical aspect to consider. The time dimension, on the other hand, is an essential component that should not be overlooked here.

Table 8: Short run ARDL estimates

Conditional Error Correction Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	70.18228	15.98028	4.391805	0.0003
LNIND(-1)*	-1.161094	0.223754	-5.189143	0.0000
LNEC(-1)	-0.981280	0.371680	-2.640121	0.0157
LNUP(-1)	14.64845	3.161110	4.633958	0.0002
LNDC(-1)	0.081772	0.059473	1.374935	0.1844
LNGDP**	-0.085735	0.186918	-0.458675	0.6514
LNPT**	-7.058067	1.536593	-4.593323	0.0002
D(LNEC)	-0.519122	0.398306	-1.303323	0.2073
D(LNEC(-1))	0.392207	0.390105	1.005389	0.3267
D(LNUP)	-18.79136	9.321295	-2.015961	0.0574
D(LNUP(-1))	-17.21560	12.10487	-1.422204	0.1704
D(LNUP(-2))	-19.51763	10.81597	-1.804519	0.0862
D(LNDC)	0.010464	0.059256	0.176597	0.8616
* p-value incompatible with t-Bounds distribution.				
** Variable interpreted as Z = Z(-1) + D(Z).				

We then estimate Eq. (4) following the ARDL cointegration technique for long-run estimates. We estimated the model by considering the different criteria, such as R2 criterion, Hannan Quinn criterion, AIC criterion and SBC criterion, to find the coefficient of the level of the variables. The long-run and short-run results of all models were almost identical. Therefore, we present only the results of the model that was selected based on the AIC criterion, because the Monte Carlo experiment of Liew, (2004) showed that the AIC is superior to the other criteria, especially when the period is less than 60 observations. The results of the long-run estimates are presented in Table 7.

Table 7: Long run ARDL estimates

Dependent variable is industrialization				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
lnEnergy Consumption	-0.845134	0.294211	-2.872540	0.0094
lnUrban Population	12.61608	2.336469	5.399634	0.0000
lnDomestic Credit	0.070426	0.052355	1.345164	0.1936
lnGDP/Pop	-0.073840	0.162684	-0.453883	0.6548
lnTotal Population	-6.078809	1.131712	-5.371341	0.0000
Intercept	60.44498	11.72537	5.155061	0.0000
Source : Autor from Eviews 10				

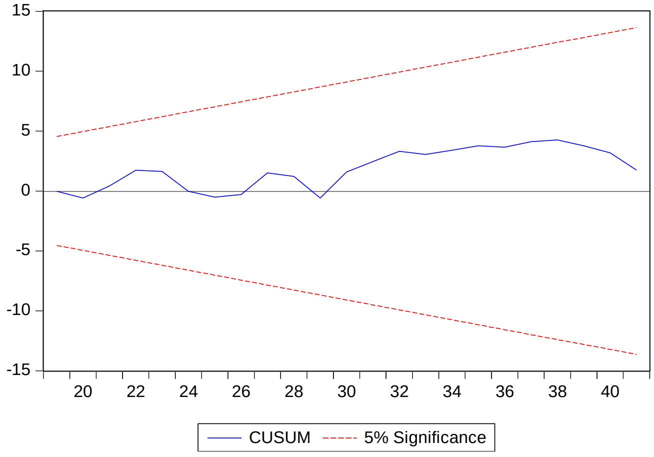
Furthermore, contrary to the short-term results, the other control variables exhibit the expected (positive) long-run effects, constituting factors favoring industrialization, with the exception of GDP and total population, whose effects on industrialization remain negative in both the short and long run. Remember that this unexpected conclusion is the result of ineffective or nonexistent economic policies, political instability, and so on. This is the time to encourage the country's political leaders to implement realistic economic policies (energy redevelopment plans) that are time-bound and likely to benefit Cameroon's industrialization strategies.

Stability test

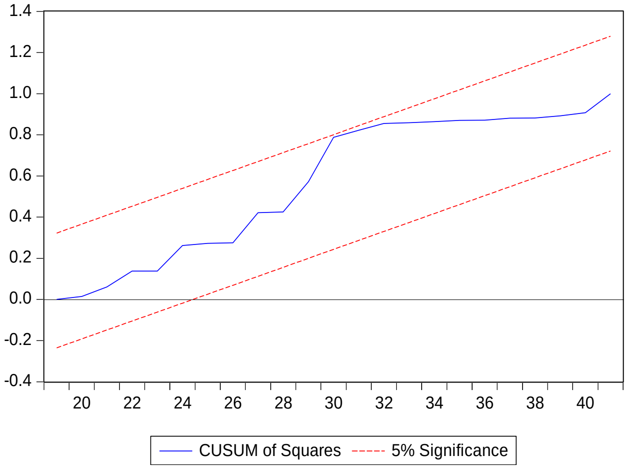
In order to determine the energy consumption level of our estimates, CUSUM[2] and CUSUMSQ[3] of Brown et al., (1975) were performed on the acquired error correction estimates to assess the energy consumption level of our estimates. The tests are typically depicted graphically. These tests are carried out to determine the level of consistency of the model parameters.

Figure 1. Plots of CUSUM and CUSUMSQ Statistics for Coefficient Stability

Plot of Cumulative Sum of Recursive Residuals



Plot of Cumulative Sum of Squares of Recursive Residuals



The CUSUM test results demonstrate that all of the model's parameters are stable over time, since the recursive residuals remain inside the confidence interval at the 5% threshold at all times, indicating that the model is structurally stable. The CUSUMSQ test results show that the cumulative sum of squares of the recursive residuals always stays within the interval for the 5 percent confidence level, indicating that the residual variance is stable.

IV. CONCLUSION

Industrialization is preceded by the development of electrical energy sources. To do so, the country may fund its rise through a structural reorganization of energy consumption, which would effect investment expenditure, raise salaries, and have a beneficial impact on Cameroon's industrialization. What impact does energy usage have on Cameroon's industrialization process? In other words, how does energy use affect Cameroon's macroeconomic performance? This study's goal was to find an answer to this issue. We calculated an ARDL (Auto Regressive Distributed Lag model) to evaluate the link between energy consumption and the industrialization process in Cameroon, which is a unique approach to this topic for the instance of Cameroon. The temporal effects (adjustment lag, expectancies, etc.) in the explanation of a variable may be captured using this dynamic model, which belongs to the class of dynamic models. In our study, the estimated ARDL model helped capture the effects on the industrialization process (IND: dependent variable) of energy consumption (EC: variable of interest), controlling for other indispensable control variables commonly used in the empirical literature: urbanization (UP) control variables commonly used in the empirical literature: urbanization (UP); domestic credit (DC); GDP (GDP) and total population (TP). Thanks to the test of cointegration at the limits, which enabled us to estimate the coefficients in the short term and the elasticities in the long term, the technique of Pesaran et al., (2001) led us to conclude on the presence of a cointegrating connection between variables. In reality, we discovered the following in the near term: I Energy consumption has a

---

[2] Cumulative Sum of Recursive Residuals
[3] Cumulative Sum of Squares of recursive residuals

smaller proportionate negative impact on the industrialization process: a 1% increase in energy consumption delays the industrialization process by 0.52 percent in the short term. In the long run, these impacts stay the same, with a 1% increase in energy use resulting in a 1% slowdown in Cameroon's industrialization process.

V. RECOMMENDATIONS

In addition, the following recommendations are made to the governmental authorities of the developing Cameroon by 2035, based on the findings of this study:

(i) Investment, as one of the transmission belts of the effects of energy consumption on the industrialization process, to put in place realistic economic policies (investment policies for the construction of new dams, investment in the production of energy transformation) that are time-bound and likely to encourage local and international upper and middle-class business and capital flow;
(ii) Encourage research and development, which will have the impact of increasing investment in the development of new energy sources, making the economic openness favorable to industrial investors;
(iii) Fighting for and preserving the country's political stability, as a guarantee of long-term efficient economic policies.

REFERENCE

[1] Al-Iriani, M. A. (2006). Energy--GDP relationship revisited: an example from GCC countries using panel causality. Energy Policy, 34(17), 3342–3350.
[2] Apergis, N., & Payne, J. E. (2009). Energy consumption and economic growth: evidence from the Commonwealth of Independent States. Energy Economics, 31(5), 641–647.
[3] Asafu-Adjaye, J. (2000). The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian developing countries. Energy Economics, 22(6), 615–625.
[4] Bahmani-Oskooee, M., & Bohl, M. T. (2000). German monetary unification and the stability of the German M3 money demand function. Economics Letters, 66(2), 203–208.
[5] Blanchard, O. (1992). Energy consumption and modes of industrialization: four developing countries. Energy Policy, 20(12), 1174–1185.
[6] Blanchard, O. J., & Summers, L. H. (1992). Hysteresis in unemployment. In Economic Models of Trade Unions (pp. 235–242). Springer.
[7] Brown, R. L., Durbin, J., & Evans, J. M. (1975). Techniques for testing the constancy of regression relationships over time. Journal of the Royal Statistical Society: Series B (Methodological), 37(2), 149–163.
[8] Cheng, B. S. (1995). An investigation of cointegration and causality between energy consumption and economic growth. The Journal of Energy and Development, 21(1), 73–84.
[9] Coakley, J., Fuertes, A.-M., & Smith, R. (2006). Unobserved heterogeneity in panel time series models. Computational Statistics \& Data Analysis, 50(9), 2361–2380.
[10] Cole, M. A. (2006). Does trade liberalization increase national energy use? Economics Letters, 92(1), 108–112.
[11] Dolado, J. J., Jenkinson, T., & Sosvilla-Rivero, S. (1990). Cointegration and unit roots. Journal of Economic Surveys, 4(3), 249–273.
[12] Eberhardt, M., & Bond, S. (2009). Cross-section dependence in nonstationary panel models: a novel estimator.
[13] Eberhardt, M., & Teal, F. (2010). Productivity Analysis in Global Manufacturing Production.
[14] Eberhardt, M., & Teal, F. (2011). Econometrics for grumblers: a new look at the literature on cross-country growth empirics. Journal of Economic Surveys, 25(1), 109–155.
[15] Engle, R. F., & Granger, C. W. J. (1987). Co-integration and error correction: representation, estimation, and testing. Econometrica: Journal of the Econometric Society, 251–276.
[16] Gregory, A. W., & Hansen, B. E. (1996). Practitioners corner: tests for cointegration in models with regime and trend shifts. Oxford Bulletin of Economics and Statistics, 58(3), 555–560.
[17] Johansen, S. (1988). Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control, 12(2–3), 231–254.
[18] Jones, M. C., & Sheather, S. J. (1991). Using non-stochastic terms to advantage in kernel-based estimation of integrated squared density derivatives. Statistics \& Probability Letters, 11(6), 511–514.
[19] Karanfil, F. (2009). How many times again will we examine the energy-income nexus using a limited range of traditional econometric tools? Energy Policy, 37(4), 1191–1194.
[20] Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. The Journal of Energy and Development, 401–403.
[21] Lee, C.-C. (2005). Energy consumption and GDP in developing countries: a cointegrated panel analysis. Energy Economics, 27(3), 415–427.
[22] Lee, C.-C., & Chang, C.-P. (2008). Energy consumption and economic growth in Asian economies: a more comprehensive analysis using panel data. Resource and Energy Economics, 30(1), 50–65.
[23] Lee, K., & Mathews, J. A. (2008). Upgrading in the same industry and successive entries in new industries for sustained catchup: cases of Korean and Taiwanese Firms. Catch--up Workshop Held in Mexico City, 22–24.
[24] Liddle, B. (2004). Demographic dynamics and per capita environmental impact: Using panel regressions and household decompositions to examine population and transport. Population and Environment, 26(1), 23–39.
[25] Liew, V. K.-S. (2004). Which lag length selection criteria should we employ? Economics Bulletin, 3(33), 1–9.
[26] Mahadevan, R., & Asafu-Adjaye, J. (2007). Energy consumption, economic growth and prices: A reassessment using panel VECM for developed and developing countries. Energy Policy, 35(4), 2481–2490.
[27] Narayan, P. K. (2005). The saving and investment nexus for China: evidence from cointegration tests. Applied Economics, 37(17), 1979–1990.
[28] Narayan, P. K., & Smyth, R. (2008). Energy consumption and real GDP in G7 countries: new evidence from panel cointegration with structural breaks. Energy Economics, 30(5), 2331–2341.
[29] Ozturk, I., Aslan, A., & Kalyoncu, H. (2010). Energy consumption and economic growth relationship: Evidence from panel data for low and middle income countries. Energy Policy, 38(8), 4422–4428.
[30] Parikh, J., & Shukla, V. (1995). Urbanization, energy use and greenhouse effects in economic development: Results from a cross-national study of developing countries. Global Environmental Change, 5(2), 87–103.
[31] Persan, M. H., & Pesaran, B. (1997). Microfit 4.0: interactive econometric analysis. Oxford University Press Oxford.
[32] Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16(3), 289–326.
[33] Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. Journal of the American Statistical Association, 94(446), 621–634.
[34] Pesaran, M. H., & Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels. Journal of Econometrics, 68(1), 79–113.

[35] Revue synthétique des résultats pays. (2017).

[36] Sadorsky, P. (2013). Do urbanization and industrialization affect energy intensity in developing countries? Energy Economics, 37, 52–59. https://doi.org/10.1016/j.eneco.2013.01.009

[37] Samouilidis, J.-E., & Mitropoulos, C. S. (1984). Energy and economic growth in industrializing countries: the case of Greece. Energy Economics, 6(3), 191–201.

[38] siècle avec la révolution industrielle britannique. Des mouvements d'industrialisation se sont ensuite succédé au cours du XIX. (2009). 1–13.

[39] Stern, D. I. (1993). Energy and economic growth in the USA: a multivariate approach. Energy Economics, 15(2), 137–150.

[40] Wolde-Rufael, Y. (2006). Electricity consumption and economic growth: a time series experience for 17 African countries. Energy Policy, 34(10), 1106–1114.

[41] York, R. (2007). Demographic trends and energy consumption in European Union Nations, 1960--2025. Social Science Research, 36(3), 855–872.

[42] Yu, E. S. H., & Choi, J.-Y. (1985). The causal relationship between energy and GNP: an international comparison. The Journal of Energy and Development, 249–272.