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Article

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Oil Products Consumption and Economic Growth in Cameroon Households: An Assessment Using ARDL Cointegration and Granger Causality Analysis

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ABSTRACT

This study identifies the factors accountable for the historical growth trends in kerosene and liquefied petroleum gas (LPG) consumption in Cameroon households, thereby quantifying their short- and long-run effects for the period 1994-2014. ARDL bound test and Granger-causality following Toda-Yamamoto procedure under an augmented VAR framework are estimated. Empirical results validate the presence of a long-run equilibrium relationship on one hand between kerosene consumption, prices, income, and urbanization; and on the other hand between LPG consumption, prices, income, and urbanization. Prices, income and urbanization have significant positive impact on kerosene and LPG consumption both in the short- and long-runs, with evidence of high degree of fuel substitution from kerosene to LPG. Granger causality test show that there exists bidirectional causality between LPG consumption and income at the 5% significance level, whereas there is no causality between kerosene consumption and income. This means that an increase in LPG consumption affects economic growth with feedback effect. Consequently, supporting energy policies aimed at increasing LPG consumption while reducing kerosene consumption is achievable in Cameroon. Other captious policy measures and sensitive issues such as market liberalization, energy accretion programs and market competitiveness to upgrade availability, accessibility, distribution and extension of energy services are discussed.

Keywords: Oil Products Consumption, Elasticity, Autogressive Distributed Lag, Causality, Households, Cameroon
JEL Classifications: C22, C4, C5, R2

1. INTRODUCTION

In sub-Saharan Africa (SSA), over 600 million people currently depend on so-called traditional energies such as firewood, coal, charcoal, wood residues, crop residues and animal dung for cooking, lighting and other heat applications (Nkue and Njomo, 2009; Olabisi et al., 2019). Although traditional biomass is renewable, its traditional use pattern releases a multitude of noxious chemical compounds and many inhalable particulates that are harmful to the environment and human health (Nkutchet, 2004; Clark et al., 2009; Mehetre et al., 2017). Often, these fuels are incinerated in opened fires or three-stone furnaces, leading to the release of dangerous levels of nitrogen dioxide, carbon monoxide, cilia toxic, formaldehyde and polycyclic aromatic hydrocarbons (Han et al., 2018; Irfan et al., 2018). As a result of the use of solid fuels, nearly 300 thousand people in SSA die prematurely yearly because of indoor air pollution, and many more suffer from severe diseases such as lung infections, asthma, eye infections, cancer, sinus problems, tuberculosis and cardiovascular diseases (WHO, 2015; IEA, 2016). The consumption of firewood, charcoal, wood residues and animal dung also affects the environment. Roughly 7.3 million hectares of forest are cleared each year in SSA to provide agricultural lands or for use as firewood (IEA, 2016; FAO, 2018). Humans depend on forests for their survival, from the air they breathe to the wood they use, and medicines they need (Irfan et al., 2018; Carvalho et al., 2019). Besides providing habitats for animals and subsistence for humans, forests also prevent soil erosion, offer watershed protection and alleviate climate change. The use of solid fuels for cooking, heating and lighting still prevails in SSA despite the negative externalities on the environment and human health, and the rate of access to modern and cleaner sources such as electricity, natural gas, liquefied petroleum gas (LPG) and kerosene is very low (Mensah et al., 2016; Appiah, 2018; Olabisi et al., 2019).

In Cameroon, like in most SSA countries, the main energy sources used for cooking and lighting include electricity, LPG, kerosene, firewood, coal, charcoal, wood residues, crop residues and animal dung. Electricity is generally used for lighting in most households, while solid fuels, LPG and kerosene are more commonly used for cooking and other heating applications by 95% of Cameroonian households (SIE-Cameroon, 2011; 2015). LPG and kerosene are the only petroleum products consumed in this sector. What is worrisome, however, is the low use of LPG and kerosene (12.3% of the shares), which are relatively cleaner, portable and efficient for multiple uses (SIE-Cameroon, 2011; 2015). This is due to the high cost of gas cylinders and their refilling, as well as incessant shortages, leaving little room for households and small businesses to rely on primary sources such as solid fuels to meet their energy needs. Rural populations depend much more than urbanites on kerosene and solid fuels, and suffer from more poverty and poorer access to other options such as grid electricity.

It is crucial to understand how income and prices influence household energy choices in order to plan policies that handle the challenges of population pressure on forests and the costs of new energy sources (Mensah et al., 2016; Irfan et al., 2018; Uhr et al., 2019). Studying household fuel choices is directly related to public policy in Cameroon. Promoting households' access to purchasable energy is the first and foremost wish of the Government of Cameroon (GoC). To realize this goal, the GoC has launched the National Energy Plan (NEP) that include: (i) Increasing LPG accessibility to rural households via the promotion of public/private cooperation with the aim of increasing the proportion of rural households having access to LPG from 10.1% in 2010 to 40% by 2035 (GESP, 2009; SIE-Cameroon, 2015); (ii) maintenance, rehabilitation, and development of energy infrastructure to increase production by upgrading the gas potential especially LPG for households, alternative energies and the modernization of distribution networks (GESP, 2009; Cameroon Vision 2035, 2009; SIE-Cameroon, 2015); (iii) vulgarizing the use of LPG as a substitute for solid fuels such as wood and charcoal, to reduce deforestation, protect the forest, and reduce indoor pollution, so that the 32.5% of the current population cooking with LPG become 60% (about 14 million Cameroonians) by 2030; (iv) Increase import taxes on kerosene (Cameroon Vision 2035, 2009; SIE-Cameroon, 2015) to address environmental issues because kerosene emits more than GPL. The goal of this policy is to reduce the level of kerosene consumption. Eventually, the efficiency of the policy will depend on the elasticities of demand (Smith, 2017; Coelho et al., 2018). Although opinions on fuel taxation and subsidization are mixed and conflicting (Breisinger et al., 2019), this topic is of paramount importance for the economic and political discourse in Cameroon. It is therefore essential to accurately analyze the role that kerosene and LPG consumption play in economic growth to inform decision makers of the policy portfolio to adopt to reduce the negative impacts on consumers and the environment without harming economic growth. Thus, Cameroon risks compromising its economic growth by maintaining taxation policies if there is a causal link between kerosene consumption and economic growth; and (v) Guaranteeing the sustainability of distribution of oil products in Cameroon and ensuring that SONARA (the only country's refinery) continues to cover 80% of the country's oil product needs.

By the way, it is important to underline here that SONARA caught fire on the night of May 31st, 2019. This fire destroyed four of its 13 production units, stopping the refining activities within this company. According to current government forecasts, this shutdown will last between 2 and 4 years. The oil sector in Cameroon might therefore experience a new crisis despite the fact that the GoC revised upwards in early 2019 the provision to support fuel prices at the pump, from 208.6 to 248.6 million USD (Jeune Afrique, 2019). During this shutdown, SONARA will no longer refine crude oil, which should normally reduce this deficit. In fact, this loss represents the difference between the price at which the fuels should have been sold, taking into account the purchase price of crude on the world market, and the prices actually charged at the pump, according to a grid approved by the GoC. The resulting difference is often borne by state coffers as part of its price support policy at the pump. Clearly, the GoC will have to find solutions to cover the losses of SONARA this year.

Since the early studies of Kraft and Kraft (1978), many other researchers have repeatedly studied the energy consumption-growth nexus in different aspects (Masih and Masih, 1998; Mavrotas and Kelly, 2001; Ghosh, 2002; Wolde-Rufael, 2010; Fondja, 2013; Rahman and Kashem, 2017; Appiah, 2018; Salmanzadeh-Meydani and Ghomi, 2019). Most studies on energy consumption-growth nexus attempt to answer the question formulated by Masih and Masih (1998): "*does economic growth take precedence over energy use, or can energy use itself be a stimulate economic growth through the direct channels of effective aggregate demand and human capital, improved efficiency and technological progress?*" There is a general agreement about the usefulness of dealing with such dynamic relationship, which seems to be an essential element in setting any policy strategies (energy, economics and ecological). Payne (2010), Ozturk (2010), and Tiba and Omri (2017) for instance surveyed more than 160 past studies on Granger causality analysis, alongside with discussion on the various hypotheses associated. The conclusions of various studies depend on the economic structure of the country, data size and type, time horizon, methodological approach, interpretation of results, and many other properties. There is not yet a factual and general result on the causal link between energy consumption and economic growth (Payne, 2010; Tiba and Omri, 2017; Appiah, 2018; Salmanzadeh-Meydani and Ghomi, 2019). How then about the case of Cameroon? For, conclusions for other countries cannot simply be inferred to Cameroon. Fondja (2013), Tamba et al. (2012, 2017a, 2017c) and Tamba (2017b) have attempted to answer this question; however their works suffer from omission variable bias as argued by Caporale and Pittis (1995a, 1995b) concerning studies employing bivariate models, leading to spurious results. This study basically explores the time series features of the underlying series by using different unit roots test approaches, specifically, the Augmented Dickey and Fuller (ADF) (1981) and Phillips and Perron (1988) tests. In addition, the Autogressive Distributed Lag (ARDL) bound test by Pesaran et al. (2001) is used to test for cointegration relations between the variables. Finally, a Granger causality test is conducted using the Toda and Yamamoto (TY) (1995) procedure. This study therefore seeks to check the empirical cointegration, short- and long-run dynamics, and causal channels between oil products consumption and economic growth in Cameroon households through a multivariate approach. The objectives of the study are:

1. To provide a thorough analysis of the drivers of oil products consumption in Cameroon households for the mastery of energy demand dynamics
2. To find out whether, and up to what degree income, prices and urbanization impact on oil products consumption
3. To unfold the short- and long-run dynamics between oil products consumption, economic growth, prices and urbanization in Cameroon
4. To show whether oil products consumption contribute to economic growth in Cameroon and vice versa. In other words, this paper also attempts to answer the question of Masih and Masih (1998)
5. To propose related policy viewpoints to improve economic growth in the long-run.

The study contributes to the current literature in several ways: (i) It examines the dynamics and causal connections between LPG and kerosene consumptions, their prices, income and level of urbanization in Cameroon from 1994-2014 implementing ARDL cointegration bounds test and Granger causality testing method through taking care of the stochastic features of the data; many captious policy measures and sensitive issues such as market liberalization to upgrade availability, accessibility, distribution and extension of energy services are discussed in this study; (ii) unlike earlier studies, variables are used in their growth form rather than in their simple ratio form in order to reveal the direction of movements of the variables in the period relative preceding period t–1; (iii) this study uses real income as a barometer of economic growth which is more associated to LPG and kerosene consumption; (iv) this study employs more recent data according to their availability; (v) the current situation of SONARA leaves much room for investors and marketers. This work will therefore guide policymakers on how to fill shortfall in the supply that was made by SONARA until its shutdown besides the shortfall in profits. Finally, (vi) the factual results of this study will provide the GoC with new insights of energy consumption, energy prices, urbanization and economic growth to develop energy policies aimed at reducing pressure on forests and the level of indoor pollution. The methodology used in this paper is the same as that used in the works of Appiah (2018) and Salmanzadeh-Meydani and Ghomi (2019).

The rest of this paper is as follows: The next section presents an overview of household oil products demand trends in Cameroon. Highlights on the econometric techniques and datasets which are employed in this study are discussed in Section 3. Section 4 presents and analyzes the empirical results, while Section 5 concludes the paper with a summary and discussion of policy suggestions.

2. OVERVIEW OF THE OIL PRODUCTS SECTOR IN CAMEROON

According to the World Bank statistics development indicators, Cameroon's GDP is amongst the ten highest in sub-Saharan Africa, with a GDP of US$26.4 Billion in 2017. The country is aiming to become an emerging economy by horizon 2035. To achieve this challenge, the GoC presented in 2009 referenced documents such as the Growth and Employment Strategy Paper (GESP, 2009) and Cameroon Vision 2035 (2009), where relevant sectorial indicators and growth strategies for the targeted period are presented. Cameroon has experienced a period of strong economic performance prior to 1986, with an average GDP growth rate of about 4% yearly. Unfortunately, the insufficiency of energy, principally electricity (especially in the rural areas) is still the major delay for further economic development. Electricity consumption is 266kWh/capita. This is very low compared with the African average (561 kWh/capita) and is insignificant compared to the average of OECD countries (8012 kWh/capita) (Fondja, 2013).

With the actual oil production rate (3.3 million metric tons/year), Cameroon's oil production would last no more than 10 years (Tamba, 2017b). New exploration and exploitation permits have been granted, particularly at the borders of Lake Chad and the off-shores of South-west region, boosted by the hope of developing the Bakassi Peninsula, which is possibly rich in light oil. Consequently, unlike consumption of oil products that has witnessed an abrupt increase, crude production has been on a steady decrease for the previous decades. To close this gap, Cameroon depends at 90% on imports principally from Nigeria (Tamba et al., 2017c). The remaining 10% come from its yearly production of oil.

In 2010, Cameroon produced 3.3 million metric tons of crude oil of which only 396,220 metric tons was refined by SONARA[1]. Indeed, the structure of the market and the technological profile of the refinery (Hydroskyming or Topping Reforming type) compel it to choose light crudes on the world market, adapted to its refining tools and to obtain refined products needed by the domestic market. However, Cameroon is currently producing heavy crudes and there is a discrepancy between the actual refining tools and crudes produced in Cameroon. Given this situation, SONARA has launched a project to expand and modernize its production units. The strategy is to maximize the transformation of Cameroon's crude oil. Economically, this project will achieve a critical size to improve the utilization rate of all refining units and its refining gross margin, thereby maximizing the supply of products needed in the Cameroonian oil market. On one hand, this will improve the balance of payment and on the other hand reduce

1 Note that SONARA works mainly with light crude oil. However, the Cameroonian crude oil is heavy; hence the external supply can satisfy the domestic market for oil products.

energy dependence from neighboring countries like Equatorial Guinea and Nigeria that currently supply SONARA with crude oil. The second phase of the project will be the installation of a hydrocracker, which will refine the local crude with fewer residues. The overall objective of this project is to increase SONARA's production capacity from 2.1 to 3.5 million metric tons yearly (SIE-Cameroon, 2015). The expansion and modernization plan started at the end of 2009 and is still ongoing despite the initial 2013 deadline.

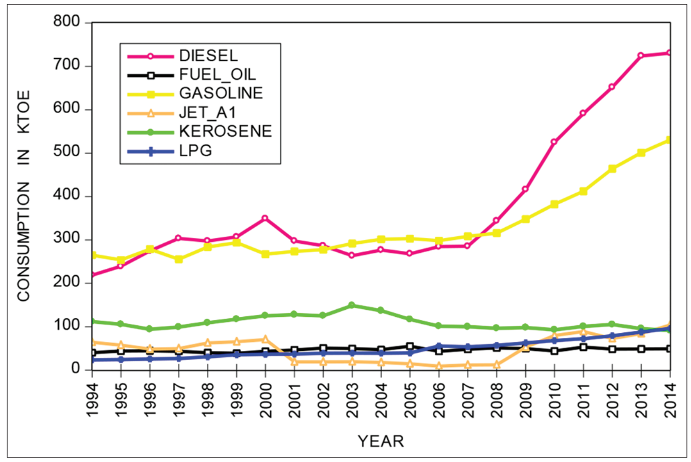
Several public, parastatals and private companies are involved in the oil sector. The National Hydrocarbons Corporation (SNH) in the upstream sector is responsible for the promotion, development and supervision of oil activities throughout the national territory. Until the oil sector reforms of July 1985, SNH had been the sole supplier of crude in Cameroon. It now competes with PECTEN, ADDAX and PERENCO. In the downstream sector, many companies have been approved. They include: SONARA[2] that refines crudes and supplies 80% of the domestic market (the remaining 20% is liberalized) ; storage is done by SCDP; HYDRAC (Hydrocarbon Analysis-Control) controls the quality and quantity of oil products distributed on the local market; while marketers (TOTAL, BOCOM, MRS, PETROLEX, OILYBIA, SCTM, TRADEX, CAMGAZ, GULFIN, CAMOCO, DELTA OIL) take care of the supply of finished products under the regulatory section of the Hydrocarbons Prices Stabilization Fund (HPSF) that insures the regulation and equalization of prices of oil products throughout the country (SIE-Cameroon, 2011, 2015).

There are six types of oil products present in the Cameroonian market: fuel oil, diesel, gasoline, jet A1, kerosene and LPG. When these products come out from SCDP, they are immediately released on the market via 612 gas stations, in more than 1000 outlets and private facilities located in industrial units. More than 85% of these sales points are located in urban centers (SIE-Cameroon, 2015). Rural areas are not well served because of seasonal roads and this is aggravated by the rugged topography.

Figure 1 shows the evolution of oil products consumption in Cameroon from 1994 to 2014. Oil products consumption is widely dominated diesel, followed by gasoline and kerosene. Only kerosene and LPG are used in the household sector. LPG is the preferred cooking fuel, and its use directly interacts with income. This is because kerosene is often used as a backup to biomass (especially amongst poorer households), even though to a lesser extent, when wood is not available (during the rainy season, and principally as an accelerant) or scarce (like in the northern regions of Cameroon). In contrast, in urban and peri-urban areas, such secondary use is prominent amongst lower and middle income groups, but then reduces with income at the highest income levels, as more households possess two LPG cylinders on average.

In 2014, in terms of end-use energy demand, oil products ranked second (1,133.58 ktoe[3], 19.72%). Biomass consumption is still

Figure 1: Petroleum products consumption from1994 to 2014



very high in Cameroon with a share of 72.61% (4,172.97 ktoe), while electricity consumption only represents 418.25 ktoe (7.28%). The residential sector (particularly households) is the largest consumer of end-use energy in Cameroon with about 74% of the shares, principally constituted of electricity. Then comes the transport sector and the primary sector with 12% and 9% of the shares respectively. The industrial sector ranks last with only 5% of end-use energy demand (SIE-Cameroon, 2015; Tamba, 2017a). This reflects the low level of industrialization in Cameroon. What is problematic is the low use of LPG which is efficient, portable and relatively cleaner with multiuse. This is due to the high cost of gas cylinders and their refilling, as well as incessant shortages, leaving little room for households and small businesses than to rely on primary sources such as solid fuels to meet their energy needs. However, the trend is changing as a result of the GoC efforts aimed at reducing overreliance on solid fuels.

What is promising though is that household LPG consumption seems to be rising although from a low base. From a share of 3.26% in 1994, LPG consumption in 2014 rose to 5.98%. This share could have been much higher in the absence of irregular supply of LPG and its high cost which most poor households cannot afford in both urban and rural zones. As exposed in Figure 1 and in accordance with what we said earlier, the transition process in the household oil product consumption pattern over the last decade has seen significant dynamics as demand is progressively shifting away from kerosene towards LPG. For illustration, between 2003 and 2014, total kerosene consumption dropped by 38.68% from 148.48 ktoe to 91.05 ktoe, respectively. Demand for LPG increased by 115% within the same period.

Since 2010, the average selling price of LPG has been stabilized at US$ 1.04/kg, i.e. US$ 13 for a 12.5 kg cylinder[4]. It is important to underline that LPG is subsidized in its bulk form, which means that even the proportion of LPG consumed by firms for economic production is subsidized. In other words, the increasing rate of LPG use in Cameroon is largely driven by efficiency and economic benefits over conventional fuels other than environmental impetus

2 SONARA is the only refinery in Cameroon with an annual processing capacity of 2.1 million metric tons. It is located in the South West region in Limbe.

3 Kilotons of oil equivalent

4 Other capacities include: 35, 12.5 and 6kg. The total number of cylinders (with all capacity combined) is estimated at 2.03 million in 2014. The 12.5 kg cylinders are the most abundant and represent 90% of the shares.

to reduce carbon emissions and deforestation. This is in opposition to the goals of the policy. Also, at the exit of the seaport of Douala, the charges related to the import of LPG already represent half of the final retail price. The retail margin represents 7% of the final price and the marketers' expenses 36%. So, if it were possible to reduce some of the costs, it would further reduce the price per kilogram of LPG to improve access to less affluent households.

Energy pricing in Cameroon is not based on a will to: promote optimal allocation of resources amongst the different forms of energy; promote the management of coherency between the level of investments, production and consumption; allow customers decide on their energy needs, their availabilities and their prices; promote environmental friendly energies, use the energy sector as an impulse for economic growth; encourage efficient and rational use of energy. Yet, there exist many structures in charge of energy management, each with a specific task. The Ministry of Energy is put out of the decision circuits albeit its competence to coordinate these activities. This pattern characterized by a complete absence of coordination of pricing activities of various energies results in paradoxal situations whereby the price at the pump for consumers is less than the cost of production especially during shortages (Nkutchet, 2004).

3. DATA AND METHODOLOGY

3.1. Variables and Data

As underlined by Caporale and Pittis (1995a, 1995b) and Salmanzadeh-Meydani and Ghomi (2019), bivariate models are compromised by omission bias. In order to remedy this and improve causality, we include real income, price of energy (all in constant 2005 USD), level of urbanization in millions, and energy consumption in ktoe in the growth model, as in the description below:

$$Q_t^E = f\left(P_t, INC_t, URB_t\right) \tag{1}$$

where Q_t^E represents growth in energy consumption per capita, INC_t represents growth in income per capita, P_t is a vector of own price growth and price growth of substitute, while URB_t is growth in urbanization (a proxy for demographic shift). Rahman and Kashem (2017) posited that the variables should be used in their growth forms rather than using them in their simple ratio form. This is because the growth form reveals the direction of movements of the variable in the current period t with respect to t–1. When this is done, the dynamic relationships between the variables are known and are used to forecast the subsequent movement of the variable. Data on kerosene and LPG consumption, and their prices were collected from HPSF (2016). GDP per capita was obtained from the World Development Indicators (WDI, 2016), while urbanization rate was obtained from the Cameroon National Institute of Statistics (NIS, 2015). It should also be noted that, Cameroon did not get used to collecting data soon after its independence in 1960. Consequently, quarterly or other high frequency data could not be used because they were unavailable for urbanization and GDP per capita. All data used here spans from 1994 to 2014.

The econometric model from Eq. (1) is as follows:

$$Q_t^{LPG} = \alpha_0 + \alpha_1 P_t^{LPG} + \alpha_2 P_t^{KER} + \alpha_3 INC_t + \alpha_4 URB_t + \varepsilon_{1t} \tag{2a}$$

$$Q_t^{KER} = \beta_0 + \beta_1 P_t^{KER} + \beta_2 P_t^{LPG} + \beta_3 INC_t + \beta_4 URB_t + \varepsilon'_{1t} \tag{2b}$$

where α_0 and β_0 are the intercepts, $\alpha_i,\beta_i;i$=1,2,3,4 are the coefficients of the dependent variables while ε_{1t} and ε'_{1t} are the error terms.

3.2. Unit Root Testing

If any of the series is integrated of order 2, I(2), then the critical bounds proposed by Pesaran et al. (2001) are not applicable. The ARDL methodology is only applicable when the series are I(0) or I(1) or both. Hence, before moving to the estimation stage, it is essential to test for unit roots to make sure all conditions underlying the ARDL bounds approach of cointegration methodology are satisfied. In this study, the ADF and PP test procedures are used to test for the presence of unit roots. Using different test methods to compare results is a good way of testing the sensitivity of results. The PP test adds more credibility to the results, by ignoring any serial correlation in the series. It ensures a higher autocorrelation consistency and heteroskedasticity correction of the time series data. Therefore the application of both PP and ADF tests ensures a robust model for checking the order of integration of the data used in this paper.

3.3. ARDL Bounds Cointegration Test

In this study, we use the ARDL bounds test cointegration technique to examine whether the series are cointegrated or not, besides deriving both the long-run and short-run dynamics. This approach has many advantages than alternative cointegration methods: (i) ARDL approach can be applied regardless of whether the variables are I(0), I(1) or both; (ii) unlike traditional methods that require large data for validity, the ARDL approach works independently of the data size; (iii) its single equation setup (for each energy source in this study) simplifies its implementation and interpretation; (iv) the lag orders of the series are not necessarily the same; (v) ARDL yields the best linear unbiased estimation of long-run relationship and long-run parameters; (vi) it removes the endogeneity and autocorrelation problems associated with the series; and (vii) the short- and long-run relationships are evaluated simultaneously.

The bounds test approach consists in assessing the following unrestricted error correction mechanism (UECM) through ordinary least squares:

$$\Delta Q_t^E = \alpha + \sum_{i=1}^{p} \theta_{1i} \Delta Q_{t-i}^E + \sum_{i=0}^{q} \theta_{2i}" X_{t-i} + \phi_1 Q_{t-1}^E + \phi_2 X_{t-1} + \varepsilon_{2t} \tag{3}$$

Where α is the drift component; ε_{2t} is the random disturbance term. A crucial assumption in Eq. (3) is that ε_{2t} is independently and normally distributed with zero mean and constant variance. Δ denotes the first difference operator; θ_{mi} for m=1,2,…,5 represent the short-run dynamics in the model whilst the long-run relationships are given by ϕ_i. Q_t^E and X_t respectively denote a vector of energy types and their corresponding demand shifters.

When using ARDL models, most studies in the literature do not explore the parameters relative to both magnitude and sign of the relationship between energy consumption and other appropriate regressors. In this study, we analyze the long-run elasticities including causal relationships. Bardsen (1989) showed that the quantities $-(\phi_j/\phi_1)$; with $j\neq 1$ can directly be portrayed as long-run elasticities.

The ARDL method evaluates $(p+1)^k$ number of regressions to get the appropriate lag orders for each variable; p is the maximum lag order and k is the number of regressors in each equation. A convenient lag selection is based on minimum value of Akaike Information Criteria (AIC), because AIC tends to define more parsimonious specifications (Pesaran and Shin, 1999).

The null hypothesis H_0 and alternative hypothesis H_A are defined as follows:

H_0: There is no cointegration ($\phi_i=0$; $\forall i=1,2,\ldots,5$)
H_A: H_0 is not true

This is done using the F-test on the level form of the variables. The computed F-statistic is then compared with the Pesaran et al. (2001) asymptotic critical value bounds. We fail to accept H_0 in favor of H_A if the F-statistic is above the upper critical bound and conversely. If the F-statistic falls between the bounds, then the test is indecisive. If cointegration is established, the next step is to estimate the following short-run models using the regular ECM:

$$\Delta Q_t^E = \alpha + \sum_{i=1}^{p}\theta_{1i}\Delta Q_{t-i}^E + \sum_{i=0}^{q}\theta_{2i}\Delta X_{t-i} + \psi_1 ECT_{t-1} + \varepsilon_{3t} \quad (4)$$

ECT_{t-1} is the error correction term. It works to restore equilibrium at the speed ψ_i after shocks in the short-run (which may affect individual series). Its coefficient should be statistically significant and its sign should be negative.

3.4. Diagnostic and Stability Tests of the Models

The assumption (of independence and normal distribution with zero mean and constant variance) made on the random disturbance terms in Eq. (3) compels to verify whether it holds or not. Serial independence is tested with the Breusch-Godfrey Serial Correlation LM test. Normality is tested with the Jarque-Bera test. Finally, the Breusch-Pagan-Godfrey test is used to verify the zero conditional mean and constant variance.

When using cointegration techniques, it is important to check the correctness of the model because any misspecification will lead to instability (Tamba et al., 2017b). This study uses the cumulative sum (CUSUM) of recursive residuals and CUSUM of squares (CUSUMSQ) as suggested by Pesaran and Pesaran (1997) to check any parameter instability, misspecification, and also to allow for omitted variables bias.

3.5. Toda-Yomamoto Granger Causality Test

Traditional causality tests such as the Vector Error Correction Model Granger causality or the Engle and Granger causality tests have been criticized on their restrictive nature and finite sample properties. Toda and Yamamoto (1995) and Zapata and Rambaldi (1997) concluded that these approaches are sensitive to the values of nuisance parameters in small samples making the results unreliable to some extent. Also, they are in one-way or the other subjected to the risk of incorrectly identifying the order of integration of the series (Mavrotas and Kelly, 2001). The TY procedure reduces the risks by augmenting a Vector Autoregression (VAR) model in levels with the highest order of integration of the series, and thus making sure the Wald statistics posses the necessary power properties. In this way, it's not imperative to establish the order of integration of the series before conducting the causality test. This is because the long-run causality test adjusts the correct lag order of the VAR by the highest order of integration d_{max}, ensuring that Granger causality test statistics have the standard asymptotic distribution (Wolde-Rufael, 2010). In order to improve the Wald statistic, the augmented VAR model is estimated using a Modified Wald (MWALD) test for the causality test (Zapata and Rambaldi, 1997). Then, the significance of the first lag(s) is used to test for causality. With this procedure the following VAR model was estimated using the MWALD, to establish the causal relationships between oil products consumption, their prices, income and urbanization. For parsimony, only two out of the six models are expressed:

Model 1: LPG consumption and income

$$Q_t^{LPG} = \alpha_0 + \sum_{i=1}^{k}\beta_{1i}Q_{t-i}^{LPG} + \sum_{j=k+1}^{d_{max}}\beta_{2j}Q_{t-j}^{LPG} + \sum_{i=1}^{k}\lambda_{1i}P_{t-i}^{LPG} + \sum_{j=k+1}^{d_{max}}\lambda_{2j}P_{t-j}^{LPG} + \sum_{i=1}^{k}\phi_{1i}INC_{t-i} + \sum_{j=k+1}^{d_{max}}\phi_{1j}INC_{t-j} + \sum_{i=1}^{k}\psi_{1i}URB_{t-i} + \sum_{j=k+1}^{d_{max}}\psi_{1j}URB_{t-j} + \varepsilon_{1t} \quad (5)$$

Model 2: Income and LPG consumption

$$INC_t = \alpha_1 + \sum_{i=1}^{k}\beta_{1i}Q_{t-i}^{LPG} + \sum_{j=k+1}^{d_{max}}\beta_{2j}Q_{t-j}^{LPG} + \sum_{i=1}^{k}\lambda_{1i}P_{t-i}^{LPG} + \sum_{j=k+1}^{d_{max}}\lambda_{2j}P_{t-j}^{LPG} + + \sum_{i=1}^{k}\phi_{1i}INC_{t-i} + \sum_{j=k+1}^{d_{max}}\phi_{1j}INC_{t-j} + \sum_{i=1}^{k}\psi_{1i}URB_{t-i} + \sum_{j=k+1}^{d_{max}}\psi_{1j}URB_{t-j} + \varepsilon_{2t} \quad (6)$$

LPG consumption Granger causes income if $\phi_{1i}\neq 0,\forall i=1,2,\ldots,k$ in Eq. (5). In a similar way, income Granger causes LPG consumption if $\beta_{1i}\neq 0,\forall i=1,2,\ldots,k$ in Eq. (6). There is bidirectional Granger causality between LPG consumption and income if and $\beta_{1i}\neq 0,\forall i=1,2,\ldots,k$ in both Eqs. (5) and (6), respectively. Finally, there is no Granger causality between LPG consumption and income if $\phi_{1i}=\beta_{1i}=0,\forall i=1,2,\ldots,k$ in both Eqs. (5) and (6).

4. RESULTS AND DISCUSSION

4.1. Unit Root Test

ADF and PP test for unit roots are exhibited in Table 1. Under ADF test, we fail to reject the null hypothesis of presence of a unit root at the 5% level for all series. This means that the series are non-stationary at level. However, we fail to accept the null

Table 1: Results of unit root test

Variable	ADF test statistics		PP test statistics	
	At levels		At levels	
	Intercept (%)	Intercept+trend (%)	Intercept (%)	Intercept+trend (%)
Q_t^{LPG}	2.137 (99.98)	–0.449 (97.43)	8.508 (100)	0.037 (99.37)
Q_t^{KER}	–1.199 (25.34)	–1.426 (42.04)	–1.508 (24.97)	–2.526** (4.04)
P_t^{LPG}	–2.645 (10.09)	–2.560 (29.95)	–2.499 (13.05)	–2.397 (36.94)
P_t^{KER}	–1.183 (65.88)	–2.460 (34.10)	–0.731 (81.68)	–1.735 (69.70)
INC_t	0.750 (49.02)	–2.190 (36.91)	0.748 (47.30)	–3.182** (3.30)
URB_t	0.174 (66.35)	–2.239 (44.47)	0.174 (44.76)	–4.233** (4.76)
First differences			First differences	
Q_t^{LPG}	–4.048*** (0.64)	–5.284*** (0.24)	–4.048*** (0.64)	–5.923*** (0.07)
Q_t^{KER}	–3.344** (2.70)	–3.373* (8.49)	–3.315** (2.07)	–5.292*** (0.06)
P_t^{LPG}	–4.705*** (0.18)	–4.593*** (0.96)	–6.810*** (0.00)	–7.021*** (0.01)
P_t^{KER}	–2.059** (4.07)	–2.501** (4.309)	–2.561** (4.012)	–2.059** (4.07)
INC_t	–4.051*** (0.63)	–4.240** (1.75)	–4.052*** (0.63)	–4.241** (1.74)
URB_t	–4.909*** (0.11)	–4.755*** (0.65)	–4.909*** (0.11)	–5.755*** (0.05)

*, ** And *** denote statistical significance at the 10%, 5% and 1% levels respectively

hypothesis at the 1% (and consequently at 5%) level when ADF test is carried out on the first differences of series. We conclude that the series are I(1) in nature. Under PP test however, the order of integration of INC_t, URB_t and Q_t^{KER} is not certain. The test reveals that they are non-stationary at level. They are however level stationary when intercepts and trends are incorporated in the test equations. So INC_t, URB_t and Q_t^{KER} can either be I(0) or I(1). The remaining series are I(1). The uncertainty on the order of integration of INC_t, URB_t and Q_t^{KER}, jointly with evidence that none of the series is I(2), license to look into the long-run relationship amongst the series as prescribed by Pesaran and Shin (1999) and Pesaran et al. (2001).

4.2. ARDL Model Estimation and Diagnostic Tests

From AIC, the best lag order is 2 for $Q_t^{LPG}, Q_t^{KER}, P_t^{KER}$ and 1 for P_t^{LPG}, INC_t and URB_t. The selected models are therefore ARDL (2, 1, 2, 1, 1) for LPG consumption model and ARDL (2, 2, 1, 1, 1) for kerosene consumption model.

R^2 is 0.993 and 0.939 for ARDL (2, 1, 2, 1, 1) and ARDL (2, 2, 1, 1, 1) respectively, indicating the existence of a strong relationship between consumption and the regressors. Therefore, a very large fraction of consumption is explained by the independent variables. The Durbin-Watson (DW) statistic is 2.356 (resp. 2.398), and it confirms that the models are not spurious. Also, the F-statistic shows that all variables are jointly significant at the 1% level in both models. The conclusion is that none of the regressors have zero coefficients. The Breusch-Godfrey serial correlation shows that there is no serial correlation in the residuals, while the Breusch-Pagan-Godfrey test indicates that we fail to reject the null hypothesis of homoskedasticity, which shows that the residuals have a constant variance. Finally, the p-value of the Jarque-Bera confirms that the residuals are normally distributed (Table 2).

4.3. ARDL Bounds Test

The critical bounds are exhibited in Table 3. The computed F-statistics are clearly beyond the upper bounds at the 1% level. Thus, we fail to accept the null hypothesis of no cointegration. Consequently, we can treat income, price of LPG and kerosene, and urbanization as the 'long-run forcing' variables explaining household oil products consumption.

4.4. Long-run and Short-run Relationships

4.4.1. Long-run relationship

Given that the models have kerosene and LPG consumption as the dependent variables, we proceed to estimate the long-run oil products consumption for Cameroon households. The estimated long-run estimates of kerosene and LPG consumption are exhibited in Table 4 alongside with the corresponding elasticities estimates.

4.4.1.1. LPG consumption

Table 4a shows that the coefficients of the ARDL (2, 1, 2, 1, 1) model are significant for all the regressors. The signs and statistical significance of kerosene price, income and urbanization indicates that they have significant positive impacts on LPG consumption in the long-run. The results confirm the existence of negative inelastic and significant price effect on LPG consumption, evidencing that LPG is a normal good. In accordance with demand theory, this suggests that continuous increases in LPG prices imposes a limiting factor on demand for the product in the long-run as a unit increase in price will decrease demand by 0.54%. However, the inelasticity suggests a very low demand response to price changes. This is particularly true given the fact that oil products prices in Cameroon are largely subsidized especially LPG, with the key objective of encouraging households to switch from traditional energy sources such as charcoal, firewood, animal dung, wood residues, etc to modern energy such as LPG in order to create sustainable development and growth.

Cross price elasticity with respect to kerosene is positive (0.073) and is also significant. The implication is that households respond to LPG price hikes by substituting with kerosene. This is particularly so as most LPG consumers possess kerosene stoves that can be used in case of need during price hikes and also during irregular shortages of LPG supply. The National Institute of Statistics (NIS, 2015) reveals that it is the case for over 95% of LPG consumers.

a. ARDL (2, 1, 2, 1, 1) for LPG model

The income elasticity of LPG demand is positive, inelastic and significant at 1%. Thus a 1% increase in income will lead to a 0.59% rise in demand for LPG consumption in the long run. The implication is that an increase in income level with its related rising living standards influences household preference for modern and more efficient energy sources such as LPG for domestic cooking relative to less efficient sources like charcoal, firewood, animal dung, wood residues, etc. This result is in accordance with expectations of the energy ladder hypothesis-that when income increases, households move up the energy ladder, thereby switching from traditional energy towards modern energy such as kerosene, LPG and electricity Arthur et al. (2012). This inelastic income effect compares favorably with the results of Akpalu et al. (2011) and Mensah et al. (2016) in Ghana and those of Arthur et al. (2012) in Mozambique. These SSA countries share similarities with Cameroon in their demographics and economic background.

Table 2: Diagnostic tests

Test	ARDL (2, 1, 2, 1, 1)		ARDL (2, 2, 1, 1, 1)	
	Coefficient	P-value (%)	Coefficient	P-value (%)
R^2	0.993		0.939	
Adjusted R^2	0.983		0.843	
DW-statistic	2.356		2.398	
F-statistic	92.955	0.00	90.805	0.30
Serial correlation	3.664	46.66	1.096	66.71
Heteroskedasticity	2.366	33.17	0.708	77.57
Normality	1.567	72.01	1.122	57.07

Finally, in opposition to the income and price elasticities estimates, the elasticity of urbanization is highly elastic and significant as well. Like in most developing countries, as acknowledged by Mensah et al. (2016) "*the rising urban sprawl in developing economies is a significant driver of LPG demand*". Results from the ARDL (2, 2, 1, 1, 1) model corroborate this statement. The model reveals that urbanization is the principal driving force behind the abrupt increase in LPG consumption in Cameroon over the last decades. An urbanization elasticity estimate of 18.1 means that a 1% rise in the level of urbanization will impel LPG demand by 18.1%. This result is intuitive, given the fact that the majority of LPG distribution centers in Cameroon are located in urban zones and accounts for more than 90% of LPG users in Cameroon in 2014 (NIS, 2015). Moreover, the standard of living in the urban centers with its accompanying housing systems makes LPG the preferred household energy choice relative to other alternatives such as charcoal, firewood, etc.

4.4.1.2. Kerosene consumption

The long-run relationship amongst the variables is estimated using the ARDL (2, 2, 1, 1, 1) model for kerosene consumption. The computed results are exhibited in Table 4b. The results reveal that the coefficients are significant for all variables. Also, price of LPG, income and urbanization have positive impacts on kerosene consumption which is confirmed by the sign and statistical significance of their coefficients.

b. ARDL (2, 2, 1, 1, 1) for kerosene model

From our results, own price elasticity for kerosene is –0.470 and is also significantly negative. This implies that kerosene demand will fall by 0.47% for every unit rise in kerosene price in the long-run. Thus, kerosene is an ordinary good. These results match well with those of Arthur et al. (2012), Iwayemi et al. (2012) and Mensah et al. (2016). Due to the degree of kerosene-LPG substitutability, we also estimate the cross price elasticity for LPG.

Across the whole country, most kerosene consuming users are low-income households. Therefore, when kerosene is the main

Table 3: ARDL bound test

Model	F-statistic	Critical values[a]			
		1%		5%	
		Lower bound I(0)	Upper bound I(1)	Lower bound I(0)	Upper bound I(1)
$F\left(Q^{LPG} \vert P^{LPG}, P^{KER}, INC, URB\right)$	7.27[b]	4.72	6.29	3.53	4.80
$F\left(Q^{KER} \vert P^{KER}, P^{LPG}, INC, URB\right)$	6.83[b]				
$F\left(P^{LPG} \vert Q^{LPG}, P^{KER}, INC, URB\right)$	7.43[b]				
$F\left(P^{KER} \vert P^{LPG}, Q^{KER}, INC, URB\right)$	4.91[c]				
$F\left(INC \vert Q^{LPG}, P^{KER}, P^{LPG}, URB\right)$	4.89[c]				
$F\left(INC \vert Q^{KER}, P^{LPG}, P^{KER}, URB\right)$	6.55[b]				
$F\left(URB \vert Q^{LPG}, P^{KER}, P^{LPG}, INC\right)$	5.21[c]				
$F\left(URB \vert Q^{KER}, P^{LPG}, P^{KER}, INC\right)$	5.64[c]				

[a]The critical values are taken from Narayan (2005, p. 1900). [b]and [c]Rejection of null hypothesis of no cointegration at the 1% and 5% levels respectively

Table 4a: Long-run estimates using ARDL approach

Dependent variable is Q_{t-1}^{LPG}				Elasticities	
21 observations used for estimation from 1994 to 2014					
Regressor constant	Coefficient	t-Statistic	P-value (%)		
	1.058***	3.413	0.21	Own price	–0.542***
Q_{t-1}^{LPG}	–4.006**	–2.899	1.34	Cross price	0.073**
Q_{t-2}^{LPG}	–1.157***	–5.622	0.01	Income	0.591***
P_{t}^{LPG}	–0.749***	–4.311	0.03	Urbanization	18.102***
P_{t-1}^{LPG}	–2.171***	–2.998	0.43		
P_{t}^{KER}	1.317***	2.976	0.81		
P_{t-1}^{KER}	0.292**	2.425	2.75		
P_{t-2}^{KER}	2.003**	2.516	2.61		
INC_{t}	0.701***	3.577	0.14		
INC_{t-1}	2.367***	5.434	0.09		
URB_{t}	0.473***	3.492	0.12		
URB_{t-1}	72.517***	2.523	2.38		

** And *** denote statistical significance at the 5% and 1% levels respectively

Table 4b: Long-run estimates using ARDL approach

Dependent variable is Q_{t}^{KER}				Elasticities	
21 observations used for estimation from 1994 to 2014					
Regressor constant	Coefficient	t-Statistic	P-value (%)		
	7.924*	1.999	9.37	Own price	–0.470***
Q_{t-1}^{KER}	–0.394***	–2.932	0.39	Cross price	0.008***
Q_{t-2}^{KER}	–0.122	–1.044	12.17	Income	2.718***
P_{t}^{KER}	–0.579	–1.044	15.12	Urbanization	2.954*
P_{t-1}^{KER}	–0.185	–2.902	0.31		
P_{t-2}^{KER}	–0.007	–0.079	28.04		
P_{t}^{LPG}	4.324	2.995	0.70		
P_{t}^{LPG}	0.003***	2.333	2.19		
INC_{t}	0.156	1.241	15.71		
INC_{t-1}	1.071***	2.951	0.12		
URB_{t}	–0.169	–1.484	12.50		
URB_{t-1}	1.164*	–7.382	0.01		

*, ** And *** denote statistical significance at the 10%, 5% and 1% levels respectively

cooking fuel in a household, it is difficult for this household to switch for LPG even when the price of the later decreases. The explanation is that LPG is already more expensive than kerosene but taking into account the equipment related to its use such as regulator, valve, stove, pipe, and the gas cylinder itself, it becomes obvious that LPG is nearly a luxury good for such households. On the other hand, the use of kerosene only requires the oil stove and the wick which are both very cheap. Our results confirm that LPG is a weak substitute for kerosene as the model yields a significant but a small cross-price elasticity estimate of 0.008. The sign and magnitude imply that kerosene consumption rises very slowly with increments in LPG price and conversely. These results favor the findings of Authur et al. (2012) and Iwayemi et al. (2012).

Also, the effect of income on kerosene consumption is positive (2.718). The elasticity estimate is elastic and significant at 1% level. It shows that if the level of income rises by one unit, then kerosene consumption will increase by 2.72%. These results are analogous to those of Iwayemi et al. (2012) and Arthur et al. (2012). We find urbanization elasticity is positive, statistically significant at 10% level and is elastic (2.954). This means that a unit rise in urban growth will result in 2.95% increase in kerosene consumption. The fact that this estimate is far lower than that of LPG reinforces the opinion that kerosene is not the first choice of cooking fuel in cities. Therefore, consumers who already had access to LPG before migrating to urban zones are most likely to keep consuming LPG once they come to live in urban zones.

4.4.2. Short-run dynamics

The results of Eq. (4) are exhibited in Table 5.

a. LPG consumption

4.4.2.1. LPG consumption

We conclude from Table 5a that there are short-run relationships in accordance with the long-run dynamics as shown by the value, sign and statistical significance of ECT_{t-1}. As expected, the coefficient of ECT_{t-1} is negative and is significant at 1% level. This proves the existence of a long-run connection between LPG consumption and its regressors. We find the coefficient to be –0.946, suggesting that LPG consumption restores toward its long-run equilibrium with almost 95% of the total adjustment occurring within the 1st year. This is a strong and fast adjustment to equilibrium (it takes about 13 months for convergence to equilibrium once the system is shocked).

From the outcomes, lagged periods of ΔP^{KER}, ΔINC and ΔURB have positive and significant effects on LPG consumption in the short-run, while lagged values of ΔP^{LPG}, ΔQ^{LPG} and current values of ΔP^{KER} have significant negative impacts on LPG consumption. Hence, we conclude that the overall impact of all regressors have analogous short- and long-run impact on LPG demand growth.

b. Kerosene consumption

4.4.2.2. Kerosene consumption

We conclude from Table 5b that there are short-run relationships in accordance with the long-run dynamics as shown by the value, sign and statistical significance of ECT_{t-1}. Its coefficient is negative (between –1 and 0) and is statistically significant. This shows that the deviation of variables from the short to the long-run equilibrium is balanced by 62.2% annually.

We obtain comparative results with the ARDL (2, 1, 2, 1, 1) LPG model. In the short-run, lagged periods of ΔP^{LPG}, ΔINC and ΔURB are positively connected to kerosene consumption. Lagged values of ΔP^{KER}, ΔQ^{KER} and current values of ΔP^{LPG} have significant negative influence on kerosene consumption. Hence, we conclude that the overall impact of all regressors on kerosene demand growth is time invariant.

Table 5a: Short-run estimates from ECM

Dependent variable is ΔQ_t^{LPG}			
21 observations used for estimation from 1994 to 2014			
Regressor constant	Coefficient	t-Statistic	P-value (%)
	4.002***	3.024	0.89
ΔQ_t^{LPG}	2.994	1.028	17.12
ΔQ_{t-2}^{LPG}	1.255*	2.076	5.48
ΔP_t^{LPG}	–0.041***	–3.854	0.13
ΔP_{t-1}^{LPG}	–0.016***	–3.636	0.48
ΔP_t^{KER}	–0.363***	–2.941	0.64
ΔP_{t-1}^{KER}	–0.621**	–2.648	1.55
ΔP_{t-2}^{KER}	–0.826*	–1.888	6.41
ΔINC_t	6.086	1.029	37.68
ΔINC_{t-1}	2.266	1.074	33.95
ΔURB_t	1.912*	2.064	7.09
ΔURB_{t-1}	2.178*	2.074	6.14
ECT_{t-1}	–0.956***	9.245	0.00

*, ** And *** denote statistical significance at the 10%, 5% and 1% levels respectively

Table 5b: Short-run estimates from ECM

Dependent variable is ΔP_t^{KER}			
21 observations used for estimation from 1994 to 2014			
Regressor constant	Coefficient	t-Statistic	P-value (%)
	0.050*	2.156	9.73
ΔQ_{t-1}^{KER}	3.672**	3.918	1.74
ΔQ_{t-2}^{KER}	0.589	1.697	16.49
ΔP_t^{KER}	–1.171	–1.756	15.42
ΔP_{t-1}^{KER}	–1.162***	–3.284	0.17
ΔP_{t-2}^{KER}	2.347*	2.289	8.39
ΔP_{t-1}^{LPG}	–0.059*	–2.557	6.28
ΔP_{t-1}^{LPG}	–0.071**	–2.801	4.88
ΔINC_t	–0.124**	–2.530	3.79
ΔINC_{t-1}	0.314	1.011	36.89
ΔURB_t	–0.331***	–16.555	0.00
ΔURB_{t-1}	–1.701***	–3.477	0.16
ECT_{t-1}	–0.622***	–3.916	0.03

*, ** And *** denote statistical significance at the 10%, 5% and 1% levels respectively

4.5. Stability of the Model

To confirm the correctness of the models specification, we test the regular ECM model with plots of CUSUM and CUSUMSQ in order to check any misspecification of the functional form that might lead to instability and to allow for omitted explanatory variables that might be pertinent in the model (Pesaran and Pesaran, 1997). Figure 2 shows that the CUSUM and CUSUMSQ values do not cross the 5% critical bounds. The recursive residuals lie between the limits suggesting that we fail to reject the null hypothesis of absence of a structural break. Hence, the model is stable over time (no structural break has occurred) and thus, implies that no relevant explanatory variable has been omitted from the model.

4.6. Granger Causality Test

Subsequent to setting up the existence of long-run connection amongst the variables using the ARDL approach, we are now interested in the direction of causality. Since we found that the series are cointegrated, we may envisage the existence of Granger-causality but cointegration does not indicate the direction of the causality relationship. We investigate the causal relationships within an augmented VAR following the TY procedure. Table 6 summarizes the short-run Granger Causality test among the variables.

A non-Granger causality test is performed with the standard MWALD test of Toda and Yamamoto (1995). As argued in section 3, the first step is to establish the maximum order of integration of all the series (d_{max}) as well as the optimal lag order for the augmented VAR. The series are either I(0) or I(1), hence the maximal order of integration is one (d_{max} = 1), and the optimal

Figure 2: Plots of cumulative sum of recursive residuals. (a) LPG consumption. (b) Kerosene consumption

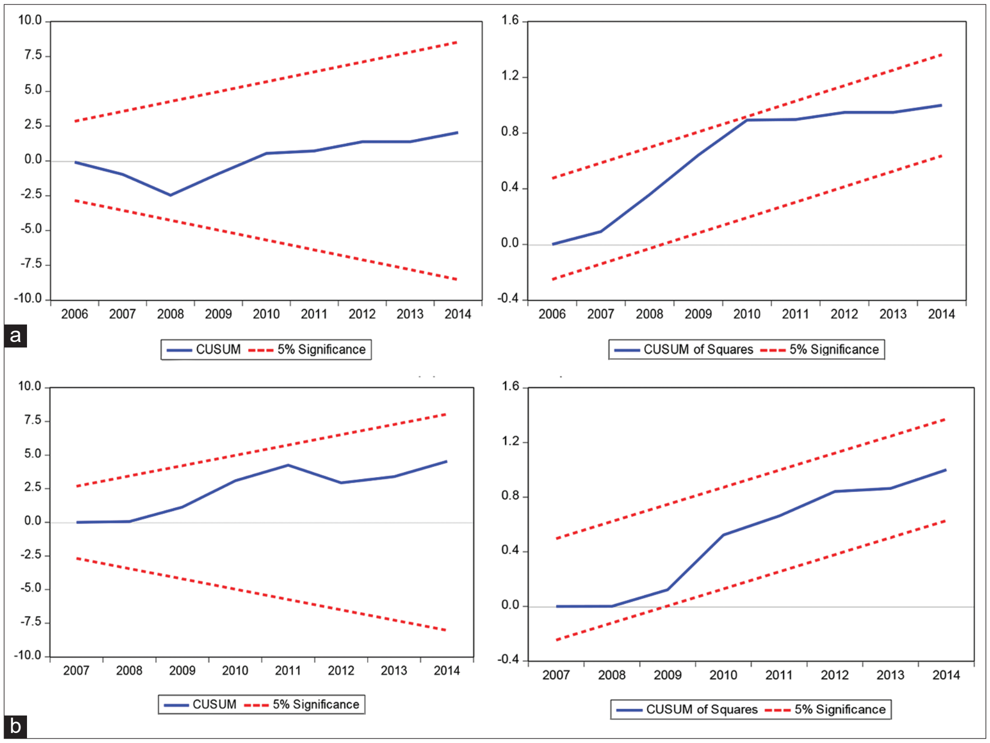


Table 6: Granger non-causality tests

Null hypothesis	MWALD statistics	P-value (%)	Decision
$Q^{LPG} \nrightarrow INC$	5.125	2.50	Reject**
$INC \nrightarrow Q^{LPG}$	5.831	1.40	Reject**
$URB \nrightarrow Q^{LPG}$	8.132	0.36	Reject***
Diagnostic tests			
Lagrange multiplier	2.80	9.00	
Heteroscedasticity	5.73	28.0	
Normality	5.24	59.0	
Null hypothesis	**MWALD statistics**	**P-value (%)**	**Decision**
$Q^{KER} \nrightarrow INC$	1.508	19.32	Accept***
$INC \nrightarrow Q^{KER}$	1.019	26.25	Accept***
$URB \nrightarrow Q^{KER}$	1.586	16.96	Accept***
Diagnostic tests			
Lagrange multiplier	3.01	8.21%	
Heteroscedasticity	5.86	22.27%	
Normality	4.75	66.18%	

$X \nrightarrow Y$ means X does not Granger cause Y. ** And *** denote statistical significance at the 10%, 5% and 1% levels respectively

lag order (k=1) for the augmented VAR ($k+d_{max}$) estimation is chosen based on AIC criteria. In order to test for non-Granger causality, a standard modified Wald test based on the standard asymptotic distribution is performed on the coefficients of the various series. As the P-value of 2.50% is less than the 5% significance level, we fail to accept the null hypothesis of no Granger causality from LPG consumption to economic growth at 5% test level. Still under the assumption of the model, we fail to accept the null hypothesis of no Granger causality from economic growth to LPG consumption at a 1% significance level. Therefore, there is bidirectional Granger causality from LPG consumption to economic growth. This result confirms the feedback hypothesis which suggests that there is a bidirectional causal interaction between energy consumption and economic growth. This interaction therefore, implies that there is a causal interdependence between energy consumption and economic growth. This result is similar to those of Tamba et al. (2012), Fondja (2013), Tamba (2017b) and Tamba et al. (2017c).

However, one can clearly observe the absence of causality between kerosene consumption and economic growth (Table 6). This result of no causality between kerosene consumption and economic growth is an empirical support for the hypothesis of neutrality which argues that there is no causality between energy consumption and economic growth. The neutrality hypothesis found in this study confirms the works of Akinlo (2008), Wolde-Rufael (2011) and Tamba et al. (2017a). These authors found that there is no Granger causality between energy consumption and income in Cameroon. Consequently, any drastic cut in kerosene consumption will not affect economic growth and vice versa. The implication is that kerosene consumption does not constitute a significant portion of GDP.

As for the relationships between urbanization and oil products consumption, we find unidirectional Granger causality from urbanization to LPG consumption while there is no causality between kerosene consumption and urbanization. A possible explanation is that massive rural exodus caused by execrable living conditions has engendered unplanned settling in the surrounding areas of the capital city of Yaoundé and the port city of Douala. Unfortunately, in most cases, the housing style in urban centers is not suitable for kerosene use. Thus, they are obliged to consume modern and cleaner energies such as electricity and LPG which are much more adapted to their new habitats.

5. CONCLUSION AND POLICY IMPLICATIONS

5.1. Summary of Conclusions

This paper analyzed the cointegration, short- and long-run dynamics and causality between oil products consumption, their prices, economic growth and urbanization in Cameroon households for the period 1994-2014. For this, we applied the ARDL Bounds approach to test for cointegaration, UECM for short- and long-run forcing variables that drives oil products consumption in the household sector alongside with their elasticities, and the TY procedure for Granger causality in a VAR framework. Instead of centralizing on one energy type as in the literature, we used two energy types: kerosene and LPG.

Our results show a mix of factors influencing LPG and kerosene consumption in Cameroon households. They include oil product prices, income and urbanization. Whereas income and urbanization exert positive influences on demand for LPG, the market price of the commodity is negatively associated with demand in the long-run. For kerosene consumption, the main factors to consider include price of kerosene and income. A striking feature is that urbanization has the highest impact on the dynamics of LPG demand. In other words, the persistent increase in LPG consumption in the country often resulting in supply shortfalls is largely due to increasing urban population. Another interesting finding is the high degree of inter-fuel substitution in oil products consumption in Cameroon households. This is evidenced by the significance of the cross-price elasticities in the models. The evidence from this study validates the claim that there is a high extent of substitutability from kerosene to LPG consumption. This is due to the increase use of LPG by industries largely as a consequence of the subsidies on LPG in Cameroon. In other words, the increasing rate of LPG use in Cameroon is largely driven by efficiency and economic benefits over conventional fuels other than environmental motivation to reduce carbon emissions and deforestation. This calls for a careful review of the current subsidy policy in Cameroon.

The ARDL bounds tests confirm cointegration between all the series. Empirical results show a combination of factors affecting household oil products demand including their prices, income and urbanization. Specifically, for LPG consumption, results reveal that real income, prices and urbanization significantly impact the consumption of these oil products in both the short and long-runs. The estimated models were properly specified and were validated by diagnostics and stability tests. The Granger causality test following the Toda-Yamamoto procedure in an augmented VAR framework exposed a variety of causalities. We found on one hand that there is bidirectional causality between LPG consumption and economic growth. We also found unidirectional causality running from urbanization to LPG consumption. On the other hand we found no causality between kerosene consumption and economic growth, and between urbanization and kerosene consumption. These results thus favor all four research objectives.

5.2. Policy Implications

The results confirm that rising income, prices and urbanization are significant drivers of LPG demand in Cameroonian households. Hence, it is crucial for policy makers to guarantee the provision of reliable, stable and efficient supply of LPG services to meet the rising demand. The following types of policy options, along the line of Nkutchet (2004), should be seriously considered:

5.2.1. Market based policy option

Instead of subsidizing LPG in its bulk form, it should be subsidized in its conditioned form to ensure that industries and carriers do not benefit from the subsidy. As a way forward, given the fact that LPG consumption in Cameroon households is still low at around 32%, supply constraints should be removed because they often lead to irregular shortages. This is crucial to incentivize household LPG consumption. However, measures must be implemented to ensure that carriers are excluded from enjoying the subsidy. An alternative means to avoid the *"unintended beneficiary"* dilemma will be to redirect the subsidy from LPG to its end-use equipments, such as cylinders, stoves, relief valve, tubes, etc. In Ghana for instance, these measures were successful in eliminating the high amount of unintended beneficiaries (Mensah et al., 2016).

Further, information of the existence of kerosene-LPG substitution attributable to price changes has implications for these oil products pricing in Cameroon. In order words, since households are responsive to both price of energy type and its substitute, oil products pricing can be used as a means to incite energy switching from environmentally unfriendly sources like kerosene to LPG which is cleaner and more efficient. Once more, our results suggest that price elasticity estimates are less than unity, meaning that the response of households to price changes is minimal. Nonetheless, given the existence of a high extent of substitutability and the overall benefit implications of higher energy prices, oil product price increases must be done gradually to avoid all likely spillover effects.

5.2.2. Supply infrastructure development based policy option

With regard to irregular shortages, an effective measure will be to liberalize the oil sector so that marketers (TOTAL, OILYBIA, TRADEX, BOCOM, MRS, etc.) play a more important role in Cameroon's LPG and kerosene market configuration. This would certainly give way to competition. It will also be important to increase the number of LPG and kerosene deposits, especially in the northern regions where there are no deposits. This will secure the country's strategic stocks, prevent any possible shortage, and continue to supply the domestic market. A long-run measure towards sustainable supply of kerosene and LPG is to reduce transportation cost by building pipelines infrastructures to carry oil products from production plants to end-users. Though this will require huge investments, it has proven to be the most cost effective means of fuel transport (Mathews, 2014).

5.2.3. Public policy option

There is need for the development and utilization of modern and efficient appliances such as "improved stoves" for solid fuel use, because overdependence on traditional fuels is deemed unsustainable. The utilization of such appliances will reduce biomass intensity and therefore decrease pressure on forests. Unlike traditional appliances, the use of improved stoves have lower emission rate, and thus the health benefits are manifold.

These appliances will contribute to a reduction of lung infections, asthma, eye infections, cancer, sinus problems, tuberculosis, and cardiovascular diseases associated with inhalation of particulates from the incineration of solid fuels. Morocco, Ghana, Mali, Senegal and Niger are successful in having benefits of using improved stoves (UNEP, 2016). Cameroon can follow these countries.

5.2.4. Restructuring policy option

Given the current situation of SONARA, it is imperative that significant investments be made in order to recruit as soon as possible a firm of expertise to establish a diagnosis and propose a new rehabilitation scheme. While waiting for the refinery to be operational, SONARA will have to engage in trading and participate in fuel imports. This should be easy to implement as last year, the State granted the refinery by mutual agreement all purchases of hydrocarbons following the technical shutdown of its refining units for 8 months, during works of extension and modernization of the refinery. The GoC will have to quickly activate the clearing mechanism for importers, in the event of higher costs than the selling price at the pump. In the past, this support generated huge backlogs.

5.2.5. Administrative reform policy

In order to encourage more investments in the oil sector, it is proper time for the GoC to rearrange the regulatory and institutional framework of this sector. This could be done by suppressing the numerous structures that exist in the oil sector and put in place a single organ in charge of harmonizing prices, providing energy for households and businesses at competitive prices; increasing energy access rates, research and investment in clean energies, implementing environmental protection laws aimed at saving the economy and preserving public health.

5.2.6. Research and development based policy option

The current structure of the economy of Cameroon, based on limited and exhaustible resources is unsustainable (SIE-Cameroon, 2015). Oil products are nonrenewable resources, and would become scarce in the long-run. Furthermore, they emit GHG, which in turn speed up climate change phenomenon for the whole globe. It is therefore proper time for the GoC, in the coming years, to start investigating a variety of alternative and cleaner energy options that are appropriate for the country in the long-run. The switch of energy resources would need high initial capital investments, manpower, huge human resources, and time. Energy planning in Cameroon with considerations of alternative energies is needed to ensure energy security and sustain the economic growth in the country for the coming years.

Finally, it should be noted that any particular policy option in isolation of others may not be so fruitful. Therefore, a coordinated approach with regards to the market based and non-market based policy options should be adopted for a sustainable energy system in Cameroon in order to support economic development.

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