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Preliminary version

Abstract

This article is designed to investigate the existence of relationship between daily per capita demand for nutrients (calorie, protein, and animal fat intake) and economic growth indicator measured by per capita *real* Gross Domestic Products (GDP). Using annual time series data covering 1961-2007 from Nigeria, the study employed vector error correction model (VECM). The daily per capita demands for nutrients are analyzed as endogenous variables while real per capita GDP was taken as exogenous variable. These series are defined in logarithm. Preliminary investigation revealed that the series were found to be I (1) process at initial level while the series become I (0) after first differences. The trace statistics test shows that the pear of the series on the daily per capita demand for nutrients and per capita real GDP are co-integrated. Hence, the results of VECM shows that in the long-run, per capita *real* GDP positively and significantly impact per capita demand for nutrients in Nigeria over the years. Specifically, we observed that 1% increase in *real* GDP significantly increases the demand for calorie, protein and animal fat by 0.073%, 0.068%, and 0.059%, respectively. Also, the result of the short-run dynamics indicated that the speed of adjustment of the demand for calorie, protein and animal fat intake towards long-run equilibrium relationship associated with the shocks in the *real* GDP from the previous period is about 29%, 41% and 26%, respectively in the current period. Furthermore, we noted that the result of the impulse response function lend support to the observation that *real* per capita GDP increases the demand for calorie, protein, and fat intake in Nigeria. Our findings provide no support for the hypothesis that growth in *real* GDP is constrained by the nutrient intake in the same period.

Key words: *Real* per capita GDP, calorie, protein, fat, long-run relationship, short-run dynamics, Nigeria

JEL Classification: C32, O11, P44,

Introduction

Food policy analysts consider the level of nutrient intakes in particular calorie (energy) as an important indicator of performance measure when it is related to labour productivity. In the developing economies where agriculture accounts for most of the economic activities, this observation is taking in high esteem. Stightz, (1976) pointed out the significant role of calorie as one of the key drivers of productivity and health related issues in the economic development of any given society.

According to Neeliah and Shakar (2008), nutrition is the fundamental prerequisite for human welfare and contributes to human and social capita. However, lack of key nutrient intake such as calories, protein, iron, calcium, and vitamin is a common phenomenon in most developing countries. Inadequate nutrient can be used to describe dietary shortage or nutrient deficiency in general. Berg (1981), revealed that there is distinction between nutrition and malnutrition. The former relates to inadequate nutrient intake while the later refers to an inadequate intake of specific nutrient.

The main economic determinants of food demand as stressed in the literature are price and income (Angulo *et al,* 2001). But there growing resentment among the nutrition economist that in addition to income and price, nutritional content also informed the demand for food. However, if food choices are informed by their nutritional values, it is also meaningful to examine, the demand for nutrients and its key determinants as impetus for effective nutritional policy and consumer welfare in general.

The relationship between nutrition and consumer's income has attracted interest among the researchers for the past four decades. The cause and effect between nutrition and income runs either ways. Because as income enhances nutrition security, healthy active and nourished citizens are important precondition for sustained income growth (Benson, 2004). In fact, there are two lines of inquiries with regards to the relationship between calorie (nutrient) intake and household income level in the literature as revealed by Bouis (1994). *First*, does calorie intake rise with income? *Second*, is income generation affected by calorie intake? The former underscores policy relevance of increasing income on the nutritional status of a given population while the later is at the center of the efficiency wage hypothesis of Stiglitz (1976) where the author hypothesized efficiency of workers as a function of their wages through nutrition their income allows them to purchase.

The econometric analysis of the demand for nutrient vis-à-vis calories has previously been linked to macroeconomic indicator implied by *real* per capita GDP (*e.g.,* Bouis 1994; Dawson and Tiffin 2002; Mushtaq *et al.,* 2007; Neeliah and Shakar 2008; Tiwari and Zaman 2010) and microeconomic indicator such as the per capita household income (e.g., Abdulai and Aubert 2004; Bocoum and Dury 2009; Orewa and Iyangbe 2009) around the globe. For example, recent studies using household survey data from Nigeria (Aromolaran 2004; Babatunde and Qaim 2010; Ayinde *et al.* 2010; Babatunde *et al* 2010) provided empirical nexus between calorie intake and household's per capita income with the evidence that per capita income significantly increase calorie intake in the country. However, the crucial question is that at the national level using macroeconomic variable, do daily per capita demand for nutrients respond positively and significantly to economic growth indicator such as per capita *real* GDP in the long-run in Nigeria?

Providing answer to this question is important because the estimated nutrient-income elasticities could be explored as critical parameters needed to determine impacts of any policy change either in the short or long term period on the consumer welfare in the country. In fact, as pointed out by World Bank (1986), a good knowledge of how income growth impact the demand for calorie intake can be used as a guide to alleviate and eventually eliminate inadequate calorie intake around the globe.

The present study builds on the earlier work by Dawson and Tiffin (1998), Dawson (2002), Tiffin and Dawson (2002), Neeliah and Shakar (2008), and Tiwari and Zaman (2010) where the authors investigated the long-run relationship between demand for calorie intake and *real* per capita national income represented by *real* GDP in India, Pakistan, Zimbabwe and developing countries, respectively using aggregated annual time series data from respective countries. Therefore, contrary to these studies, the study seeks not only to understand how *real* per capita national income response to calorie intake but also to examine how *real* per GDP respond to other nutrient intake vis-à-vis daily per capita protein and fat intake by using annual time series data covering 1961-2007 from Nigeria. Specifically, we intended to analyze an aggregated Engel curves which is defined to investigate the long-run and short run dynamics relationship between daily per capita nutrient and *real* per capita national income (GDP) in Nigeria over time.

To the best of our knowledge, there is dearth of study relating economic growth indicator implied by real GDP and the demand for nutrients in Nigeria. This observation, however, motivated this study. Hence, we envisage that the study will contribute to the existing literature on the food demand analysis in the country. Specifically, it is envisaged that the outcome of the study will be useful as an important planning tools for food policy design in Nigeria.

The rest of the article is structured as follows. Section 2 discusses theoretical framework. Section 3 describes the methodology vis-à-vis the data, estimation method and model specification, and empirical model. Section 4 focuses on the results and discussion. The final section offers the conclusions and policy implications.

2 The theoretical model

The theoretical framework for the present study is defined to enable us understand how per capita nutrient intake respond to its key determinants in Nigeria. Hence, the demand for nutrients NT_t is assumed to depend on quantity of food consumed (FC_t) and level of per capita income in a given period "t" as specified below.

$$NT_t = f\left(FC_t, Y_t\right) \qquad 1$$

where f represents connecting function. In the present framework, we assumed that at equilibrium, quantity of food consumed (FC_t) equate the quantity of food produced (FP_t)[1] *ceteris paribus*. Conversely, FP_t is assumed to depend on a number of factors which includes; national population (N_t), food price (P_{wt}), and taste (T_t) as:

$$FP_t = f\left(N_t, P_{wt}, T_t\right) \qquad 2$$

Substituting equation 2 into 1 gives

$$NT_t = f\left(N_t, P_{wt}, T, Y_t\right) \qquad 3$$

[1] This assumption seems plausible in the developing economy like Nigeria where subsistence agriculture characterized food production with zero food export and occasional food importation most especially non traditional foods such as rice, wheat, fish among others

Dividing equation 3 all through by N_t gives per capita value of the variables in the equation 3 which yields

$$\left(NT_t/N_t\right) = f\left(P_{wt}, T, \left(Y_t/N_t\right)\right) \qquad 4$$

The economic interpretation of equation 4 is that, per capital nutrient intake NT_t/N_t depends on price of food (P_{wt}), taste (T_t), and per capita income Y_t/N_t *ceteris paribus*. Because taste (T_t) is difficult to measure while large changes in consumption patterns create difficulties in choosing appropriate weights for food prices (P_w), we follow Reuthger and Selowsky (1976), Dawson (2002), Dawson and Triffin (1998), Triffin and Dawson (2002) and Mustaq et al (2007) framework where sole determinant of per capita nutrient intake $\left(NT_t/N_t\right)$ is *real* per capita national income $\left(Y_t/N_t\right)$ specified as[2]:

$$\left(NT_t/N_t\right) = f\left(Y_t/N_t\right) \qquad 5$$

By taking the logarithm of equation 5 gives a specification that is consistent with aggregated Engel's curve when $\left(NT_t/N_t\right)$ is regressed on $\left(Y_t/N_t\right)$ as:

$$log\left(NT_t/N_t\right) = \mu + \beta log\left(Y_t/N_t\right) + \varepsilon_t \qquad 6$$

The estimated coefficient β is regarded as nutrient-income elasticity. μ is the intercept. ε_t is the traditional white noise error assumed with mean zero and constant variance.

Because the study covers three different nutrients vis-à-vis calories, protein and fat intake in Nigeria, the study elicit $\left(NT_t/N_t\right)$ as daily per calorie intake in kcal represented by C_t, daily per capita protein intake in gram represented P_t and daily per capita fat consumed in gram represented by F_t. To avoid tedious exposition, we dropped $\left(NT_t/N_t\right)$ simply as NT_t and $\left(Y_t/N_t\right)$ as Y_t in the subsequent section.

[2] Specifically, Dawson and Triffin (1998), Triffin and Dawson (2002) and Mustaq *et al.* (2007), respectively observed that inclusion of weighted price index in the aggregated Engel curve is significantly not different from zero. The authors end up estimating parsimonious Engel curve with real per capita GDP as sole determinants of calorie intake in the respective studies.

3. Methodology

3.1. The data

The data used for the study represents the annual series for 1961-2007 (47 years) which covered daily per capita calorie intake in kilocalories, daily per capita protein intake in gram and daily per capita fat intake in gram from Nigeria. The data are derived from the national food balance sheets based on food supply which is the annual residual from the total food supply less feed, seed, industrial uses and waste (FAOSTAT, 2010). The food nutrient data was also supplemented from the World Development Indicators dataset obtained from the World Bank website on the current per capita Gross Domestic Product-GDP expressed in million Nigerian Naira (World Bank, 2010). The per capital GDP was later deflated by using GDP deflator also obtained from the World Development Indicators dataset.

The use of *real* per capita GDP as a proxy for consumer income is less than an idea. According to Tiffin and Dawson (2002), changes in the *real* GDP which arise for different reasons, may affect calorie consumption of different consumers in different ways. For example, incident of drought may have possibility of distorting food production and affect per capita GDP. Hence, our approach fits within a body of literature which examines the calorie-income relationship at the aggregate level (*see* Dawson, 1997; Dawson and Tiffin 1998; Dawson 2002; Tiffin and Dawson 2002; Mushtaq *et al,* 2007; Tiwari and Zaman 2010).

However, as stressed by Harris (1995), many economic time series are non-stationary and such ordinary least squares (OLS) regression between non-stationary data will lead to spurious results. Hence, the data generating process (DGP) for time series data require that we check for the property of the series such as presence of unit root and existence of co-integration relationship between the pair of series available prior the empirical analysis. This is essential because the presence of unit root in the autoregressive representation of a time series data leads to non-stationary, and such series is referred to as being integrated of order one (*i.e.,* I (1)). The implication of this is that I (1) series must be first-differenced to render the series stationary or being integrated of order zero (i.e., I (0)). Intuitively, where I (1) series move together and their linear combination stationary, the series are co-integrated and the problem spurious regression does not arise.

Also, existence of co-integration relationship between series is important to establish whether there is an evidence of a meaningful long-run relationship between series. This is because co-integrating relationship cannot exist between two variables which are integrated of a different order. In view of this, we make attempt to test for the order of integration of the variables using Johansen (1988) trace test approach.

3.2. Estimation method and model specification

The employment of a particular econometric model depends on the relationship between the economic time series (Labys, 2006). Economic theory highlights the bi-directional causality effect between the demand for nutrient and per capital income (Triffin and Dawson 2002). That is better nutrition could lead to increase income known in the literature as efficiency wage hypothesis developed by Stightz (1976). Conversely, increase income could improve nutritional status of an individual in a given society.

In light of this, we specify the econometric analysis of the relationship between the demand for nutrient (NT_t) and *real* per capita income (Y_t) using Vector Auto-regression (VAR) framework as:

$$Z_t = \mu + A_1 Z_{t-1} + A_2 Z_{t-2} + \ldots\ldots + A_{k-1} Z_{t-k+1} + \varepsilon_t \qquad 7$$

where Z_t is a vector of I(1)) endogenous variables such that $Z_t = \left[NT_t, Y_t\right]'$ which is a (2x1) vector ; μ is a (2x1) vector parameters; ε_t is a (2x1) vector of white noise errors with $E\left[\varepsilon_t\right] = 0$. k is the number of lags. By including lagged values for both NT_t and Y_t implies that the specification will allow for a wide variety of dynamic patterns in the series.

Because Vector Error Correction Model (VECM) adds error correction terms (ECT) to a multi-factor model such as Vector Autoregression (VAR) above; such that VECM could be explore to develop a refined dynamic model which has a focus on short-run adjustment in addition to the long-run equilibrium relationship between any pair of series. Like VAR, VECM could be used to simultaneously investigate effect of income on the demand for nutrient as well as effect of nutrient on the per capita income. Both VAR and VECM do not require the specification of causality prior the estimation.

The study employed VECM and a typical VECM can be written as:

$$\Delta Z_t = \mu + \underbrace{\omega_1 \Delta Z_{t-1} + \omega_2 \Delta Z_{t-2} + \ldots\ldots + \omega_{k-1} \Delta Z_{t-k+1}}_{short-run\ dynamics} + \underbrace{\pi Z_{t-k}}_{long-run\ equilibrium} + \varepsilon_t \qquad 8$$

$\Delta Z_t = Z_t - Z_{t-1}$ while Δ is difference operator; ω and π are (2 x2) matrices of parameters with $\omega_k = -(1 - A_1 - A_2 - \ldots\ldots - A_k)$, $(k = 1, 2, \ldots.K)$ and $\pi = -1 - \pi_1 - \pi_2 - \ldots\ldots.\pi_k$.

Equation 8 provides short run adjustment dynamics and long-run relationship to changes in Z_t through ω_k and π, respectively while information about the long run equilibrium relationship between the variables in Z_t is provided by πZ_{t-k}. The number of co-integrating relationship among the variables in Z_t is provided by the rank of π denoted by *r*. If π is of reduced rank, the model is subject to a unit root; and if $0 < r < k$, π can be decomposed into $\pi = \alpha\beta'$ with a two (k x r) matrices α and β, where $\beta' Z_{t-k}$ is stationary. Hence, $\alpha = [\alpha_1, \alpha_2]$ is an adjustment matrix otherwise known as error correction term (ECT) which measures the speed of adjustment in ΔZ_t while $\beta = [\beta_1, \beta_2]$ is the co-integrating vectors with *r* distinct co-integrating vectors which measures co-integrating relationship between non-stationary variables in Z_t. Therefore when equation 8 is re-written in full matrix it becomes:

$$\begin{pmatrix} \Delta NT_t \\ \Delta Y_t \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + \sum_{k=1}^{K} \begin{pmatrix} \omega_{k,11} & \omega_{k,12} \\ \omega_{k,21} & \omega_{k,22} \end{pmatrix} \begin{pmatrix} \Delta NT_{t-k} \\ \Delta Y_{t-k} \end{pmatrix} + \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} (\beta_1 \ \beta_2) \begin{pmatrix} NT_{t-k} \\ Y_{t-k} \end{pmatrix} + \begin{pmatrix} \varepsilon_{t1} \\ \varepsilon_{t1} \end{pmatrix} \qquad 9$$

To simultaneously ascertain the effect of per capita income on the demand for nutrient and effect of nutrient on the per capita income, Lütkepol's (1993) orthogonalise impulse response analysis is used in the present study. Impulse response according to the author gives a better picture of the relationship between pair of series for further policing. Besides, impulse response could as well be used to assess adjustments to long-run equilibrium between the pair of series. Specifically, if two co-integrated variables let say A and B are in a meaningful long-run equilibrium (i.e., π-matrix is of the r rank determined by the trace statistics), what impulse response analysis does is to show how shocks from one variable let say A impact another individual variable B or better still, how individual variable let say B response to the shocks from another variable A. Since deviation from the long-run equilibrium are believed to be stationary, therefore, any shock to the system will generate time paths which eventually return to a new equilibrium provided no further shocks occur. In summary, each impulse response is the response of a variable to a shock of one standard error in another variable.

3.3. Empirical model

Modeling long-run relationship between demand for nutrient and real per capita GDP:

Following the work of Dawson (1997), Dawson and Tiffin (1998), Tiffin and Dawson (2002) and Mustaq *et al.* (2007), the empirical model to investigate the long-run relationship between nutrient intake and level of *real* per capita GDP in Nigeria using aggregated Engel curve is specified as follows:

$$NT_t = \mu + \sum_{k=1}^{K} \beta_{k1} NT_{t-k} + \sum_{k=0}^{K} \beta_{k2} Y_{t-k} + \varepsilon_t \ ; t = 1961, 1962, ...2007 \qquad 10$$

where $NT_t = [C_t, P_t, F_t]'$ is a vector of endogenous variables which represents nutrient intake considered in the present study. The nutrients; C_t = daily per capita calorie intake, P_t = daily per capita protein intake and F_t = daily per capita fat intake.

Modeling the short-run dynamic between demand for nutrient intake and real per capita GDP:

The essence of short-run dynamics analysis is to investigate the length of time it will take change in the demand for nutrient ΔNT_t to adjust in case there is any disturbance away from the equilibrium as a result of change in real per capita income ΔY_t in order to restore the long-run equilibrium relationship between them. Specifically, the short-run speed of adjustment α_1 shown in the equation 11 measures how fast deviations from the long-run equilibrium are eliminated following changes in the demand for nutrient and real per capital income.

A typical short run dynamic model for the relationship between nutrient intake and per capita income is described as:

$$\Delta NT_t = \mu_1 + \sum_{k=1}^{K} \omega_{k1} \Delta NT_{t-k} + \sum_{k=1}^{K} \omega_{k2} \Delta Y_{t-k} + \alpha_1 ECT_{t-1} + \varepsilon_{t1} \qquad 11$$

ECM_{t-1} represents the error correction term derived from the long-run co-integrating relationship of equation 10. The α is the speed of adjustment for the dependent variables usually expressed in percentage when the endogenous variables are in logarithm form.

The JmulTi software (http://www.jmulti.org) was used to estimate the parameters of the equation 10-11 using Johansen (1988) reduced rank regression in a single stage with r =1.

4. Results and Discussion

4.1. *The trends in the demand for nutrient and real GDP in Nigeria, 1961-2007*

Table 1 presents the result of a 10 years average in the demand for nutrient and *real* per capita GDP in Nigeria from 1961-2007. Also, presented in Figure 1 is the plot of the demand for nutrients and *real* per capita GDP within the same period under scrutiny.

Although not presented in table format to conserve space, the summary statistics of the series showed that an average daily per capita calorie of 2,116 kcal was obtained which varied between 1,947 kcal in 1961 to 2,741kcal in 2007 with an average annual growth rate of about 0.87%. The growth rate is comparatively higher than 0.6% obtained in Pakistan by Mushtaq *et al.,* (2007). The average calorie intake of 2,116 k cal in Nigeria was found to be lower to the FAO recommended 2500kcal/day for an adult in Nigeria. Likewise, we observed an average daily protein intake of about 48g which varied between 46g and in 1961 to about 63g in 2007 with an annual average growth rate of about 0.84%. An average daily fat intake of about 53g was observed which varied between 56g and 66g in 1961 and 2007, respectively with an annual growth rate of about 0.41%[3]. The estimated average 48g of crude protein from the data is far below the minimum recommended daily requirement for an adult in Nigeria which varies between 65-85g per person per day (Omotosho 2004)

[3] The daily calorie intake in Nigeria was found to be at lowest level in 1972 with value of 1,645.42kcal. Also, we observed that the daily protein intake was at lowest in 1979 with value of 38.6g1 while demand for fat recorded the lowest value of 41.97g in 1984.

Table 1 shows that there is evidence of increasing trend in the demand for nutrient in Nigeria for the period 1961-2007. For example, using the 10 years average data presented in Table 1, we observed that the per capita calorie, protein and fat intake decreased by about 7%, 7% and 12%, respectively between 1960s and 1970s. Further analysis indicated growth of about 8%, 9%, and 0.4% in the consumption of calories, protein and fat, respectively between 1970s and 1980s. Also, growth rate of about 31%, 24% and 15% in the demand for calorie, protein and fat, respectively was noted from the analysis between 1980s and 1990s. Although still increasing, but at slow rate, our series show growth increase of about 5%, 8% and 0.4%, respectively for the demand for calorie, protein and fat intake between 1990s and 2000s. The real current per capita GDP expressed in the local currency (Naira) was found to have an annual growth rate of 1.45% between the same periods from 1961-2007.

An intrinsic part of Table 1 is the fact that, daily per capita calorie intake in Nigeria was found to be highest in the 2000s with an average energy intake of 2,628 kcal which is quite above the FAO recommended daily calorie intake of 2500kcal for an adult. Similar observation was noted for protein and fat intake for the same period. A plausible argument for this could be attributed to various policies and reform initiated by the Nigeria government to improve consumption and equitable income distribution in Nigeria. A significant example of these polices is National Economic and Empowerment Development Strategy (NEEDS) introduced since 2001.

The plots of the *real* GDP and the demand for nutrients in Figure 1 revealed that the nutritional status of Nigerian increased with real GDP while the trend analysis on the bottom right of the figure shows that the demand for nutrients and real GDP trend upward which is an indication of a positive correlation between them. This observation is contrary to observation of Deaton and Dreze (2009) that per capita calorie and protein intake in India is declining despite the rise in the real per capita income in the country over the years.

Table 1: Trends in Nutrient intake in Nigeria, 1961-2007

Periods	**Calorie intake kcal/day/capita**	**Protein intake g/day/capita**	**Fat intake g/day/capita**	***Real* GDP /capita[a]**
1960s	1905.44	43.62	53.90	892.59
1970s	1778.78	40.72	47.24	1274.91
1980s	1914.69	44.52	47.43	1008.21
1990s	2507.94	55.24	54.58	1116.62
2000s[b]	2628.35	59.72	64.40	1284.95

[a]The real GDP is expressed in the local currency Unit (LCU)-Naira; [b]the 2000s covered 2000-2007; source: FAO data base

4.2. *Unit root and co-integration* test

In testing for the presence of unit root in the series in logarithm, we employed both the Augmented Dickey-Fuller (ADF) test (Dick and Fuller, 1981; Said and Dickey 1984) and the KPSS tests (Kwiatkowski *et al.* 1992) presented in Table 2 with lag equals 1. The ADF test is under the null hypothesis of a unit root (*i.e.,* I(1)) while the alternative hypothesis is stationarity in the series (*i.e.,* I(0). The KPSS test is under the null hypothesis of stationarity (*i.e.,* I(0))while the alternative hypothesis is a unit root in the series (*i.e.,* I(1)). The number of the lags is guided by the Akaike Information Criterion (AIC) to ensure that the series serial correlation in the series is absent.

The test was carried with the specification of only constant on one hand and trend plus constant on the other hand as presented in table 2. The result revealed, however, that the series are non-stationary (*i.e.,* the series are I (1) process) while the series become stationary after first differences (i.e., I(0)) fort both specification.

Table 2: Unit root tests

Variable	ADF				KPSS			
	Constant		Trend + constant		Constant		Trend + constant	
	Statistics	CV (lag)	Statistics	CV (lag)	Statistics	CV (lag)	Statistics	CV (lag)
C_t	-0.3011	-2.86 (1)	-2.5582	-3.41 (1)	1.9006	0.463 (1)	0.4247	0.146 (1)
ΔC_t	-5.4568		-5.7283		0.2164		0.0655	
P_t	-0.4766		-3.1039		1.9015		0.4270	
ΔP_t	-5.9387		-6.3212		0.2047		0.0384	
F_t	-0.7173		-2.4243		1.2412		0.4712	
ΔF_t	-5.7094		-6.3133		0.2383		0.0391	
Y_t	-0.0692		-2.1882		2.3296		0.4157	
ΔY_t	-3.5866		-3.5153		0.4470		0.2175	

CV implies critical value at 5% level of significance

Following the result of the unit root tests, we sought to determine the existence of co-integration relationship between the pair of the series using the Johansen (1988) trace statistics. The trace statistic is designed to test the null hypothesis of at most *r* co-integrating vectors against the alternative that the number of co-integrating vectors is greater than *r*.

Table 3 presents the result of the trace statistics for non-trended model with only constant included in the series. The LR-tests in the table revealed that the null hypothesis of no co-integration vector (i.e., $r = 0$) between the pair of the series is rejected with p-value of 0.000 while null hypothesis of one co-integration relationship (i.e., $r=1$) between the pair of the series could not be rejected at p-value ranges between 0.11-0.18.

Table 3: Trace statistics

Equation tests	Ho	H_1	Trace statistics	CV of Trace	p-value
C_t, Y_t	$r=0$	$r=1$	38.80	20.16	0.0000
	$r=1$	$r=2$	6.21	9.14	0.1810
P_t, Y_t	$r=0$	$r=1$	42.66	20.16	0.0000
	$r=1$	$r=2$	7.45	9.14	0.1067
F_t, Y_t	$r=0$	$r=1$	44.03	20.16	0.0000
	$r=1$	$r=2$	6.39	9.14	0.1679

CV implies trace statistics with critical value at 5% level of significance

In summary, the results of table 2 and 3 indicated that, the π-matrix in the equation 8 is of reduced rank, $r \leq 1$. Hence, there is evidence that the series are not only non-stationary in the level but there also existence of a single co-integrating vector between the pair of the series which is an indication of a meaningful long run relationship between them.

4.3. *Estimates of Long-run co-integration relationship*

Following the evidence of the single co-integration analysis between the pairs of the series, presented in Table 4 is the result of the Co-integrating vectors β which depict the long-run relationship elasticity between the demand for nutrient and *real* per capita national income implied by the real GDP in Nigeria without trend.

The empirical estimates revealed that real per capita national income significantly and positively increased the demand for calorie, protein and fat from 1961-2007 in Nigeria. Specifically, our estimates revealed an income-calorie elasticity of 0.073, income-protein elasticity of 0.068, and income-fat elasticity of 0.059. Economic interpretation of these figures is that over the years, 1% increased in the real per capita national income increases the calorie, protein and fat consumption in Nigeria by 0.073%, 0.068%, and 0.059%, respectively. One plausible hypothesis justifying the positive relationship between real per capita national income and calories consumption in Nigeria could be associated with the fact that increase in calorie intake is due to increase in the level of physical activity in the country. Of course, this make sense considering the fact that Nigeria being an agrarian economy with over 70% of her population engage in agriculture and agricultural related activities with rudimentary farming tools that require a significant amount of energy (Ogundari and Ojo, 2005). It may also be due to various polices aimed at improving nutrition and increase income at household level in the country over the years by successive governments.

A comparatively analysis of the estimated calorie-income elasticities in the present study with previous studies indicated that, our estimate is far below 0.34, 0.31, and 0.12 obtained for India, Zimbabwe, and Pakistan by Dawson and Tiffin (1998), Tiffin and Dawson (2002) and Mushtaq *et al.* (2007), respectively.

The significant of the intercepts across the equations in table 4 suggests that even at zero income, a minimum level of calorie, protein and fat intake are necessary to maintain healthy life in the country.

Table 4: Long-run equilibrium estimates for the demand for nutrient

Variables	*Co-integrating vector (β)*		
	Demand for Calorie C_t	Demand for Protein P_t	Demand for Fat F_t
C_t	1.000	-	-
P_t	-	1.000	-
F_t	-	-	1.000
Y_t	0.073***(0.009)	0.068***(0.007)	0.059***(0.012)
Intercept	-7.952***(0.047)	-4.149***(0.035)	-4.259***(0.067)

*Figure in parenthesis are standard error; *** implies that the estimates are significant at 1%.*

3.4. *Estimates Short-run dynamics*

Table 5 presents the result of the short run dynamics between the demand for nutrient and real per capita GDP in Nigeria. The result revealed a positive and significant effect of previous calorie demand on the current calorie intake while effect of the previous *real* per capita income was found to be positive on current demand for calorie intake within a short-term. The later is significantly not different from zero. This observation also applies to the demand for protein and fat intake as presented in the second and third column of Table 5, respectively.

However, the result of the adjustment vectors have the correct sign and it is significantly different from zero for each of the equations. Specifically, the size of the speed of adjustment α_1 shows that the deviation of the change in the demand for calorie, protein and animal fat from long-run equilibrium associated with the long-run value of the change in the *real* per capita GDP in the previous year is corrected by about 29%, 41%, and 26%, respectively in the current period. These estimates, however, indicated that there is evidence of slow adjustment to long-run equilibrium as a result of shocks in the real per capital national income by the demand for nutrients in Nigeria which call for attention. The demand for protein was found to have the slowest adjustment, calorie and finally animal fat.

Typically, one would expect a five to ten years period for full adjustment by consumers to a change in income, but our results prove otherwise. The slow adjustment of the demand for the nutrients could probably associate with the nexus between general consumption pattern and prevalence of poverty in the country.

Although, it is evident that in the long-run relationship the demand for calorie response faster to the rise in per capita national income in Nigeria, nonetheless, the short-run dynamics relationship shows that the demand for protein adjust faster to deviation from long-run equilibrium associated with the long-run value of the real per capita income in the previous year compared to the other two nutrients considered in the present study. The implication of this is that, any policies targeted at increasing per capita income within a short term might lead to increase in protein consumption in the country while long term policies might favour calorie consumption in the country.

Table 5: Short-run dynamics and adjustment vectors

Variables	ΔC_t	ΔP_t	ΔF_t
ΔC_{t-1}	0.218* (0.129)	-	-
ΔP_{t-1}	-	0.264** (0.126)	-
ΔF_{t-1}	-	-	-0.183 (0.129)
ΔY_{t-1}	0.021 (0.030)	0.044 (0.035)	0.047 (0.047)
Adjustment vectors (α)			
ΔECT_{t-1}	-0.294*** (0.080)	-0.411*** (0.095)	-0.263*** (0.084)

*Figure in parenthesis are standard error; *, ** and *** implies that the estimates are significant at 10%, 5%, and 1%, respectively.*

3.5. *Impulse response estimate*

Impulse responses give a better picture of the relationship between co-integrated series as stressed by Lükepohl (1993). In light of this, figures 2-4 demonstrate the response of the demand for nutrients to increase in the real per capita GDP and vice versa to the unitary orthogonal shocks in the series for 40 years horizon with 95% confidence bounds. Because the series are expressed in logarithms, the responses are interpreted as annual percentage changes.

Hence, Figure 2 (left hand side) shows the response of calorie intake to one standard error shock in the per capita income measured by *real* per capita GDP. The graph revealed initial response of 0.011% which decreased to -0.01% within the span of 3 years period. This later increased rapidly to 0.04% for the next 23 years before returning back to the long-run equilibrium. That is within the first 3 years, per capita calorie intake respond negatively to increase per capita income while in the next 23 years, the *real* per capita calorie intake respond positively to increase per capita GDP before reaching long run equilibrium.

Economic interpretation of these estimates is that, increasing *real* per capita income in Nigeria has a positive effect on nutritional status of Nigerians which also support earlier finding of the long-run equilibrium relationship between calorie intake and per capita income of Table 4. Similar observation was noted for responses of the demand for protein and fat intake to the shocks from the *real* per capita income which is presented in the left hand side of figure 3 and 4, respectively. For example, with initial effect of 0.018% and 0.04%, respectively for the demand for protein and fat, respectively, the responses increased to 0.11% for protein and 0.38% for fat before reaching equilibrium level in about 40 years and 31 years span. Meaning that, there is evidence that increase in *real* per capita income has a positive effect on the demand for protein and fat in Nigeria over the years. These results lend support to the conclusions of the work of Dawson and Tiffin (1998), Tiffin and Dawson (2002) and Mostiq *et al.,* (2007) that calorie intake is determined by *real* per capita income in India, Zimbabwe and Pakistan , respectively. Conversely, we found no evidence that one standard error shocks in the demand for calorie, protein and fat presented in the right hand side of the figure 2, 3 and 4, respectively, have significant effect on the *real* per capita GDP in the present study.

In summary, while there is evidence that economic growth indicator implied by *real* per capita national income influences the demand for calorie, protein and fat in Nigeria, there is no evidence that real per capital national income is constrained by nutritional status of Nigerians as also noted by Deolaiker (1998) and Dawson and Tiffin (1998) for Indian datasets. This observation substantiates theory underlying Engel curve relationship.

4. Conclusions

This paper made attempt to estimate the long-run equilibrium relationship and short- run adjustment parameters between the demand for nutrients (*i.e.,* calorie, protein, and fat intake) and economic growth indicator denoted by the *real* per capita Gross Domestic Product (GDP) from Nigeria. Using annual time series data covering 1961-2007, the study employed a vector error correction model (VECM) for the empirical analysis.

The result of the long-run equilibrium relationship between the pair of the series revealed that real per capita GDP positively and significantly impact the demand for calorie, protein and fat intake in Nigeria over the years. Specifically, we found evidence that 1% increase in *real* per capita national income raises the daily per capita calorie, protein, and fat intake significantly by 0.073%, 0.068%, and 0.059%, respectively. This, however, is an indication that in the long-run, economic growth indicator enhances nutritional status of Nigerians.

Also, the result of short-run dynamics indicated that, adjustment of the demand for calorie, protein and fat intake towards long-run equilibrium relationship associated with short-run shocks in the *real* per capita GDP (economic growth indicator) from the previous period is about 29%, 41% and 26%, respectively in the current period. Meaning that in the short term, the demand for the consumption of fat respond faster to any increase in the *real* per capita national income. Besides this, we observed that all estimated speed of adjustment parameters indicated slow adjustment to long run equilibrium.

The economic implication of these findings suggest that, in the long term, the *real* per capita GDP have a significant positive effect on the demand for the nutrient in Nigeria whilst the demand for consumption of fat was found to respond faster to shocks in *real* per capita GDP in the short-term. Of course, these observations implied that, economic policies aimed at increasing per capita national income in the short-term might possibly induce the demand for the consumption of animal fat relative to other nutrients. In a related development, policies aimed at increasing per capita national income in the long term might favour calorie consumption in the country.

A Further confirmation of the earlier observation that, *real* per capita GDP positively impact the demand for nutrients is the result of the estimated impulse response function. The result clearly shows that, one standard error shocks in *real* per capita GDP increased the demand for calorie, protein, and fat take rapidly to 0.04%, 0.11%, and 0.38%, for a period of 23 years, 40 years, and 31 years, respectively before the system returns back to long-run equilibrium. These estimates unfortunately are further indication of slow adjustment to long-run equilibrium between the demand for nutrients and *real* per capita income as earlier noted in Nigeria.

In conclusion, our findings: *First* lend support to the economic theory that increase in the *real* per capita national income is capable of increasing nutritional status of Nigerian *ceteris paribus*; *Secondly,* the results are strong indication that long-term income growth policies can alleviate inadequate nutrient intake with capability to minimize food-poverty incidence in Nigeria; *Thirdly*, we found no evidence that one standard error shocks in calorie, protein and fat intake have a significant positive effect on the *real* per capita national income in the study.

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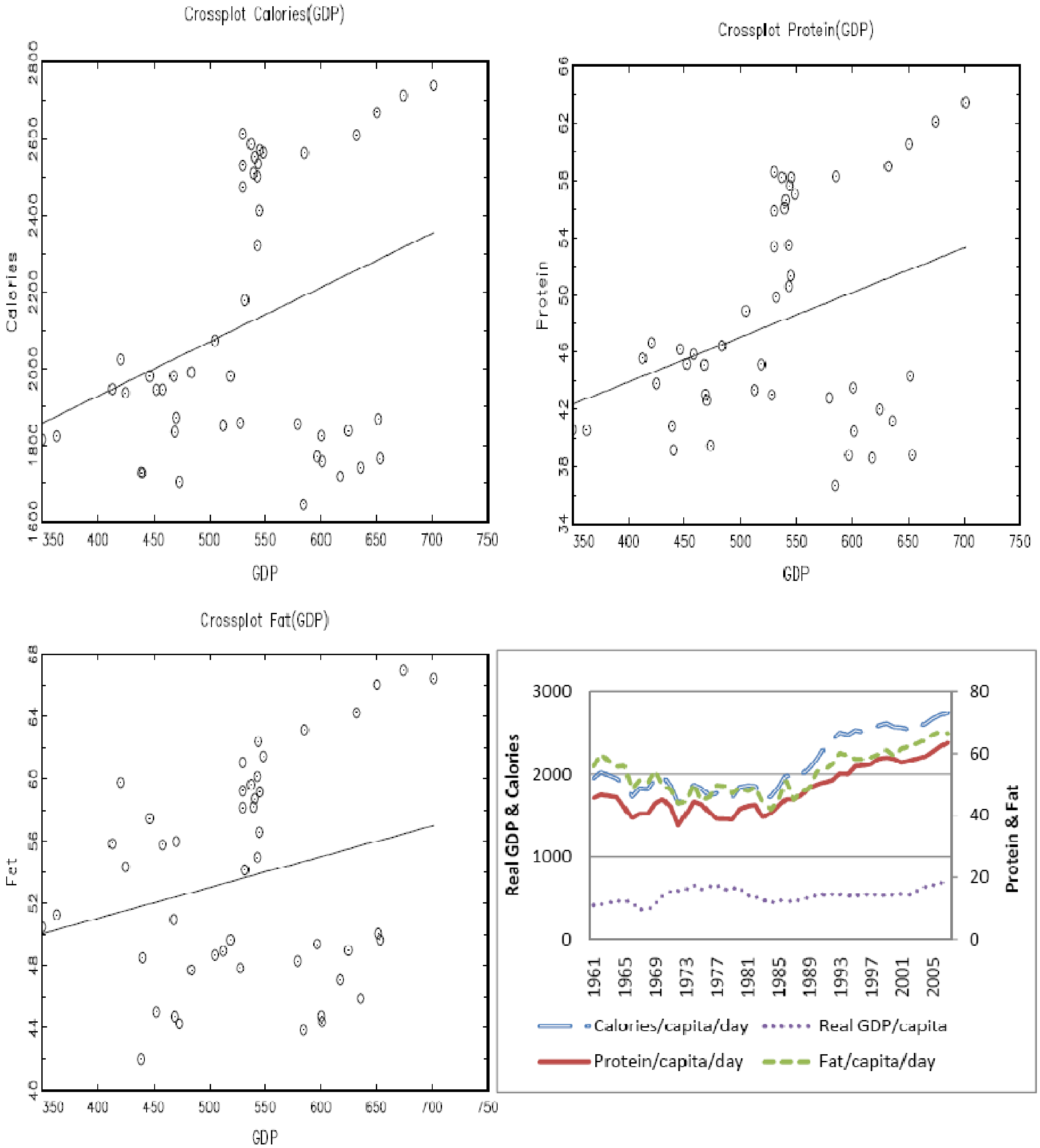

Figure 1: Trends in the demand for nutrient and Gross Domestic Product (GDP) in Nigeria 1961-2007

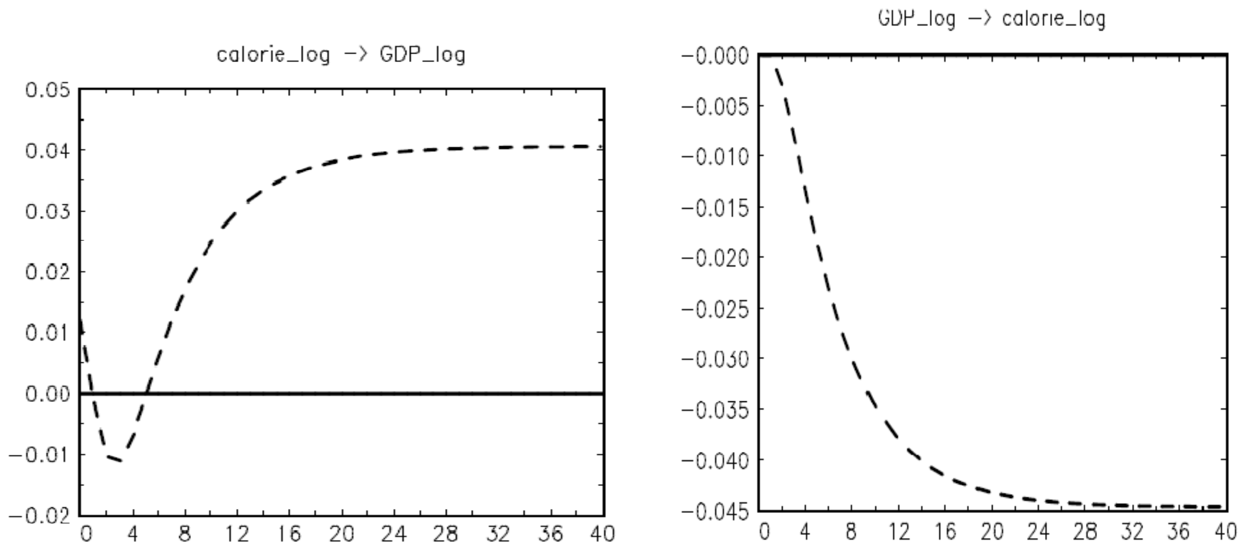

Figure 2: Impulse response for the demand for calorie intake in Nigeria, 1961-2007

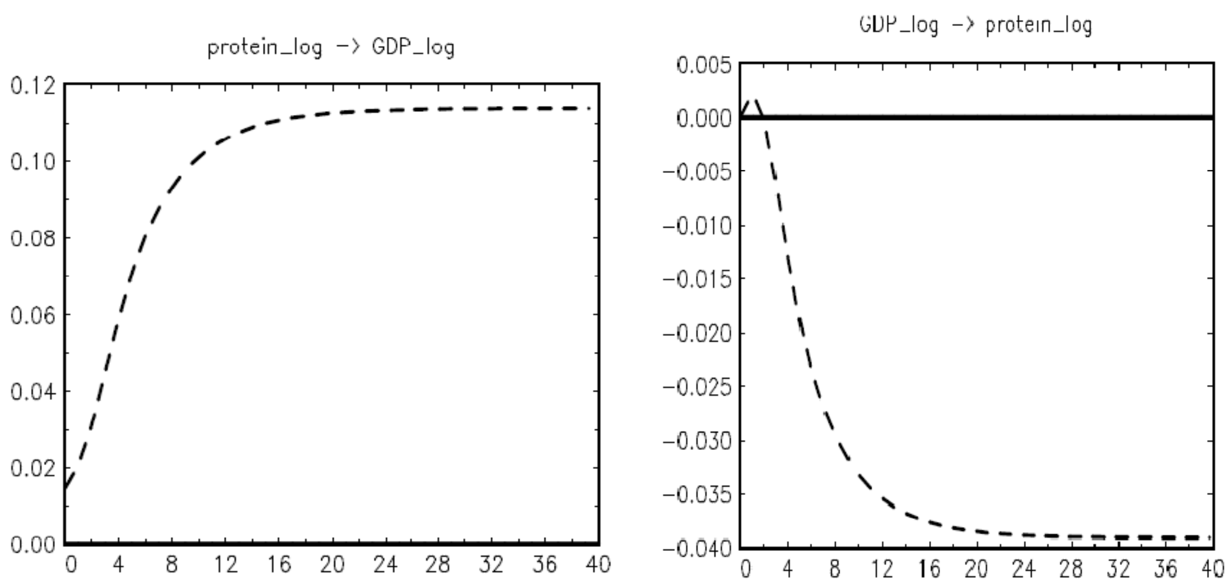

Figure 3: impulse response for the demand for protein intakes in Nigeria, 1961-2007

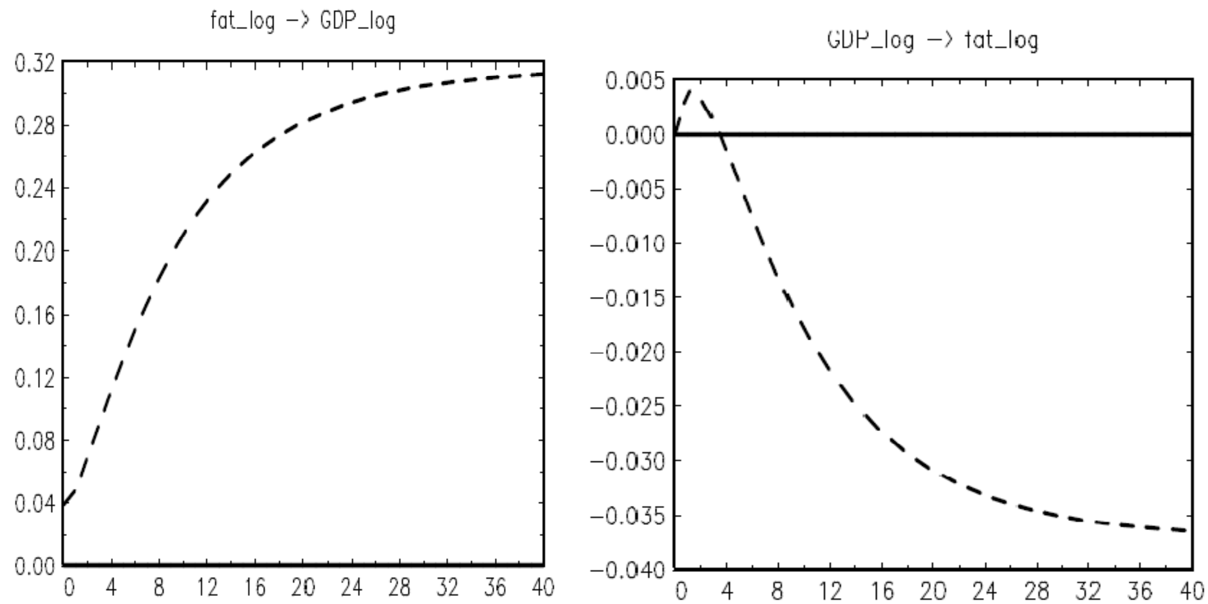

Figure 4: Impulse response for the demand for fat intakes in Nigeria, 1961-2007