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Convergence in nutrient intakes and nutrition-income elasticities in sub Saharan Africa: Implications on Health and welfare

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Convergence in nutrient intakes and estimation of nutrition-income elasticities in sub-Saharan African: Implications on health and welfare

Abstract

The objective of the study is twofold: first, to investigate whether a nutrition convergence process exists in sub Saharan Africa (SSA) countries, and second, to examine the response of per capita nutrient intake [i.e. calories, proteins and fats] to changes in income (i.e. nutrient-income elasticities) in the region. Annual time series data for 43 countries covering 1975-2009 cum balanced panel of 1505 observations was employed for the analysis. The convergence hypothesis is examined using the neo-classical growth model, whilst nutrient-income elasticities are estimated based on the aggregate Engel Curve. However, the empirical results show that the null hypothesis of no nutrition convergence is strongly rejected, which indicates tendency towards equalization of per capital nutrient intake in SSA countries. Also, the estimated nutrient-income elasticities are of modest size as the relationship between calories-income and proteins-income was found to be non-linear and linear for fat-income. Further analysis reveals that the calorie and protein-income elasticities are significantly different from zero at higher income and diminished.

Key words: Nutrition, convergence, health, welfare, income, elasticity, and SSA

JEL Classification: C33, I31, O47, O55

1. Introduction

The variation in the level of nutrient intake or per capita food consumption across countries can be linked to dissimilar levels of available food products or food production, socio-demographic characteristics and in particular differences in cross country growth performance or pattern of economic growth among others (Angulo et al., 2001). Conversely, income inequalities across countries could dictate wide differences in consumption patterns, which explain why availability and accessibility, over space and time, to sufficient nutrition for healthy and active life is necessary to ensure global food and nutrition security (Ogundari, 2014). Unfortunately, as also noted

by Arcand (2001), inadequate nutrition could lead to loss in global annual growth of gross domestic product (GDP). This suggests that combating malnutrition is not only an urgent task for humanitarian reasons, but also critical for economic development.

As food and nutrition security have now become an important developmental issue across the globe, it is pertinent to understand growth performance of per capita food consumption in sub Saharan Africa (SSA). This is very important because food consumption, in terms of per capita dietary intake is a key variable for measuring and evaluating evolution of the world food situation (Alexandratus and Brainwsma, 2012). Conversely, food consumption defines wellbeing in terms of better nutrition as it plays crucial role in many societal spheres ranging from health, welfare and economic growth in general. But at the macroeconomic level, per capita food consumption expressed in per capita nutrient intakes per day based on the national estimates is arguably one of the most important economic measures of society's wellbeing and global and regional food situation (FAO, 2003). In this regard, food policy discussion at the macro level on cross-country wellbeing has always been focused on the level of per capita nutrient intakes (calories, proteins, and fats). Given that adequate nutrient intake is synonymous to improved welfare in any society, coupled with the fact that the links between income and nutrition have been established in the literature (Ogundari and Abdulai, 2013), it is important to raise the question, "are per capita nutrient intakes converging and how has per capita nutrient intake responds to changes in income in SSA countries?"

Thus, following the Solow's (1956) seminal work, the convergence frenzy of economic indicators has always been used to show whether the standard of living of poor countries has improved or increased more rapidly relative to that of the richer countries. Also, following the work of Angulo et al., (2001), we define convergence as the tendency towards equalization of economic indicators represented by per capita nutrient intakes [i.e., calories, protein, and fats] across countries in SSA. In other words, in the present study, convergence in nutrient intakes is believed to exist when countries with initial lower per capita nutrient are growing in the long run (or catching up) on the same equilibrium or (at the same steady) as countries with higher per capita nutrient intake over time in the region. In other words, convergence takes place when there is

tendency towards homogenization in per capita nutrient intakes over space and time in SSA countries, which implies that countries in the region tend to "catch up" in terms of dietary intake over time.

Also, closely related is how per capita nutrient intakes respond to changes in per capita income in SSA countries at a macro level. According to Ogundari and Nanseki (2014), economic growth measured by per capita income is generally viewed as a double-edged sword for nutrition. In this respect, the impact of per capita income on nutrition (i.e., nutrition-income elasticity) has been an important indicator for gauging consumer welfare defined in terms of food and nutrition security. In addition, the parameter has always been use to monitor consumer health behavior at both the micro and macro levels. As also noted by Ogundari and Abdulai (2013), investigation of nutrition-income elasticities helps policymakers to deduce whether income growth alone as a policy is likely to promote nutrient intakes.

A review of the literature shows that a large number of studies have been used to raise policy discussion on the relationship between per capita nutrient intakes and income across the globe (for detail see: Ogundari and Abdulai, 2013). But the debate on the relationship appears to be unresolved because of the wide range of elasticity estimates in the literature through which this study intends to contribute in a number of ways. First, it is very unlikely that country specific results obtained from some countries where similar analysis has been carried at the national level in SSA such as the case in Nigeria by Ogundari and Nanseki (2014), Zimbabwe by Tiffin and Dawson (2002) and South Africa by Phiri and Dube (2014) can be ensured at the regional level. Second, there is no single study that has investigated the convergence hypothesis in nutrient intakes in SSA, which is major contribution of this study to existing literature. Third, while most of the previous studies from the region focused on calorie as the single macronutrient of interest, this study also considers protein and fat intakes in recognition that calorie-income elasticity alone is not enough to guide policymakers. Fourth, the present study focuses on macro analysis because it provides estimates that cannot only be generalized or vary at the macroeconomic level but also provide

essential information that can be useful in making food and nutrition policy decisions in recognition of Salois et al., (2012) argument.

The aim of the study is twofold. *First*, to investigate whether the convergence process exists for per capita nutrient intakes in SSA countries, and *second*, to examine how per capita nutrient intake responds to changes in income in the region. The first objective is useful in gauging whether countries with initial lower in per capita dietary intakes are growing relative to countries with higher per capita dietary intake across countries in SSA with implications on consumer welfare in the region. The second objective is very useful in understanding regional consumption behavior represented by the nutrient-income elasticity so as to deduce whether effective income-mediated policies are necessary to enhance welfare defined in terms of food and nutrition security and to be able to understand health implications of increasing consumption of certain macronutrients such as calories as income rises in the region.

Meanwhile, our empirical findings show that convergence exists in the selected nutrients (i.e., calories, proteins, and fats) in the study. The analysis also shows that the response of per capita nutrient levels to changes in income (i.e., nutrient-income elasticities) is significantly positive but very modest (small) judging by the size of the estimated elasticities, which also consistent with previous studies. Other results show that both calorie and protein-income elasticities are significantly lower at higher incomes, which probably implies that public programs to control diets because of diseases such as obesity epidemic due to increasing consumption of calorie at higher income is not a concern at macro level in SSA

The rest of the paper is organized as follows. The next section reviews relevant literature for the study. Section 3 focuses on the data used for the analysis and analytical model, while section 4 present the results and discussion. Concluding remarks are provided in section 5.

2.0. **Literature Review**

Food and by extension nutrient intakes has been found to have a strong empirical linkage with both human health and labour productivity (Aromolaran, 2004). In this respect, nutrition is viewed as one of the fundamental prerequisites for human welfare as it contributes to human capital development, and the lack of key nutrients such as calories, protein, iron, calcium, and vitamin is a common phenomenon in most developing countries (Neeliah and Shankar, 2008). With reference to the Food and Agriculture Organization (FAO) cross-country database, Wang and Taniguchi (2002) revealed that the average per capita nutrient intakes in SSA has shown a modest trend since 1960 with an average that is less than the minimum recommended dietary allowances (RDA) for an adult in the region. As also revealed by Honfoga and van den Boom (2001) and Ogundari (2014), the average per capita nutrient intakes from the late 1990s to date (especially calories and fats intake) has not only improved for these periods but higher than the RDA in many countries in SSA. This probably shows that the decline in long-term average per capita nutrient intakes over the years (i.e., 1960-2009) relative to the RDA observed in some of the countries in the region by Ogundari and Nanseki (2014), Tiffin and Dawson (2002), Hunfoga and van der Boo, (2001) and Phiri and Dube (2014) is not a current problem.

Meanwhile, the amount of nutrient intakes relative to RDA is very important in gauging the welfare and health implications of increasing consumption of macronutrients over time, especially calories. In this respect, while under nutrition can manifest inform of poor health, retarded growth, premature death and risk of diseases such as color blindness and kwashiorkor in children among others, over nutrition, especially calorie intake can lead to certain health problems such as obesity, diabetes and hypertension among others. Also, it is equally important to stress that over nutrition in some circumstances could be beneficial to the body. For example, excess essential nutrients in the body may be utilized to supplement temporary short falls in dietary intake, while an excess of calorie intake over a long period could result in diseases such as obesity and subsequently diabetes and many more related diseases.

However, the analysis of growth in nutrient intakes and its convergence is very important in understanding to some extent how consumer welfare defined in terms of food and nutrition security progresses over time across countries. Convergence in nutrient intakes is defined as tendency towards equalization in per capita nutrient intakes in the long run across countries (Angulo et al., 2001). In this respect, if convergence process in nutrient intakes does exist in SSA, then it is an indication that measures of consumer welfare associated with growth in capita nutrient consumption are homogenized across countries in the region. Conversely, investigation of nutrition convergence process provides a complementary view of consumer welfare with aim of providing crucial information to policy makers on the anticipated growth in consumer consumption of essential nutrients over time.

In a related development, analysis of consumer behavior measured by the response of nutrient intakes to changes in income (i.e., nutrient-income elasticity) has attracted interest among researchers over the years as noted by Ogundari and Abdulai (2013). This is because knowledge of how nutrient intakes responds to income is vital in the design of policies to combat malnutrition in poor countries and to improve diets in both rich and poor countries (Tiffin and Dawson, 2012). As also noted by Honfoga and van den Boom (2001), estimates of the calorie-income elasticity are considered an important parameter both in the literature and in the policy arena. For example, small size of nutrient-income elasticity could suggest limited scope for income enhancing economic policies as such policies could not alone decrease malnutrition or poverty. The parameter could also be use to gauge implicitly the health implications of increasing consumption of certain macronutrients, especially calorie at higher income levels.

But studies have shown that the relationship between nutrition and per capita income is entirely not linear as demonstrated by Ohri-vachaspati et al., (1998), Skoufias et al., (2009), Banks et al., (1997), and Salois et al., (2012). The non-linear relationship could help cast light on consumer health implication of consumption of certain

macronutrients at higher income levels. For example, if calorie-income/fat-income elasticity shows no indication of decreasing at higher income is a signal for need for public health programs that would influence diets in a given population (Salois et al., 2012). In this case, at higher income levels, nutrient-income elasticity estimates could help health and food policy analysts understand health implications of consumption of certain macronutrients, especially calories intake in reference to diseases such as obesity and diabetes.

3.0. **Methodology**

3.1 **Data**

The study employs annual time series cum balanced panel data of 1505 observations for 43 sub Saharan African (SSA) countries for which data was available covering 1975-2009. The aggregated data on per capita nutrient intakes [e.g., calories, proteins and fats] was obtained from the national food balance sheet of the Food and Agriculture Organization (FAO) database (FAOSTAT, 2013), while data on real per capita Gross Domestic Product–GDP adjusted purchasing power parity [PPP] at the 2005$ constant price per annum was taken from the Peen World Table [PWT] database (PWT 2013).[2] The data used for the empirical analyses are expressed in logarithms to ease the interpretation of the results.

An attempt was made to investigate the time series property of the data using panel unit root test in order to make efficient reference in the study. This is not presented to retain brevity. The results however, show that per capita nutrient intakes considered and per capita income is non-stationary at level but become stationary after first differencing.[3]

Meanwhile, summary statistics containing the mean and standard deviation of the daily per capita calories, proteins, fats, and GDP adjusted PPP are presented in Table 1A, while Table 1B presents the growth of these variables. Since, recommended dietary allowance (RDA) vary across regions, countries, gender, height, occupation, age groups,

[2] We employ PPP adjusted GDP because it is designed to ease international comparison of economic variables.
[3] The detail result of the panel unit root tests could be requested from the author.

and many more indicators (WHO-FAO, 1985), we pay special attention to the historical data on country basis.[4] In this respect, we observe that 28% and 23% of the countries in the sample (total is 43 countries) attained the minimum RDA for calories and protein, respectively for the entire period under consideration (i.e., 1975-2009). But across the pre-and post 2000s periods, we observe that 28% and 16% of the countries attained the minimum RDA for calorie and protein, respectively for the period 1975-1999, while 53% and 34% attained the minimum RDA for calorie and protein, respectively for the period 2000-2009. The implication of this is that 25% and 18% more countries have successful crossed over the minimum RDA for calorie and protein intakes, respectively since 2000 than the previous years in SSA.

Table 1B also reveal that the trend in per capita nutrient intakes and its growth over space and time have improved significantly for the period (i.e., 1975-2009). The average kcal/capita/day calorie consumption growth rate in 2000s has been 0.72%, while between 1975-199 it was less than 0.4%. Similarly, the average g/capita/day protein and fat consumption growth rate in 20002 have been 0.82% and 1.2%, respectively compared to the rate between 1975-1999 of about 0.5% and 0.3%, respectively. We observe further that g/capita/day fat intake is growing faster than other two nutrients considered in the tables. However, the average growth rates of about 0.38% and 0.36% per annum for calories and protein, respectively in the present study is lower and higher than 0.41% and 0.35%, respectively obtain for Central West Africa countries by Hongforga and van den Boom (2003). We find also that an average growth rate of 0.32%, 0.31%, and 0.17% for calories, protein and fat intake, respectively obtained by Ogundari (2014) for Nigeria dataset is lower than what was obtain in the present study.
The distributions of the growth of per capita nutrient intakes across SSA for the entire period are presented in Figures 4 and 5. Across the nutrients, the growth fluctuates in some of the countries between -0.1 and +0.2 in the 1980s and 1990s, while it stabilizes/stationary between 0 and +0.2 across many of the countries in the 2000s. The later probably conforms with the period when majority of the countries consume per

[4] We consulted several literatures in the region that reported minimum RDA for their respective countries such as Rwanda Economic Update (2011), Ministry of Health Ghana (2010), and Babatunde et al., (2007) among others that reported average 2100 kcal/capita/day, 2400kcal/capita/day, 2300kcal/capita/day for Rwanda, Ghana, and Nigeria respectively. Similar approach was used for protein intake.

capita per day nutrients that is higher than the minimum RDA. As noted by Chauvin et al. (2012), the rapid increase in per/capita/ day nutrient intakes since 2000 in SSA countries could be linked to the surge in per capita income level in the region as this allow consumers to consume a more diverse diet compared to twenty years ago.

3.2. **Analytical model**

3.2.1. *Convergence hypothesis in nutrient intake*

Convergence hypothesis is traditionally based on the neoclassical growth model developed by Solow (1956). To investigate the existence of convergence in nutrient intakes, we employ a dynamic growth regression similar to the work of Bassanin et al., (2001), Ismail (2008) and Aiello and Scoppa (2009) defined below:

$$\triangle NT_{i,t} = \tau_{0t} + \gamma_i NT_{i,t-1} + \varepsilon_{i,t} \quad for\ t=1,...T,\ i=1,...N \qquad 1$$

where, $NT_{i,t}$ represents per capital nutrient intake for i country at time t, which includes calories, proteins and fats intake; Δ is the differencing operator; $NT_{i,t-1}$ is the lagged initial value of $NT_{i,t}$; γ_i is parameter to be estimated that measures the convergence effect; and τ_{0t} denote the intercept to be estimated and $\varepsilon_{i,t}$ is the error term of the regression.

However, empirical investigation of equation of 1 can be carried out using panel unit root tests or panel regression approach. Both approaches are subsequently discussed.

Panel unit root test approach to convergence hypothesis

The convergence hypothesis in economic variables based on equation 1 can be tested using panel unit root test in what is referred to as stochastic convergence process as revealed by Carlino and Mills (1993), Bernhard and Durlauf (1995), and Evans and Karra (1996). According to Sondermann (2013), recent development in panel unit root tests allow for group-wise tests of convergence processes in economic data across countries and they have the advantage of providing a higher power through pooling of information across units compared to the univariate variant. In this respect,

convergence is assumed if the variable follows a stationary process (or no unit root), while presence of unit root implies a non-convergence process.

Generally speaking, there are two types of panel unit root tests in the literature namely the first and second-generation panel unit root tests. The first generation panel unit root is built on the assumption of cross-section dependent, while the second generation allows dependence to prevail across units in a panel (for detail discussion see: Breitung and Pesaran, 2007).

Thus, following the work of Angulo et al., (2001), Sondermann (2013), and De (2014), we investigate the convergence hypothesis in per capita nutrient intakes (i.e., calorie, protein and fat) using Pesaran's (2007) second-generation panel unit root test, which places the convergence hypothesis in an explicitly dynamic and stochastic environment. Unlike the first generation panel unit root test, Pesaran (2007) augments the standard Augmented Dickey-fuller (ADF) regression with the cross-sectional averages of lagged levels of the dependent variable called CADF test and the average of the differences of the dependent variable in the panel. Guided by this, we define Pesaran's (2007) second-generation unit root within the context of the present study as

$$\triangle NT_{i,t} = \gamma_i NT_{i,t-1} + \psi_i \overline{NT}_{i,t-1} + \varsigma_i \triangle \overline{NT}_{i,t} + \varepsilon_{i,t} \qquad for\ t=1,...T,\ i=1,...N \qquad 2$$

where $NT_{i,t}$ and $NT_{i,t-1}$ are as defined earlier; $\overline{NT}_{i,t-1}$ denotes lagged levels of the dependent variable; $\triangle \overline{NT}_{i,t}$ denotes the differences of the dependent variable; γ_i, ψ_i and ς_i denote parameters to be estimated, while $\varepsilon_{i,t}$ is the error term of the regression equation.

As noted by Sondermann (2013), the panel unit root test is exercised by pooling the individual CADF tests' p-values in line with the suggestion of Im *et al.,* (2003), while adjusted asymptotic results are tabulated in Pesaran (2007) both for the individual CADF test statistics and their panel unit root counterpart and the cross-section augmented IPS test (CIPS).

Panel regression approach to convergence hypothesis

Following the work of Bassanini et al., (2001), we examine the convergence hypothesis in per capita nutrient intakes using the regression approach defined below:

$$\triangle NT_{i,t} = \gamma_i NT_{i,t-1} + \delta_i x_{i,t} + \tau_i + \mu_t + \varepsilon_{i,t} \quad [5] \quad \textit{for } t=1,\ldots T,\ i=1,\ldots N \qquad 3$$

$NT_{i,t}$ and $NT_{i,t-1}$ are as defined earlier; $x_{i,t}$ represents structural variables likely to be associated with differences in $NT_{i,t}$ across countries such as per capita income, trade openness, per capital agricultural production and level of human capita (average years of education) among others; τ_i represents country specific fixed effect; μ_t represents time specific fixed effect; γ_i and δ_i denote parameters to be estimated, while γ_i represents the convergence parameters and $\varepsilon_{i,t}$ is a random error.

Intuitively, convergence exists if the coefficient γ_i of the lagged initial value of nutrient intakes $NT_{i,t-1}$ is negatively related to the growth of nutrients consume over time. Thus, a statistically significant o $\gamma_i < 0$ implies that convergence is in line with the neoclassical growth model.[6]

But a major problem associated with investigation of convergence processes using regression of equations 1 or 3 is the possible serial correlation between error terms across the period in the respective equations, which may likely bias the estimated parameters. Thus, with availability of alternative method in time series econometric such as panel unit root test described above, the impact of the problem on the

[5] Equation 3 is a typical conditional Beta-convergence growth model in recognition that certain factors represented by a matrix of country-specific variables $x_{i,t}$ in the equation may potentially facilitate convergence process in nutrient intake such as per capita income, trade openness, and per capita agricultural production among others across countries in SSA. Also it is possible that Beta-convergence exists among countries with similar structural characteristics, which give rise to unconditional convergence growth model where $x_{i,t}$=0, which give rise to equation 1. In this respect, attempt was made to estimate the conditional (i.e., equation 3) and unconditional (i.e., equation1) Beta-convergence models and both the results show that the estimates are similar.

[6] Alternative approach to Beta-convergence is the sigma-convergence, which holds when standard deviation of per capita dietary intake decrease in SSA is narrowing overtime. Meanwhile, unlike sigma-convergence, we employ Beta-convergence because most studies employ this approach in the literature.

parameter which explain the convergence process can be effectively minimize as we did in the present study.

4.2. *Response of per capita nutrient intakes to income: nutrient-income elasticities*

The study of how nutrient intake responds to income is in the recognition that knowledge of nutrient-income elasticities is critical in the design of policies to combat malnutrition in poor countries (Salois et al., 2012). Conversely, it is a common and well-accepted practice for researchers to investigate the relationship between nutrient intake and income under the implicit assumption of a linear relationship. Thus, in line with the first objective of the study, we first investigate the relationship using non-parametric plots following the previous studies such as Salois et al., (2012) and Abdulai and Aubert (2004). The plot is very useful in investigating whether the relationship is non-linear or not. Thereafter, we employ the econometric (panel regression) approach to further cast light on the response of per capita nutrient to changes in income in the study. But according to Ogundari and Abdulai (2013), the presence of nonlinearity often characterizes the nutrient-income relationship, as also demonstrated in many empirical studies (see for detail, Banks et al, 2007; Skoufias et al., 2009; Salois et al., 2012).

To this end, the present study relaxes the implicit linear assumption by modeling the response of nutrient intakes to changes in income using both the linear and nonlinear specifications, while providing appropriate econometric tests to investigate which functional form best fit the data for the study across the selected nutrients (i.e., calories, proteins and fats).

Since linear and quadratic specifications of the relationship between nutrient intakes and per capita income are nested in cubic specification, we specify the cubic functional relationship within the framework of aggregate Engel Curve for the study[7]. The choice of Engel curve is motivated by the fact that previous studies have shown that large changes in consumption patterns create difficulties in choosing appropriate weights for food prices (Dawson, 1998; Tiffin and Dawson, 2002). Besides, inclusion of weighted

[7] An Engel curve describes how consumer-spending behavior varies with income level, holding prices fixed.

price index in previous studies is significantly not different from zero, which motivated many authors to estimate parsimonious Engel curve with real per capita GDP as sole determinants of calorie intake (for detail see: Dawson, 1998; Tiffin and Dawson, 2002; Mustaq et al., 2007). In this respect, the effect of income on nutrient intakes at macro level has always been assessed using an Engel curve framework in the literature (see for detail: Dawson, 1998; Tiffin and Dawson, 2002; Mustaq et al., 2007;Salois et al., 2012 Ogundari and Nanseki, 2014; Phiri and Dube, 2014). Thus, the study estimates the nutrient intake responds to income using cubic-specification specified below

$$NT_{i,t} = \phi_{1i} y_{i,t} + \phi_{2i} y_{i,t}^2 + \phi_{3i} y_{i,t}^3 + \tau_i + \mu_t + \varepsilon_{i,t} \qquad for\ t=1,...T,\ i=1,...N \qquad 4$$

$NT_{i,t}$ represents per capita nutrient intake for i country at time t, which includes calories, protein and fats intake; $y_{i,t}$ represents per capita income for i country at time t; τ_i represents country specific fixed effect; μ_t represents time specific fixed effect; ϕ is the parameters to be estimated while $\varepsilon_{i,t}$ is the error time of the regression with $\varepsilon_{i,t} \sim N\left(0,\sigma^2\right)$ and $E\left(\varepsilon_{i,t},\varepsilon_{j,t}\right) = 0$ for all $i \neq j$.[8]

The nutrient-income elasticity from the cubic functional form can be computed using the expression below:

$$Nutrient - elasticty = \phi_1 + 2\phi_2\left[\overline{y_t}\right] + 3\phi_3\left[\overline{y_t}\right]^2 \qquad 5$$

where, $\overline{y_t}$ is the mean of per capita income across the period. Thus, in reference to equations 4 and 5, if $\phi_2 = \phi_3 = 0$ and $\phi_3 = 0$ it implies that linear and quadratic are best-fit functional forms, respectively, for the data rather than the cubic specification in the study.

Meanwhile, for the empirical analysis of equations 3 and 4, we employ the two-way fixed effect panel regression approach. The approach considers the inherent heterogeneity across countries in the region so as to control for bias associated with the country and time specific effects in the data.[9]

[8] The study also performs the test for serial correlation between the error terms across the period using Baltagi and Li (1995) and Woodridge (2002) test statistics. Both results reject the existence of serial correlation in the data.

[9] During the primary analysis, we found evidence of the existence of country-specific fixed effect in the data by performing an F-test for two-way fixed effect model vs. one-way fixed effect model and the result yields a p-value of

4.0. **Results and discussion**

4.1. *Convergence hypothesis in nutrient intakes*

The results of the first-generation panel unit root test proposed by Levin et al., (2002) and second-generation panel unit root test proposed by Pesaran (2007) employed to investigate the existence of convergence in nutrient intake in the study are presented in Table 2. Both tests were developed for dynamic panel models with the null hypothesis that the series are non-stationary (or with unit root).

However, the results from both tests reject the null hypothesis of no-convergence (or unit root), which thus suggest that per capita nutrient intakes across the SSA countries converged in the long run. Although not reported for brevity, the convergence result based on the panel regression approach also lends support to the unit root tests, which perhaps indicate that country idiosyncrasies have no place in consumer welfare behavior in SSA countries.[10] Likewise, the result of the nonparametric plots between growth of per capita nutrient intakes and its lagged level presented on the right hand side (RHS) of figures 1-3 also lend support to the observed convergence process in the study. Specifically, the plots show an inverse relationship between growth of per capita nutrient intakes and its lagged level.

Meanwhile, the evidence of nutrition convergence in SSA should not be treated as exceptional case. For example, a review of the literature shows that Angulo et al., (2001) investigates convergence process in the estimated calorie –income elasticities in UE countries suing cointegration approach. Specifically, the authors found evidence that indicates a very limited convergence in calorie-income elasticities between certain products and countries considered, which suggest that country idiosyncrasies still play an important role in consumer behavior un EU.

Furthermore, a review of the literature to investigate whether convergence exists in other economic variables related to dietary intake used in the present study shows that

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0.000, which shows that both country and time fixed effect are significantly different from zero in the data. Based on this, the study employ two-fixed model for the empirical analysis.

[10] The results of the regression approach can be requested from the author.

Thirtle et al., (2003) found no evidence of convergence in agricultural productivity among regions in Botswana, while Lusigi et al., (1998) although found no evidence in a full sample of 32 African countries, but found convergence for all the sub-regions conditional on education, infrastructure and share of agricultural GDP.

However, the existence of nutrition convergence in SSA observed in the present study is not an indication that food and nutrition insecurity or nutrition gap among countries in the region has disappeared. But rather, it is an indication that dietary intake tends towards equalization across SSA countries over time.[11] That is, disparity in per capita consumption of nutrients is declining, as growth in per capita nutrient intakes is identical in the long run across countries in the region. In this respect, the convergence process provides another parsimonious approach to understand long run improvements in consumer welfare, especially when welfare is defined in terms of growth in food and nutrition security over space and time.
Also, we would like to stress that this result does not mean that the pattern of food consumption in quantity is similar across SSA, but only indicates the tendency for growth in per capita nutrient intakes to homogenize or similar in the long run in the region.

While we acknowledge that SSA is traditionally a food deficit region, we equally believe various explanation could be propose for the observed nutrition convergence process in the present study, which include; *First*, after decades of decline in per capita food production, recent statistics have shown that growth in agricultural sector and economy as a whole has outpaced population growth in many countries in recent time in SSA (Chauvin et al., 2012). *Second*, armed conflicts have been reduced as regional and sub-regional institutions are being strengthened which provide a strong potential for agricultural production to respond better to macroeconomic environment in recent years the region. *Third*, unlike 1980s and earlier part of the 1990s when decrease in

[11] Alternatively, the result could as also be interpreted as evidence that welfare of countries with initial lower per capita nutrient is growing relative to that of countries with higher per capita nutrient over the years in the regions, especially when welfare is defined in terms of growth in food and nutrition security or measures over time.

food consumption has been attributed to the region's wide economic crisis and political instability, the dietary intake for majority of countries in SSA has been increasing since mid 1990s and afterward but steadily. As noted by Chauvin et al., (2012), in addition to the growing domestic food production, per capita food consumption in many of the SSA countries has been supported by increase in food import. But the authors concluded that the volume of food trade between SSA and the World has shown a decreasing food trade deficit growth, which implies that SSA is slowly regaining food self-sufficiency.

Meanwhile to further cast light on the results, we observed that the evidence of nutrition convergence is also supported from the historical data used in the present study as earlier mentioned in section 3.1. For example, across the pre-and post 2000s periods, we observe that 28% and 16% of the countries attained the minimum RDA for calorie and protein, respectively for the period 1975-1999, while 53% and 34% attained the minimum RDA for calorie and protein, respectively for the period 2000-2009. The implication of this is that 25% and 18% more countries have successful crossed over the minimum RDA for calorie and protein intakes, respectively since 2000 than the previous years in SSA, which probably suggest that nutrition convergence is implies in the data.

To sum up, we believe many challenges still need to be overcome if agricultural food production growth is to be intensified and sustain among SSA countries so as to promote food and nutrition security and subsequently ensure nutrition convergence process in the region. Some of the challenges include; lack of irrigation facilities and water management technique, lack of high yielding seeds, lack of infrastructural facilities like good road, electricity, etc., widening technology divide such as lack of improved seeds, fertilizer, etc., across countries, slow development of input and output market, extension and associated market service such as credit market, governance and institutional shortcoming in some countries, and HIV-AIDS and other diseases etc. However, implementation of policies and programs that addresses these challenges is likely to ensure adequate food production and perhaps food and nutrition security in the region.

In addition to the discussion on increase per capita food production to ensure nutrition convergence at national level in SSA, it is equally important to stress that within the countries in the region, a number of factors if not address could pose a serious problem in achieving this at the household level. As noted by Dawson (1997), a large number of households do not have access or entitlement to food purchase because of low income, or food prices are too high and the rich consequently outbid them etc. In this respect, the challenge is that government policies and programs should be design to guarantee capacity of households to access adequate food and nutrition security at all time in SSA countries.

4.2. *Nutrient –income elasticities*

The discussion on the response of nutrient intakes to changes in income or the relationship between per capita nutrient intakes and income in the study starts with the results of non-parametric plots presented on the left hand side (LHS) of Figures 1-3. The non-parametric plots show that per capita nutrient response to income to give an inverted U-shape, especially for calorie-income and fat-income. This, however, is consistent with the argument in the literature that the relationship between calorie-income is non-linear. The non-monotonicity of the response of per capita calorie intake to changes in income suggests that as income rises, a percentage increase in income is likely to give different percentage changes in calorie intakes in the region.

Meanwhile, we explore further the nutrient-income relationship using panel regression approach with necessary tests carried out to ascertain the best-fit functional form for the data. In this respect, estimated parameters for the various specifications are presented in Table A of the appendix, while estimated elasticities used in the subsequent discussion are presented in Table 2 with preferred elasticities being the one in bold. Conversely, we find that quadratic, cubic, and linear specifications represent the best-fit functional forms for calorie-income, protein-income and fats-income

relationships, respectively in the study.[12] The results of calorie and protein are consistent with the earlier result of the non-parametric curves that non-linear relationship characterized calorie-income relationships in the study. This indicates that per capita rise in income give rise to different calories and protein consumption, while it gives rise to the same percentage increase in fat intake. However, a look at the literature shows that the non-linear relationship between calorie-income and protein-income in the present study contradicts the work of Salois et al., (2012) who found a linear relationship for these nutrients.

Therefore, conditional on the best-fit functional form, the estimated nutrient-elasticities show that the response of fat intake to changes in income has the highest elasticity of about 0.118, followed by calories [0.103] and protein [0.099] as shown in Table 2. The implication of this is that a 10% increase in income will lead to about a 1.18%, 1.03%, and 0.99% rise in fats, calories, and proteins consumption, respectively in the region. However, a look at the literature shows that the estimates, especially the calorie-income elasticity in the present study, are lower than the country specific results obtained at the macroeconomic level in some SSA countries. These include 0.35 obtained in Zimbabwe by Tiffin and Dawson (2002), 0.33 in Nigeria by Ogundari and Nanseki (2014) and 0.15 by Phiri and Dube (2014).[13] Nevertheless, the estimated calorie-income elasticity is similar to the estimate obtained by similar cross-country studies for both the developed and developing countries, such as Salois et al., (2012), while both the protein and fat income elasticities are lower that the estimates obtained by the same authors. In a related development, we observe that the estimated calorie-income elasticity is higher than the estimate obtained by Dawson (1997) that employed cross-country data to analyse impact of per capita income, Gini-coefficient, and urbanization among others on calorie intake in both the developed and developing countries.

Meanwhile for the nutritional policy-makers responsible for the long-term policy decision to combat malnutrition in the society, the estimated nutrient elasticities in the

[12] Using F-statistics test, the results show that the most preferred specification for the response of nutrient intakes to changes in income vary significantly across the selected nutrients in the study.
[13] But as noted by Salois et al., (2012), studies using aggregate data tend to obtain smaller elasticities than those that use more micro-level data

present study are very modest in size (or small). The implication of this is that income enhancing economic growth policies could not alone decrease malnutrition or poverty but likely to alleviate malnutrition to a limited extent in SSA. In other words, attempt to improve nutritional in SSA countries cannot be confided to income growth or transfer only. Consequently, the joint influences of food prices, household demographic distributions, and household income have been identified as factors likely to enhance nutrient intakes in the literature by Abduali and Aubert (2004).

Looking at the role that a non-linear specification of the nutrient-income relationship plays in investigating whether nutrient intakes may give different consumption patterns with increases in per capita income, we revisit the consumer health implications of increasing consumption of certain macronutrients, in particular calories, at higher income levels in the study. In this respect, we test whether calorie-income with best fit quadratic specification and protein-income relationship with best fit cubic specification exhibit significant diminishing elasticities judging by the sign and significance of the second order term in the respective specifications. This is very important because if nutrient-income elasticity estimates, especially that of calorie intake, shows no indication of decreasing at higher income, then it displays the need for public health programs that can influence diets of the populace (Salois et al., 2012). Based on this, the results of the present study show that both calorie and protein-income relationships exhibit diminishing elasticities or less consumption at higher incomes. The implication of this is that control of diets because of diseases such as obesity epidemic due to increasing consumption of nutrients such as calories at higher income level is not an issue of concern at the regional level in the study.

5.0. **Concluding remarks**

The study examined the convergence hypothesis in nutrient intakes and the response of per capita nutrient intakes to changes in income, which cumulates into nutrient-income elasticities estimates from SSA. The empirical analysis was based on annual time series cum balanced panel data covering 1975-2009 from 43 countries.

The result of the convergence hypothesis shows that convergence exists in the selected nutrients (i.e., calories, proteins, and fats) in the study. The analysis also shows that the relationship between nutrient intakes and income was found to be non-linear for calories and protein but linear for fats. In addition, the response of per capita nutrient levels to changes in income (i.e., nutrient-income elasticities) is significantly positive but very modest (small) judging by the estimated elasticities, which fall below majority of existing studies. The implication of this is that policies such as income growth aimed at enhancing economic growth, may be insufficient at improving nutrition and welfare but likely to alleviate malnutrition to a limited extent in SSA. Other results show that estimated calorie-income and protein-income elasticities are significantly lower at higher incomes, which thus suggests that public programs to control diets because of diseases such as an obesity epidemic due to increasing consumption of macronutrient such as calorie at higher income is not a concern at macro level in SSA.

Above all, an important finding of this study for nutritional policy-makers as guide for regional food and nutrition security decision is the existence of nutrition convergence process in the SSA countries. The convergence indicates tendency towards equalization of per capita dietary intakes, which can be view as improvement in well being expressed in food and nutrition security (i.e., nutrient intakes) across countries in the region *ceteris paribus*. In this respect, the study suggests introduction of nutrition enhancing intervention programs as part of the long-term commitment to mainstream food and nutrition security in public policies across the countries in SSA. Besides, the study also suggest the introduction of agricultural programs designed to tackle the problem of agricultural food production development so as to improve per capita food production and subsequently per capita food consumption in the region.

Meanwhile, we acknowledge the limitations associated with the data used in the study, especially the use of per capita GDP as proxy for income and the use of FAO data for dietary intake, which may underestimate the nutrient elasticity. Nevertheless, we believe the results of the findings conform with the previous studies on the nutrient-

income relationship, especially at macroeconomic level and perhaps similar studies carried out at micro level across the globe.

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Tables

Table 1 A: Summary statistics per capita nutrient intakes and income, 1975-2009

Variable Name	*Pooled* N=1505	*1975-1979* N=215	*1980-1989* N=430	*1990-1999* N=430	*2000-2009* N=430
CALORIE *Kcal/capita/day*	2192.93 [308.05]	2115.76 [310.52]	2137.29 [307.76]	2169.18 [288.90]	2310.91 [292.92]
PROTEIN *g /capita/day*	55.35 [11.84]	54.11 [11.75]	54.22 [10.86]	54.31 [10.97]	58.15 [11.99]
FAT *g/capita/day*	46.55 [15.03]	42.19 [11.60]	43.38 [13.43]	46.75 [15.55]	51.72 [15.99]
GDP [Income] *PPP/capita*	2228.83 [3616.19]	2037.28 [2905.18]	2022.48 [2933.17]	2248.22 [3932.96]	2511.57 [4173.92]

Note: Figure in parenthesis represents standard deviation of the estimates; PPP stands for purchasing power parities.

Table 1B:Growth of per capita nutrient intake and income, 1975-2009

Variable Name	*Pooled*	*1975-1979*	*1980-1989*	*1990-1999*	*2000-2009*
CALORIE	0.3750 [3.3315]	0.3882 [3.4873]	0.0888 [4.1852]	0.3078 [3.3601]	0.7218 [1.9571]
PROTEIN	0.3574 [4.2364]	0.5660 [4.6427]	-0.0288 [4.7498]	0.1757 [4.2901]	0.8209 [3.2836]
FAT	0.6923 [6.9608]	0.3075 [6.1108]	0.1851 [7.8265]	0.8416 [7.7833]	1.2427 [5.3616]
GDP [Income]	0.4404 [7.5118]	0.4301 [6.9857]	-0.1515 [7.1522]	-0.2229 [9.3369]	1.7007 [5.7241]

Note: Growth rate is calculated as LOG[NT_t]-LOG[NT_{t-1}]; Figure in parenthesis represents standard deviation of the estimates

Table 2: Panel Unit root test for the convergence process in dietary intake

Variable Name	1st Generation panel unit root test [*Levin-Lin-Chiu, 2002 test*]		2nd Generation panel unit root test [*Pesaran, 2007, test*]	
	t-statistics	*Convergence*	*t-statistics*	*Convergence*
CALORIES	-17.5431	Convergence	-4.001	Convergence
PROTEINS	-18.8083	Convergence	-4.325	Convergence
FATS	-18.6676	Convergence	-4.334	Convergence

Note: H_0: Unit root in the series for both tests

Table 3: Computed Nutrient-Income elasticities across functional forms

Functional Forms	*Calories-Income*	*Proteins-Income*	*Fats-Income*
Linear Functional form	0.0969*** (0.0101)	0.1057 (0.0118)	**0.1183***(0.0153)**
Quadratic Functional form	**0.1029*** (0.0099)**	0.1092*** (0.0118)	0.1154*** (0.0153)
Cubic Functional form	0.1006*** (0.0102)	**0.0998***(0.0120)**	0.1174*** (0.0157)

*Figure in parenthesis represents standard error of the estimates; ***, **, and * imply significance at 1%, 5%, and 10%, respectively.*

Figures

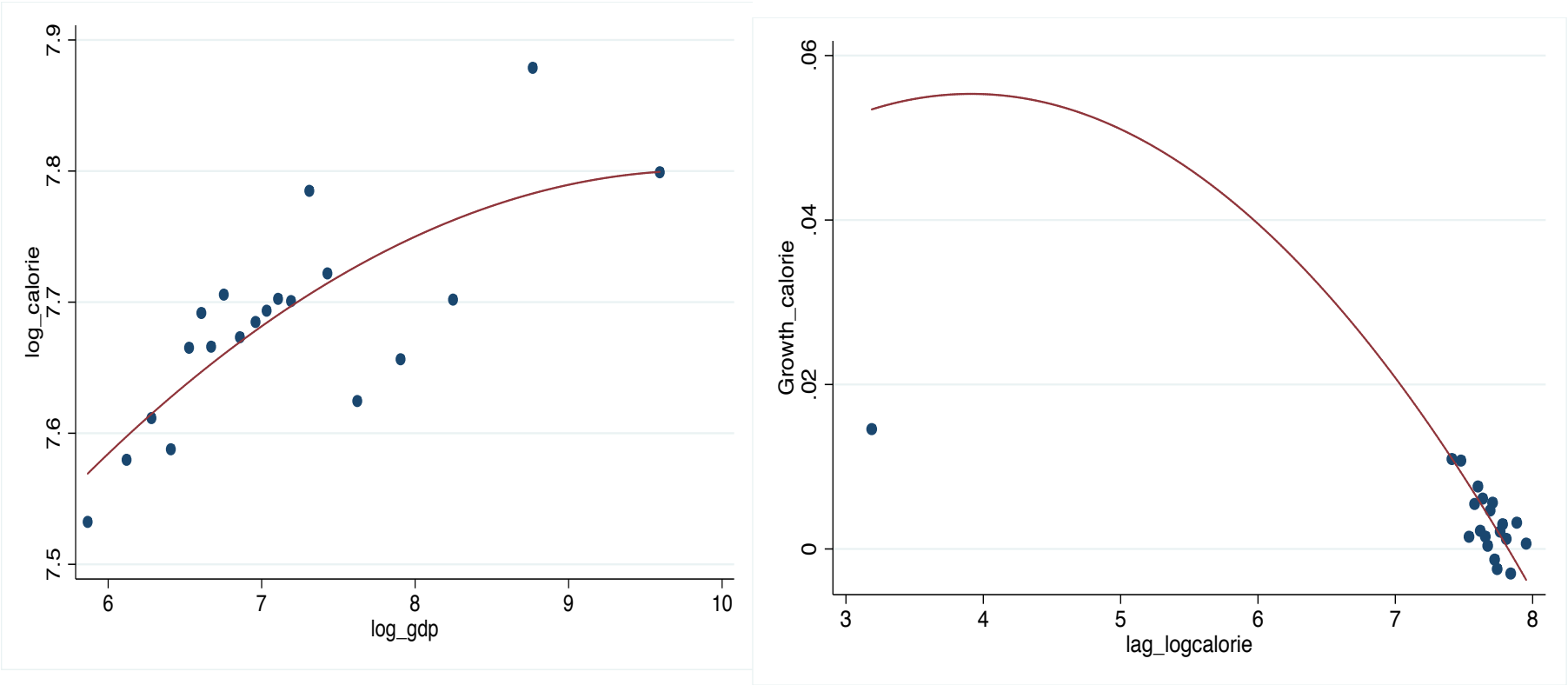


Figure 1: Log calorie consumption versus Log of income (LHS) and Growth of calorie consumption versus lagged log calorie consumption (RHS)

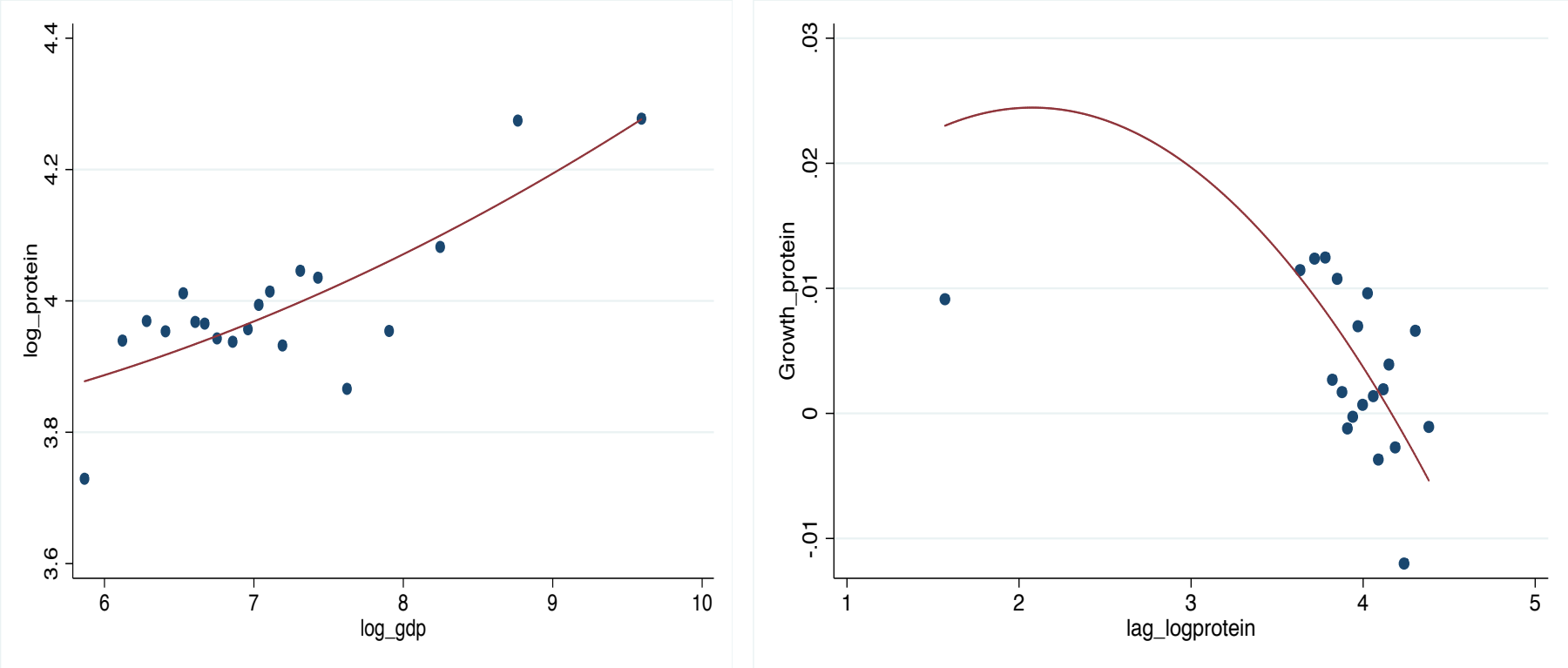


Figure 2: Log protein consumption versus Log of income (LHS) and Growth of protein consumption versus lagged of log protein consumption (RHS)

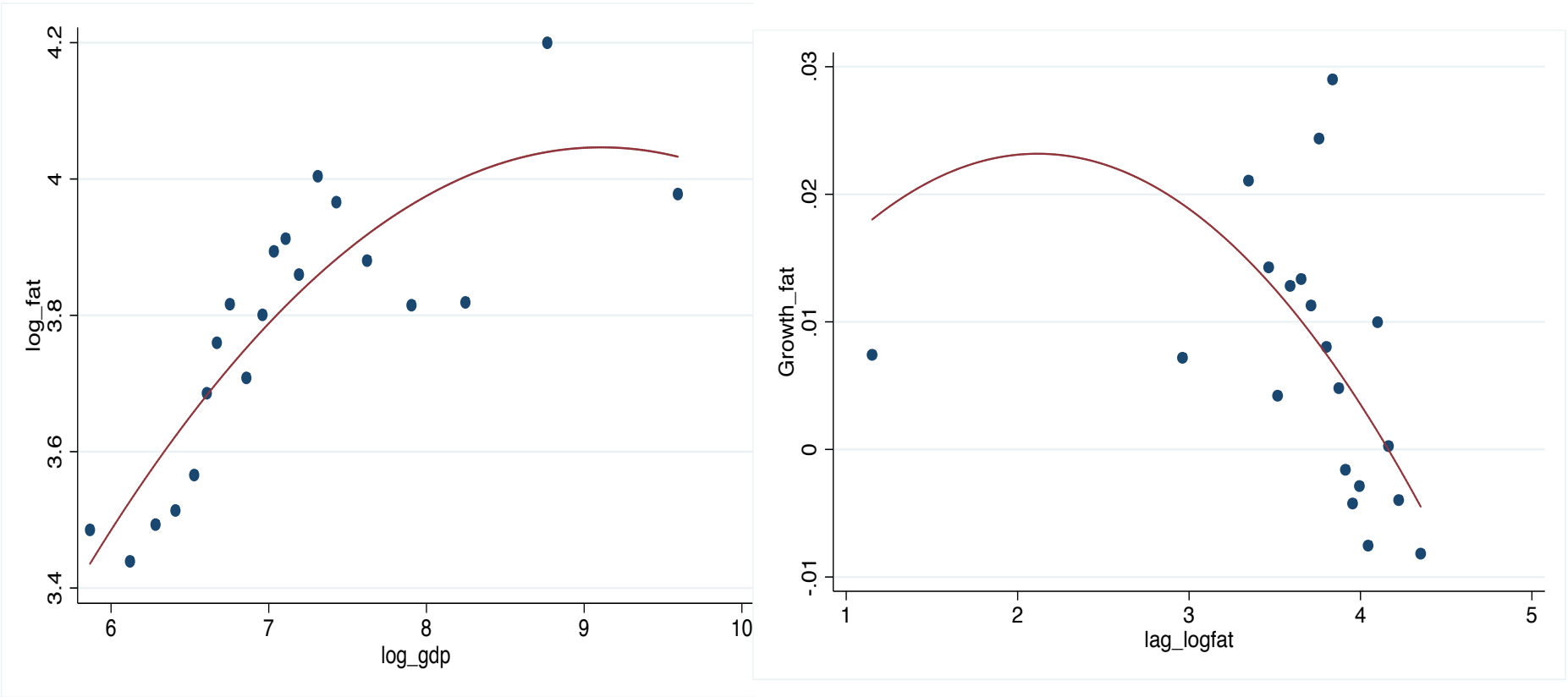
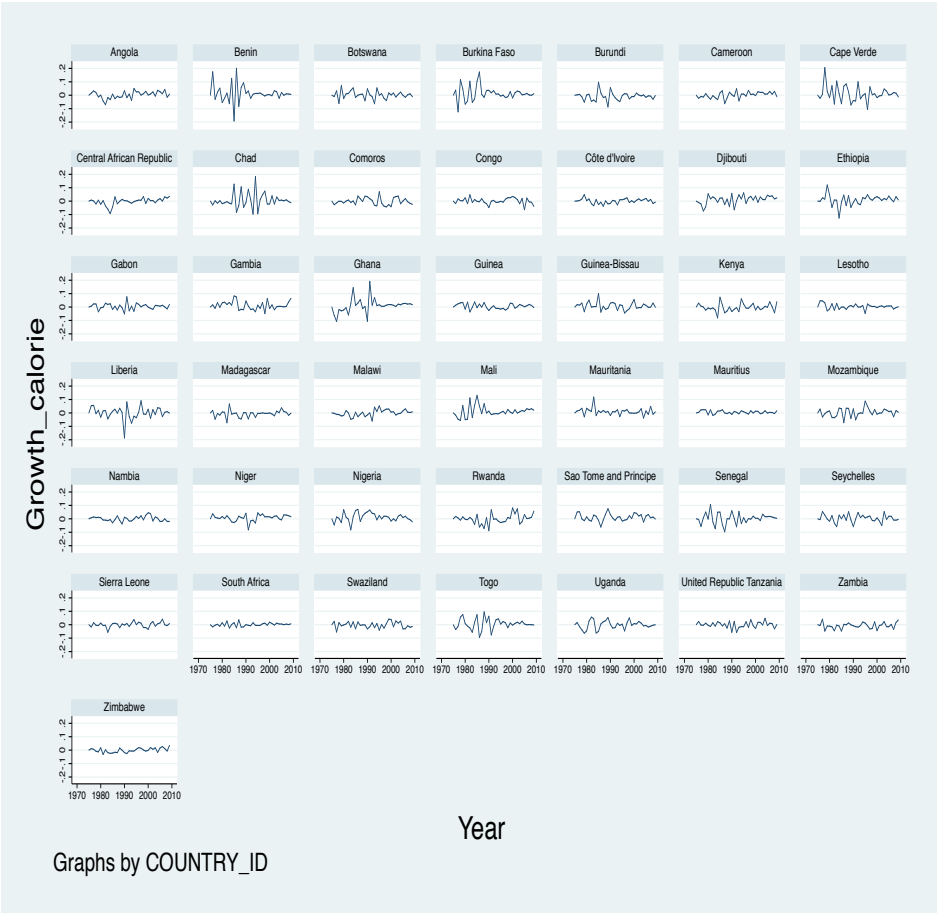


Figure 3: Log fat consumption versus Log of income (LHS) and Growth of Fat consumption versus lagged of log fat consumption (RHS)



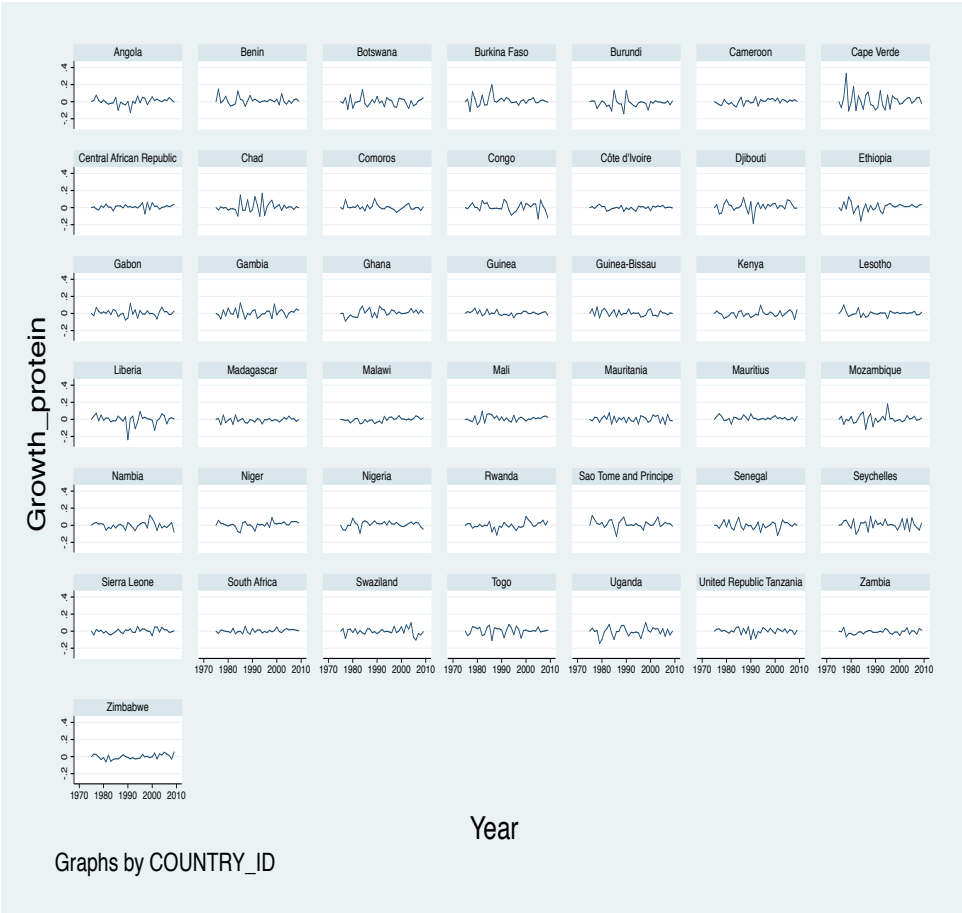


Figure 4: Distribution of Growth in the per capita calorie intake (LHS) and Growth in the per capita protein intake (RHS) across the SSA countries

Figure 5: Distribution of Growth in the per capita total fat intake across the SSA countries

Appendix

Table A: Functional response of nutrient intake to income across different functional forms in SSA

Variables	**Linear functional form**			**Quadratic functional form**			**Cubic functional form**		
	Calories	*Proteins*	*Fats*	*Calories*	*Proteins*	*Fats*	*Calories*	*Proteins*	*Fats*
Income	0.0969*** [0.0101]	0.1057*** [0.0118]	0.1183*** [0.0153]	0.5669*** [0.0697]	0.3889*** [0.0825]	-0.1088 [0.1076]	1.032** [0.4761]	2.3602*** [0.5609]	-0.5331 [0.7347]
$[\text{Income}]^2$	-	-	-	-0.0324*** [0.0048]	-0.0195*** [0.0056]	0.0157** [0.0073]	-0.0951 [0.0636]	-0.2851*** [0.0749]	0.0728 [0.0982]
$[\text{Income}]^3$	-	-	-	-	-	-	0.0027 [0.0028]	0.0117*** [0.0032]	-0.0025 [0.0043]
Country Fixed effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	6.6975*** [0.0802]	2.8525*** [0.0937]	2.7086*** [0.1219]	4.9985*** [0.2618]	1.8286*** [0.3096]	3.5293*** [0.4038]	3.8765*** [1.1662]	-2.9275** [1.3737]	4.5531*** [1.7994]
R-squared	0.6869	0.8007	0.8938	0.6967	0.8024	0.8941	0.6969	0.8041	0.8942
Adjusted R-squared	0.6700	0.7899	0.8881	0.6801	0.7916	0.8883	0.6801	0.7932	0.8883
F-statistics	40.65	74.45	155.96	42.00	74.22	154.40	41.48	74.04	152.38
# of observations	1505	1505	1505	1505	1505	1505	1505	1505	1505
# of countries	43	43	43	43	43	43	43	43	43

*Figure in parenthesis represents standard error of the estimates; ***, **, and * imply significance at 1%, 5%, and 10%, respectively.*