Income growth and malnutrition in Africa: Is there a need for region-specific policies?

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Abstract

Regional differences in dietary patterns, food supply, and food culture can influence the relationship between income and food demand and thus the impact of income-oriented policies on undernutrition across Africa. In order to test for evidence of regional differences in income elasticities for food demand in Africa, we conduct a meta-analysis using 1,768 food-income elasticity estimates for different categories of food, 324 nutrient-income elasticity estimates, and 103 calorie-income elasticity estimates, extracted from 66 studies covering 48 African countries. One key contribution of this study is that it considers nutrient- and food-income elasticities besides calorie-income elasticities, allowing us to explore issues relating to calorie (i.e. energy) deficiency as well as malnutrition. We find that heterogeneity in the income elasticities can be explained by both differences in primary study characteristics (e.g. data, methodology) and the characteristics of the countries to which the income elasticities refer. The findings for food groups suggest there are significant regional differences in the size of the income elasticities. Some of the regional differences can be related to differences in diet and food supply structures across Africa but there may be other factors captured by the geographic variables (e.g. socio-cultural practices). In terms of country-level characteristics, the demand for calories, nutrients, and food becomes less responsive to changes in income as countries become more urbanised. The effect of economic growth is complex and appears to vary according to the type of income elasticity. The overall food-income elasticity appears to decline with income growth, and the relation holds for cereals, dairy and fruit and vegetables, although it is weaker for the other main food groups. Interestingly, we find a positive relation between a country's economic growth and the magnitude of the nutrient-income elasticity and that economic growth is associated with increased demand for foods with greater nutrient content but fewer, or no additional, calories. Further country-specific analysis is needed to ensure that income-based policies targeting undernourishment and malnutrition in Africa achieve their goals.

Keywords Food demand; malnutrition; income elasticities; meta-analysis; Africa

JEL code Consumer Economics: Empirical Analysis (D12); Agricultural Policy; Food Policy (Q18).

1. Introduction

Official estimations indicate that over 200 million people in Africa are hungry (FAO IFAD and WFP, 2015). The nature and extent of food insecurity (in terms of undernourishment and/or malnutrition) varies across the continent with the countries most severely affected located in Sub-Saharan Africa (SSA). The share of undernourished people in SSA has declined (from 27.6% in 1990-1992 to 20.7% in 2010-2012), but at a considerably slower pace than in the rest of the developing world. Given that by 2050 the population of SSA is expected to double (UNPD, 2015), feeding the poor will remain an enormous challenge. Not only will the demand for food continue to rise, but also the composition of food demand will change with rising incomes and growing urbanisation contributing to changing diets (Popkin, 1994).

By and large, the existing literature on income and food demand has focused on the relationship between income and calorie consumption (i.e. calorie-income elasticities), while relatively few studies have considered the nutrient composition (e.g. fats, proteins, carbohydrates) of calorie consumption (Salois et al., 2012). Both dimensions - calorific intake and nutrient intake - are of significant policy interest. The distinction is important because many African countries face specific nutrient deficiencies (e.g. proteins, vitamins), despite normal, or close to normal, levels of calorie intake. The combat of malnutrition, with consequent detrimental impact on growth and development, therefore requires understanding the relationship between income growth and the change in the level of consumption of different nutrients as wells as calories (and different types of food).

Generally, food demand is income inelastic. The higher the elasticity, the more effective an income-oriented policy intervention is likely to be in combatting undernutrition, while a low elasticity indicates that income growth will affect food demand only to a limited extent and that other types of policy interventions may be needed. Studies have shown that the relationship between income and calorie consumption is not linear and that the increase in the demand for calories as a result of income growth becomes smaller as income levels become higher (i.e. reflecting Engel's Law). This is thought to result from the reaching of a saturation point in calorie consumption (e.g. Skoufias et al., 2011, Salois et al., 2012). Studies have also found evidence that increased income leads to a preference for higher quality foods and more diversified diets which may result in fewer calories (per unit of cost) than basic staple food diets (e.g. Skoufias et al., 2011) but could lead to better nutrition. Evidence for developed countries (and increasingly also for developing countries), however suggests that, overall, rising country income levels can lead to calorie overconsumption (leading to obesity) and bad (over)nutrition. In some developing countries, especially in their largest cities, the two realities of undernutrition and overnutrition often coexist, reflecting the "nutrition paradox" (Caballero, 2005). As income and urbanisation levels in African countries increase, it becomes crucial to consider the implications both for calorific intake and nutrient intake.

Overall, at a global level, projections point to both "trading up" (whereby consumption patterns shift as income levels increase towards high value protein rich meat and dairy products, more convenience foods) and "convergence" (whereby the consumption patterns in low-to-middle income countries converge, over time, towards the consumption patterns in high income countries). However, as Fabiosa (2011) notes, underlying these general trends, countries at similar stages of economic development have very different dietary patterns. This might be due to a variety of different factors including food supply structures, degree of urbanisation and, more generally, different cultures. It follows that the effectiveness of income-based policy mechanisms in addressing undernourishment and malnutrition is likely to vary across regions including across Africa.

Many African countries are proactive in the design and implementation of food policies and related programmes. These policies and programmes are often predicated on a need to address food insecurity, undernutrition (e.g. stunting, low birthweight) and disease among the poor, children, women and other vulnerable sections of their populations. Income-oriented macroeconomic policies relating to food demand normally involve indirect income transfers (taxing wealthier populations to subsidise food access for the poor), consumer taxes (taxing foods in the higher income bracket to support price reduction and stabilisation for nutritious staple foods) and tariffs and quotas on food imports (aimed at raising rents to support food access, or making prices of domestic produced foods competitive to support poor farmers) (Babu et al., 2014). Other policies have also included cash transfer (CT) programmes provided through international and/or national aid programmes (e.g. World Bank, national governments) to alleviate poverty and food insecurity (e.g. Garcia and Moore, 2012).

In this paper we examine the relation between income and food, calorie and nutrient demand in Africa through a systematic review of the existing literature to provide a better understanding of the relationship between income and food demand and how this varies across the regions of the continent. This in turn will provide a better basis for the design and implementation of policy mechanisms to address undernourishment and malnutrition in the context of ongoing challenges associated with population growth and rapid urbanisation. Through a meta-analysis approach, we aim to explain the large heterogeneity in income elasticities across the African continent in terms of country attributes, the specific food or nutrient categories considered, and the methodological characteristics of the data and estimation techniques. The paper draws on several recent review studies, including other meta-analyses of food demand (e.g. Bouis and Haddad, 1992, Salois et al., 2012, Ogundari and Abdulai, 2013, Zhou and Yu, 2014).[1] Yet, we extend the work in a number of ways. First, most review studies focused on the relation between income and calorie consumption. This study provides evidence for income elasticities associated with different types of food and nutrients, besides calories, in order to improve our understanding of the relationship between income and nutrition. The exception is Salois et al. (2012) who considered different nutrient-income elasticities (including carbohydrates, proteins and fats). However their analysis is based on a smaller sample and did not control for a number of methodological attributes which may also influence results. Second, we consider a comprehensive list of potential sources of variation in income elasticities, relating to the attributes of the primary studies as well as the countries they refer to. Previous reviews and meta-analyses have focused on either one set of factors or the other, but not the two simultaneously. Bouis and Haddad (1992) and Ogundari and Abdulai (2013) carried out detailed meta-analyses of calorie-income elasticities focusing only on the data and methodological attributes of the primary studies analysed to explain heterogeneity in estimated elasticities. By contrast, Zhou and Yu (2014) and Salois et al. (2012) focused on the relation between income level and income elasticity to explain different elasticity estimates, but did not control for (any) other potential sources of variation relating to differences in the data and methodology across primary studies. Moreover, some of the factors considered in our analysis, including urbanisation rates and the different geographical controls, were not analysed in previous studies. Finally, our analysis is different from previous reviews and meta-analyses in that it provides specific evidence for Africa. With the exception of Bouis and Haddad (1992), none of these studies have looked specifically at Africa or even exclusively at developing countries.

[1] Table A.1. in Appendix A provides a summary of the main features of previous review studies of calorie-income elasticities.

The remainder of the paper is organised as follows. Section 2 provides a summary of the data and research methods used in the analysis including the construction of the meta-sample of calorie-, food-, and nutrient-income elasticities, key descriptive statistics of the meta-sample, and meta-regression models. Section 3 presents and discusses the results from the meta-regression models, while Section 4 summarises the key findings and their implications for food policy.

2. Data and research methods

The research consisted of two stages. The first stage involved a systematic review of the relevant empirical literature and the construction of a meta-sample of income elasticities of food demand. The second part of the study consisted of a meta-regression analysis including sensitivity tests. The successful estimation of the meta-regressions (stage two) is strongly dependent on the quality of the meta-sample (stage one). This section describes the approach adopted in both stages and presents descriptive statistics from the meta-sample.

2.1. The meta-sample

To identify candidate the primary studies to include in the meta sample a search was carried out using a combination of terms including "nutrition and income elasticity", "food and income elasticity", "calorie-income elasticity" and the combination of "income elasticity" and "demand elasticity" with a list of keywords such as "developing countries", "Africa", "food", "calorie", "nutrition", type of food (e.g. "eggs", "dairy", "milk", "cereal", "fruit", "vegetable", "fish", "meat").[2] The search was carried out across various online databases including both published peer-reviewed literature (e.g. journal articles) and 'grey' literature (e.g. working papers, reports) in the economics, medical and nutrition discipline areas. The databases searched were: ISI Web of Knowledge, ScienceDirect, EconLit, PubMed, AJOL (African Journals Online), World Bank, AgEcon, USAID (US Agency for International Development), FAO (UN Food and Agriculture Organization, IFPRI (International Food Policy Research Institute), RePEc (Research Papers in Economics), Google Scholar). In addition, we also considered the references of primary studies included in previous review studies of food demand (e.g. Salois et al., 2012, Green et al., 2013, Ogundari and Abdulai, 2013, Zhou and Yu, 2014) as well as the references to studies of the calorie-income elasticity for developing countries listed in the literature review conducted by Bouis and Haddad (1992).

The selection process was first based on the relevance of the abstract to the research objectives. In particular, the decision to accept or reject the study was based on whether the abstract mentioned a combination of the words "food", "calorie", "nutrient", "income", and "elasticity". In situations of doubt, the studies were scanned for clarification. To avoid problems of comparability between income elasticity estimates, the search only considered unit-free elasticity estimates of food demand with respect to income. Where a study produced multiple income elasticities, we included all estimates in the meta-sample to increase sample size. Once a study was selected, a process of data extraction was initiated following a specific protocol about which attributes of the study to select (i.e. internal variables). These internal variables

[2] Given the focus on developing countries in Africa, we also specified the search terms in Portuguese, French and Spanish, besides English although, in the event, none were located. A subsequent search (after the completion of the meta-sample) using "AIDS" (Almost Ideal Demand System) as a search term found three studies written in French. We thus suggest that future similar studies consider using this search term.

describe attributes of the primary studies (e.g. type of publication, number of income elasticities) and attributes of the elasticity estimates (e.g. country, time period, nature of data, estimation technique) which are thought to help explain variability in the income elasticity estimates.

In addition to the attributes obtained directly from the primary studies, a number of variables obtained from sources external to the primary studies (e.g. FAO, World Bank) were added *a posteriori* to the meta-sample. The rationale for including these variables is that they may contribute to heterogeneity in the observed income elasticities. They include several geographic characteristics of countries (i.e. African regions, whether country is in the Sahel region, whether country is landlocked), the degree of urbanisation, and the country's income level (i.e. gross domestic product per capita). The variables and the reasons for their inclusion are described below while Table 1 provides a summary of all variables included in the meta-sample.

Geographic characteristics of countries

Differences between country's climatic and other geography-related characteristics (e.g. soils, elevation, etc.) may help explain part of the variability in income elasticities. As a result we created a set of indicators intending to capture potential heterogeneity across countries due to these features. Each country in our sample was assigned a region according to its membership of the five main regional economic organisations or the classification used by the United Nations Statistical Divisions (UNSD) (see Figure 1). The five regions identified (North, Southern, East, West and Central Africa) can also capture existing commonalities at the regional level in climate patterns and soil characteristics across countries, which in turn affect the suitability and yields of foods that are grown in the regions. This may have implications for prices and taste, and thus demand for locally grown foods as well as imported substitutes. Cultural influences and proclivities for foods are likely to be stronger across the countries making up a region. In addition, we included a second indicator based on whether a country is landlocked. For landlocked African countries, structural challenges in access to world markets are compounded by their reliance on neighbouring maritime countries for the import of goods. The administrative and transportation costs incurred on goods in transit through these neighbouring countries has implications for food prices (Dillon and Barrett, 2015) and hence for food demand and income elasticities, particularly for those foods in which the landlocked countries are not self-sufficient. Finally, we also included a third geographic characteristic with respect of whether a country is in the Sahel region of Africa. Countries in this region frequently face droughts and have a significant proportion of their landmass made up of semi-arid soil that is agriculturally difficult to manage. This situation has fostered significant food insecurity and recurrent famines in the region.

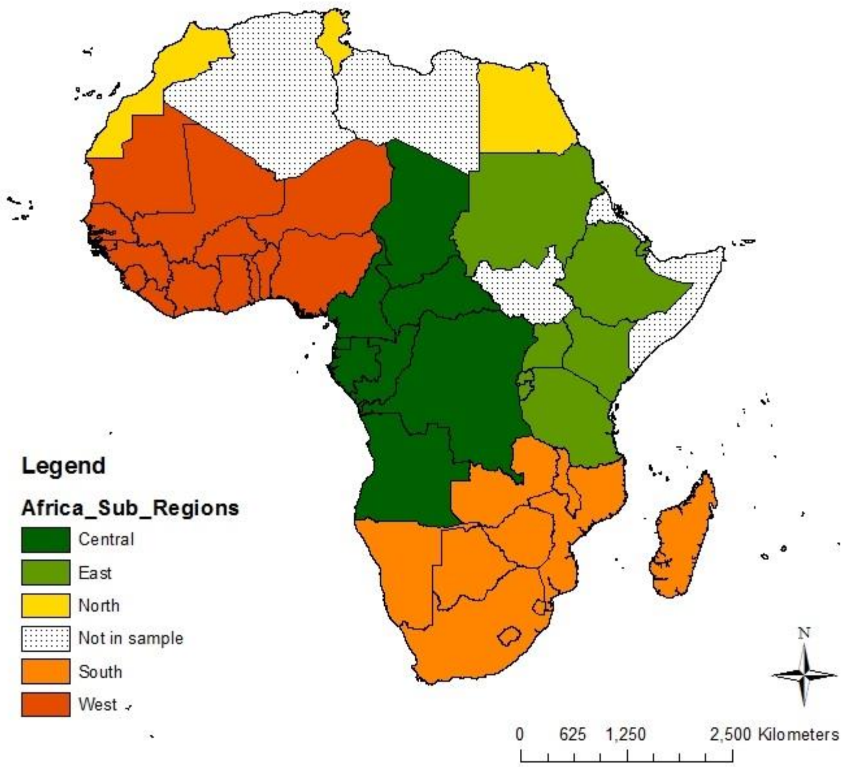

Figure 1. African regions studied in the meta-regression analysis.

Income level

As noted earlier the level of a country's income influences the amount and composition of its food demand. On average, individuals in low-income countries spend nearly half of their budgets on food, while individuals living in high-income countries spend only one-fifth of total income on food (Murcott et al., 2013). As a result, low income countries may be more responsive to volatility in food prices and income shocks especially for the high value products. To account for the role of country's income level in the size on the income elasticity of food demand, we therefore include gross domestic product per capita (GDP pc, in constant 2005 dollar terms) from the World Bank's WDI database as a proxy for the national income level. For studies using panel and time series data, we take the average of these incomes for the period of the data in the underlying study.

Urbanisation

Urbanisation influences food demand in three main ways (Regmi and Dyck, 2001). First, urban lifestyles are typically sedentary whilst rural lifestyles are labour intensive. As a result, calorie requirements in rural diets are greater, leading to greater dependence on calorie rich foods such as tubers, cereals and coarse grains. Second, rural livelihoods are typically based on subsistence agriculture and the ability of households to diversify the composition of their diets is constrained by the amount, as well as marketability, of their produce. Rural diets are therefore often dominated by households' own produce, which is often based on high yielding calorie-rich tubers, cereals and grains. In contrast, urban households typically purchase their foods and are exposed to a wider array of food choice. This leads to greater diet diversification. Thirdly, the opportunity cost of time for women in urban locations is typically higher than in rural areas, leading to greater percentage of women working outside the home. This increases the dependence of households on foods sold outside the home (e.g. street fast foods, supermarket readymade food). In rural locations, foods are mostly home cooked as women engage in domesticated occupations, often linked to agriculture. For these reasons, countries with higher urbanisation rates are expected to face a smaller overall demand for calorie-rich foods such as tubers, cereals and grains, and increase in the demand for protein-based foods such as meat, fish, eggs and dairy products, and other types of foods (e.g. fruits, vegetables). We include a measure of urbanisation based on the percentage of population living in urban areas. This is high in countries such as Nigeria and South Africa which have very large and densely populated mega cities. Urbanisation data were taken from the World Development Indicators dataset (World Bank WDI, 2015). For studies using panel and time series data, the average for the period of the data in the underlying study is used.

Food consumption and production structure

Income elasticities are also likely to differ between foods that are very common (i.e. foods traditionally produced in the country) and foods perceived as luxurious or aspirational. In order to capture which types of food can be considered as ‘basic’, we hoped to consider the extent to which a country’s diet is dominated by certain types of foods using data for the share of a certain food in the total food consumption based on the FAO food balances for African countries. Unfortunately, this measure was only available for more recent periods and hence, due to missing values, it could not be included in the meta-regression models. Nevertheless, we attempt to relate the results for regional differences in income elasticities to current food consumption and production patterns across African regions (see Figure C.1 and Figure C.2 in Appendix C).

Table 1: List of variables included in the meta-sample.

Variables in meta-sample	Description
Study level attributes (Z)	
Type of publication	peer reviewed journal, report from international organisation, working paper/conference paper
Number of income elasticity estimates	number of income elasticities produced in the study
Estimate level attributes (X)	
Food group	beverages, cereals, meat, fish, eggs, fruit and vegetables, dairy, fat and oils, tubers and staples, legumes and nuts, other
Nutrient group	carbohydrates, fats, minerals, vitamins, proteins
Time period	pre-1990, 1991/1995, 1996/2000, 2001/2005, 2006/2015
Source of data	primary or secondary data
Nature of data	household/individual data, aggregate data
Structure of data	time series, cross-sectional, panel data
Geographical coverage – country	country to which the income elasticity refers to
Geographical coverage – type of area	all areas, rural area, urban area
Consumption measure	monetary value (expenditure) or quantity
Income measure	income data or total expenditure
Type of demand model	single-equation, demand system
Type of estimator	OLS, panel data random-effects, panel data fixed-effects, IV
Standard error	standard error of the income elasticity estimate
Sample size	number of observations used to estimate the income elasticity

Variables in meta-sample	Description
Country-specific variables (Y)	
African regions	north, central, east, west, southern
Landlock indicator	whether the country is landlocked
Sahel region indicator	whether the country is in the Sahel region
Income level	Gross Domestic Product per capita (GDPpc)
Urbanisation	percentage of population in urban areas

2.2. The meta-regression model

In order to test for regional differences in the relationship between income and food demand, we estimate separate meta-regressions for each type of income elasticity and for different food groups when sample sizes are sufficiently large. The specification of the models is based on the study- and estimate-specific attributes and country-specific attributes listed in Table 1. The regression model can be described as follows:

$$\varepsilon_{ij} = \sum_{m=1}^{M} \beta_m Z_{mj} + \sum_{k=1}^{K} \alpha_k X_{ki} + \sum_{n=1}^{N} \beta_n Y_{ni(c)} + \nu_{ij} \quad (1)$$

where ε_{ij} is the value of the estimate of the income elasticity, *i* denotes the elasticity estimate and *j* identifies the study to which the elasticity estimate belongs to.

- Z_{mj} represents the *m* variables that contain the attributes of study *j* hypothesised to explain part of the variation in the value of the income elasticity, while β_m estimates the impact of each of the *m* variables (m=1,2,…,M). These variables are constant within multiple-estimate studies;
- X_{ki} represents the *k* variables that contain the attributes of the individual elasticity estimate *i* hypothesised to explain part of the variation in the value of the income elasticity, while α_k estimates the impact of each of the *k* variables (k=1,2,…,K). Some of these variables may vary within multiple-estimate studies (e.g. type of statistical estimator), while other variables may be constant (e.g. type of data used);
- $Y_{ni(c)}$ represents the *n* country-level variables, which measure the effect of country's *c* attributes (e.g. income level, urbanisation level) on the income elasticity estimate *i*. β_n estimates the impact of each of the *n* country-level variables (n=1,2,…,N);
- Finally, ν_{ij} is the error term, which is assumed to be normally distributed while allowing for heteroskedasticity and clustering at the study level.

The model above can be estimated using pooled Ordinary Least Squares (OLS), or panel data estimators based on random-effects and fixed-effects to take account of *between*- and *within*-study variation. The advantage of the panel data estimators is that they can control for possible study-specific unobserved heterogeneity not captured explicitly in the meta-regression model by (i) the study-level variables Z_{mj} and (ii) the estimate-level variables X_{ki} that do not vary within study. Generally, researchers tend to prefer the fixed-effects estimator over the random-effects estimator to avoid possible endogeneity bias due to correlation between unit-specific (i.e. study-specific) unobserved heterogeneity and the model covariates. However, using unit fixed-effects (i.e. for each individual study) can result in a loss of variation in the estimation in the presence of covariates that have little or no within-study variation (i.e. variables that are constant within studies). This is the case of our meta-sample, which contains multiple-estimate studies. For these reasons, the fixed-effects estimator is not deemed appropriate and hence we use only pooled OLS and random-effects estimators.

2.3. Description of the meta-sample

The meta-sample includes income elasticities from 66 primary studies, covering 48 out of 54 African countries, providing a total of 2,195 elasticity estimates: 1,768 estimates of food-income elasticities, 324 estimates of nutrient-income elasticities, and 103 estimates of calorie-income elasticities[3]. To avoid potentially biased results due to bad data we excluded those estimates of the income elasticities considered to be outliers where the latter were identified by inspecting the distribution of the estimates of the income elasticity for foods, nutrients and calories and the most extreme observations for the bottom and top percentiles and how they fit with the overall distribution of the income elasticities. Appendix B lists the primary studies included in the meta-sample. Of the 66 studies included, 43 are studies which have not been included in previous meta-analyses. 11 studies were produced by international organisations (IO), 10 are working papers, while the remaining 45 are studies published in peer reviewed journals. Although the vast majority of studies account for a very small part of the meta-sample, four studies alone represent 58% of the whole sample, with one study (Muhammad et al., 2011) representing 21% of the whole sample.

Table 2 provides a summary of some of the main features of the meta-sample. Of the three categories of food demand (foodstuffs, nutrients and calories), the number of reported elasticities attributed to foodstuffs was by far the majority, constituting about 81% of the observations. The number of elasticities attributed to calorie intake contributes the least number of observations, about 5%, with the remaining 14% attributed to nutrients. Overall, the mean of the income elasticities is higher for foods (0.67), followed by nutrients (0.50) and calories (0.40). The coefficients of variation (CV) indicate that overall there is greater dispersion in the data for the calorie-income elasticities (0.77), followed by food-income elasticities (0.72) and nutrient-income elasticities (0.61). With the exception of foods, the majority of income elasticities were obtained from peer reviewed journals (79% for nutrients and 59% for calories against only 38% for foods). Generally, the mean of the income elasticities obtained from peer reviewed journals is smaller than that obtained from grey literature, but this difference is weaker for calories.

There appear to be relatively large differences in the magnitude of the income elasticities between African regions. Data for food demand indicate that the mean value of the income elasticity is the largest for Central Africa (0.79) and smallest for North and West Africa (0.59). As for nutrients, the table also shows that the mean income elasticity is highest for Central Africa (0.75) and smallest for West Africa (0.37). A similar pattern is observed for calories: the mean income elasticity is highest for Central Africa (0.81) and lowest for West Africa (0.28). Evidence for differences in the mean of income elasticities between landlocked/non-landlocked and Sahelian/non-Sahelian countries in mixed across the three categories of food demand (foodstuffs, nutrients and calories) and does not lend itself to easily identifiable patterns.

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[3] Although a total of 2,101 unique elasticities were extracted, the sum of elasticity estimates for foods, nutrients and calories (i.e. 2,195) exceeds this total due to overlaps in some estimates. For example, elasticities for foods differentiated by nutrients are classified as food as well as nutrient elasticities, resulting in duplicates.

The main food groups are: beverages, cereals, dairy, fat and oil, fruits and vegetables, legumes and nuts, meat fish and eggs, and tubers and staple foods. Overall, the food groups with the lowest mean income elasticities are those that would normally constitute the basis of a basic diet (i.e. staples, legumes and nuts, cereals,), with elasticities ranging between 0.41 and 0.46, whilst those with the highest elasticities would typically be supplements to basic diet requirements in most African countries (i.e. meat, fish and eggs, dairy products and beverages), with elasticities ranging between 0.83 and 1.26.

The main nutrient groups are: carbohydrates, minerals, vitamins, proteins and fats. The mean income elasticity is lowest for carbohydrates (0.31), which is reasonable given that carbohydrates constitute the basic components of most African diets (cereals, tubers, etc.). On the other hand, vitamins, minerals, protein and fat based products (e.g. meat, fish, eggs, nuts, dairy) are supplementary to the diets of most African households and are seen as high income household products. It is therefore as expected that the income elasticity for these nutrients is higher.

Table 2: Summary statistics of meta-sample.

Income elasticities	Number	Share (%)	Mean	CV
Food-income elasticities	**1,768**	**100%**	**0.671**	**0.72**
By type of publication				
peer reviewed journal article	675	38%	0.556	1.03
report	923	52%	0.740	0.50
working papers/conference papers	170	10%	0.759	0.73
By food group				
Beverages	92	5%	1.260	0.33
Cereals	365	21%	0.427	1.03
Dairy	114	6%	0.830	0.22
Fat and oil	112	6%	0.599	0.35
Fruits and vegetables	206	12%	0.618	0.46
Legumes and nuts	121	7%	0.405	1.00
Meat, fish, eggs	327	18%	0.851	0.51
Staple foods and Tubers	139	8%	0.464	0.93
Other*	292	17%	0.801	0.76
By African region				
Central Africa	160	9%	0.787	0.52
East Africa	274	15%	0.692	0.48
North Africa	167	9%	0.598	0.34
Southern Africa	500	28%	0.766	0.72
West Africa	667	38%	0.582	0.90
By Landlocked indicator				
Landlocked	565	32%	0.731	0.60
Non-landlocked	1,203	68%	0.643	0.78
By Sahel region indicator				
Sahel	119	7%	0.710	0.60
Non-Sahel	1,649	93%	0.668	0.73
Nutrient-income elasticities	**324**	**100%**	**0.501**	**0.61**
By type of publication				

Income elasticities	Number	Share (%)	Mean	CV
peer reviewed journal article	256	79%	0.454	0.66
report	68	21%	0.680	0.37
working papers/conference papers	0	0%	n/a	n/a
By nutrient group				
Carbohydrates	36	11%	0.311	0.86
Minerals	95	29%	0.480	0.61
Vitamins	138	43%	0.571	0.52
Proteins	37	11%	0.470	0.68
Fats	18	6%	0.520	0.60
By African region				
Central Africa	60	19%	0.745	0.26
East Africa	25	8%	0.565	0.63
North Africa	0	0%	n/a	n/a
Southern Africa	48	15%	0.685	0.39
West Africa	191	59%	0.370	0.70
By Landlocked indicator				
Landlocked	74	23%	0.587	0.54
Non-landlocked	250	77%	0.476	0.63
By Sahel region indicator				
Sahel	20	6%	0.278	0.82
Non-Sahel	304	94%	0.516	0.59
Calorie-income elasticities	**103**	**100%**	**0.404**	**0.77**
By type of publication				
peer reviewed journal article	61	59%	0.403	0.70
report	15	15%	0.482	0.67
working papers/conference papers	27	26%	0.365	1.00
By African region				
Central Africa	6	6%	0.806	0.21
East Africa	45	44%	0.410	0.62
North Africa	3	3%	0.527	0.35
Southern Africa	7	7%	0.703	0.35
West Africa	42	41%	0.283	1.12
By Landlocked indicator				
Landlocked	38	37%	0.359	0.88
Non-landlocked	65	63%	0.431	0.71
By Sahel region indicator				
Sahel	16	16%	0.244	0.98
Non-Sahel	87	84%	0.434	0.72

* includes sugar and sweets.
Notes: n/a: not applicable. CV: coefficient of variation.

3. Results and discussion

3.1. Findings from the meta-regression analysis

This section presents and discusses the main results obtained from the meta-regression models for calorie-income elasticities (Table 3), nutrient-income elasticities (Table 4), and the pooled food-income elasticities (Table 5); the results for the different foods are reported in Table D.1. in Appendix D. We present the results for both pooled OLS and random-effects (RE) estimators and two model specifications which differ in terms of the geographical variables they include: model (1) considers the African regions (i.e. North, Central, West, East, and Southern Africa), while model (2) focuses on the regional classification into Sahelian/non-Sahelian and landlocked/non-landlocked countries. Because there is some overlap between these regional groupings, we treat them separately. The discussion of the main findings is based on the preferred estimator, which was selected using the Breusch-Pagan Lagrange Multiplier (LM) test for random effects. By and large we could not reject the null hypothesis that the variance between units (i.e. studies) is zero, therefore concluding that there are no significant differences between studies and that the pooled OLS is appropriate.

The main objective is to assess whether there are significant and considerable differences across African regions, countries and their characteristics, after controlling for other internal sources of variation in the estimated income elasticities, and consider the implications for calorific and nutritional intake. As a result, the discussion is focused on the variables relating to African regions, country income level (i.e. GDP pc), and degree of urbanisation. Nevertheless, we also provide a brief summary of the key findings with respect to the study- and estimate-specific factors at the end of this section.

Calorie-income elasticities

In Table 3, the coefficient for country's GDP per capita has the expected negative sign, indicating that as countries grow the magnitude of the calorie-income elasticities declines. However, the effect is not statistically significant and hence we cannot confirm the prediction that the demand for food becomes less responsive to income increases as incomes grow. It is possible that the small sample size of less than 100 observations may help explain the lack of statistical significance. This result does not mean that there will be no differences in the response of calorie demand to income changes between different groups of the population (e.g. poor vs. rich households). It should also be noted that the fact that the calorie-income elasticity is not changing with rising country incomes does not mean that income-targeted policies will be ineffective in improving calorie intake. The latter depends on the level of the elasticity which - as we discuss further below - varies between regions. Table 3 also shows that as countries become more urbanised, the demand for calories becomes less responsive to changes in households' income. This finding is in agreement with our hypothesis for the effect of increased urbanisation on the demand for calories (and foodstuffs), as discussed in section 2.1.

There appear to be interesting differences in the size of the calorie-income elasticity across African regions, but not between Sahelian/non-Sahelian and landlocked/non-landlocked countries. Figure 2 shows that the mean value of the predicted calorie-income elasticity ranges between 0.22 for West Africa and 0.81 for Central Africa, with intermediate values for Southern Africa (0.77), North Africa (0.53), and East Africa (0.41). This suggests that policies targeting calorie intake through income augmentation are likely to have mixed results across Africa, with expected lowest effectiveness for countries in West Africa and East Africa. This again is not surprising as these two regions have the highest per capita production of calorie-rich tubers (behind Central Africa) and calorie-rich cereals (behind North Africa) (see Figure C.2 in Appendix C).

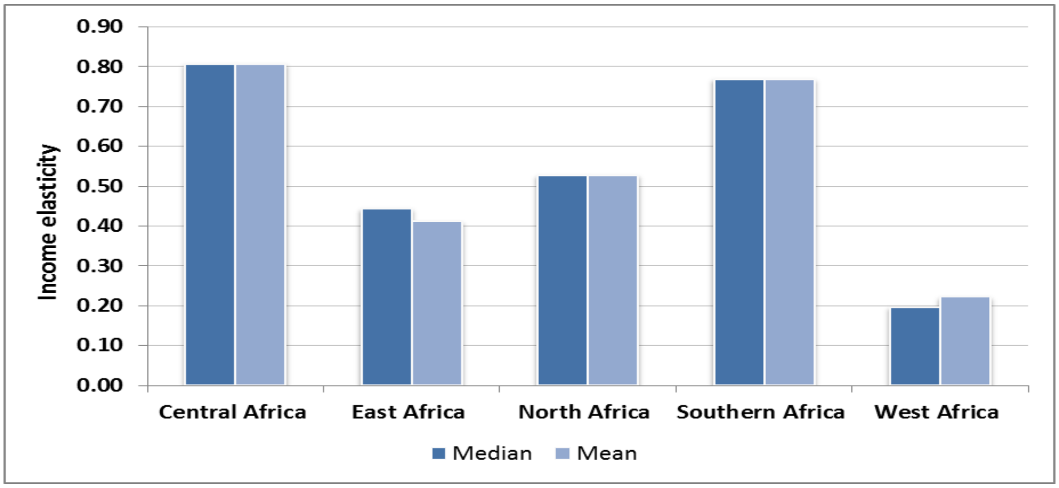

Figure 2. Predicted calorie-income elasticities by African region.

Nutrient-income elasticities

Understanding the relation between calorie intake and income is not sufficient if the ultimate goal of development policies is to improve the nutritional status of diets. This is particularly important in the context of the 'nutrition transition' resulting from the shift in caloric intake towards fat-rich and sugar-rich diets as a result of economic growth and increasing household incomes. Consequently, reducing malnutrition (i.e. both under- and over-nutrition) requires a better understanding of the relationship between changes in income and the composition of diets measured by the demand for different nutrients and types of foods.

The results reported in Table 4 indicate there is a positive relation between country's economic growth (i.e. GDP pc) and the size of the nutrient-income elasticity. This suggests that unlike calorie consumption, the demand for nutrients may become more responsive to changes in income. One possible explanation for this result is that increased income may shift consumption towards more diversified foods with greater nutrient content (e.g. Logan, 2006). Even if this is the case, we would expect the effect to play out differently depending on the type of nutrient. To explore possible differences, we estimated additional regression models with an interaction between GDP per capita and the the different nutrients. The positive relation seems to hold for all nutrients, except fats for which the income elasticity falls with increased GDP per capita. The effect of increased GDP per capita on the income elasticity is stronger for the demand for vitamins, followed by minerals, proteins and carbohydrates (all with similar values).[4] These results suggest that economic growth may in fact be associated with a beneficial shift in the nutritional status of diets.

Table 4 also shows some interesting differences in the size of the nutrient-income elasticity across nutrient macro-components. The mean of the predicted income elasticities is the lowest for carbohydrates (0.31), followed by proteins (0.47), minerals (0.48), fats (0.52) and vitamins (0.57). These figures can be related to certain types of foods and seem to align reasonably well with the expectation of lower income elasticities for cheap(er) calorie-rich foods such as cereals, tubers and staples (all containing mostly carbohydrates). However, these effects may differ across Africa as a result of differences in food diets and/or production patterns. Unfortunately, the small sample sizes of the different nutrient macro-components did not allow us to investigate possible regional differences for separate nutrient macro-components (we can only do

[4] The full set of results from the extended model with interaction terms between GDP per capita and the different nutrients can be obtained from the authors upon request.

this for the main groups of foods, as discussed below). Finally, as with calorie consumption, the results indicate that the nutrient-income elasticity becomes smaller as countries become more urbanised.

Food-income elasticities

The results for the pooled foodstuffs are presented in Table 5. There is a significant relation between economic growth and the demand for food: the food-income elasticity declines with income growth (GDP per capita). This relation also holds for cereals, dairy and fruit and vegetables, but is weaker for the other main food groups (Table D.1 in Appendix D). This result is again in line with the idea of a saturation point for food consumption and the reduction in the share of food in households' budget as income levels increase. However, there is no convincing evidence that income elasticities of demand for food in more urbanised countries are lower (both for all foods and different types of foods). The means of the predicted income elasticities also suggests that, overall, the demand for food appears to be more responsive to changes in income for beverages (1.26), meat, fish and eggs (0.83) and dairy (0.83), and less responsive for foods which tend to constitute basic diets such as cereals (0.43), tubers and staples (0.46) and legumes and nuts (0.40). This trend is generally in line with expectations with respect to the nature of demand for cheaper calorie-rich products (typically making up basic diets) versus more sophisticated and/or aspirational foods, including animal products (Macdiarmid et al., 2016).

To explore whether, and if so how, the relation between food demand and income differs across African regions, we now consider the results obtained from the models focusing on the separate food groups. The findings are summarised in Figure 3 (and reported in Table D.1. in Appendix D). We tested for regional differences for the main food group: cereals; dairy; fruits and vegetables; legumes and nuts; meat, fish and eggs; and tubers and staples. Unfortunately, due to the unbalanced coverage of countries across African regions in the analysis of tubers and staples and legumes and nuts, the results presented for these two food groups require careful interpretation.[5]

Figure 3 shows the mean of the predicted income elasticities for different food groups: there appear to be significant differences between African regions. As noted above, the seemingly remarkable differences in the mean values shown for tubers and staples and legumes and nuts should be interpreted with care due to the unbalanced representation of countries across regions. The discussion focuses therefore on the other four main groups of foods: cereals, dairy, fruits and vegetables, and meat, fish, and eggs.

The predicted income elasticity for cereals is highest for the countries in Central Africa and lowest for countries in North and West Africa (Figure 3). This result can be related to regional differences in diet composition and food production as shown in Figure C.1 and Figure C.2 respectively (see Appendix C): the size of the income elasticity tends to be smaller for the regions with the higher levels of consumption of cereals (i.e. North, West, South), and, although to a smaller extent, the higher levels of per capita production of cereals (e.g. North, West). This suggests that the demand for cereals is less responsive to changes in income for countries with higher consumption (and to some extent production) of cereals. The regional differences in the size of the income elasticity of the demand for dairy appear to be smaller and there is no clear relation between the magnitude of the elasticity and regional differences in food

[5] Unlike the other four main food groups, there were regions represented by only one or two countries in the regressions for tubers and staples (no data for north Africa, 1 country in central Africa, 1 country in east Africa, 2 countries in southern Africa) and legumes and nuts (1 country in central and east Africa, 2 countries in other regions).

consumption/production as shown in figures C.1-C.2. The elasticity estimate is lowest for North Africa, which is also the region with the highest level of consumption and production of dairy. This association, however, does not apply neatly to the other African regions. The regional differences in the size of the income elasticity of the demand for fruits and vegetables shown in Figure 3 do not tend to be statistically significant, except for Central Africa with a significantly higher elasticity estimate. There appears to be no immediate relation between these results and the pattern of fruit and vegetable consumption/production shown in figures C.1-C.2. The income elasticity of demand for meat, fish and eggs is lower for countries in North Africa, compared to other regions of Africa, but overall the differences are relatively small between regions. There is not obvious relation between these results and patterns of food consumption and production of these products across African regions.

All in all, the mean of the predicted income elasticities shown in Figure 3 indicate that the same relative increase in household income level is likely to produce different effects across African regions. Keeping all other things constant, an increase of 10 percent in household income levels for North Africa would lead to a greater relative increase in the consumption of dairy (7.5%), meat, fish, and eggs, and fruits and vegetables (6%), and smaller relative increase in the consumption of cereals (4%) and legumes and nuts (3%). An increase of 10 percent in household income levels for Central Africa would lead to a larger relative consumption of cereals (9%), meat, fish, and eggs (8.5%), dairy (8%), fruits and vegetables (7%), but only a 3% increase in the consumption of legumes and nuts. An increase of 10 percent in household income levels for East Africa would lead to larger relative increases in the consumption of dairy (9%), meat, fish, and eggs (8%), cereals (6.5%), and legumes and nuts (6%), and a smaller relative increase in the consumption of fruits and vegetables (4%). An increase of 10 percent in household income levels for Southern Africa would lead to larger relative increases in the consumption of meat, fish and eggs (9%) and dairy (8.5%), followed by fruits and vegetables and legumes and nuts (circa 6%), and cereals (4.5%). Finally, an increase of 10 percent in household income levels for West Africa would be associated with a larger relative increase in the demand for meat, fish, and eggs and dairy (8.5%), and fruits and vegetables (7%), and a smaller relative increase in the demand for cereals (3%) and legumes and nuts (2%). These figures reveal some similarities across regions, notably that income elasticities tend to be relatively larger for meat, fish, and eggs and dairy produce, and relatively smaller for fruits and vegetables. The main difference across regions refers to cereals, which has larger income elasticities for Central Africa and, although to a smaller extent, East Africa, compared to considerably lower values for North Africa, West Africa, and Southern Africa.

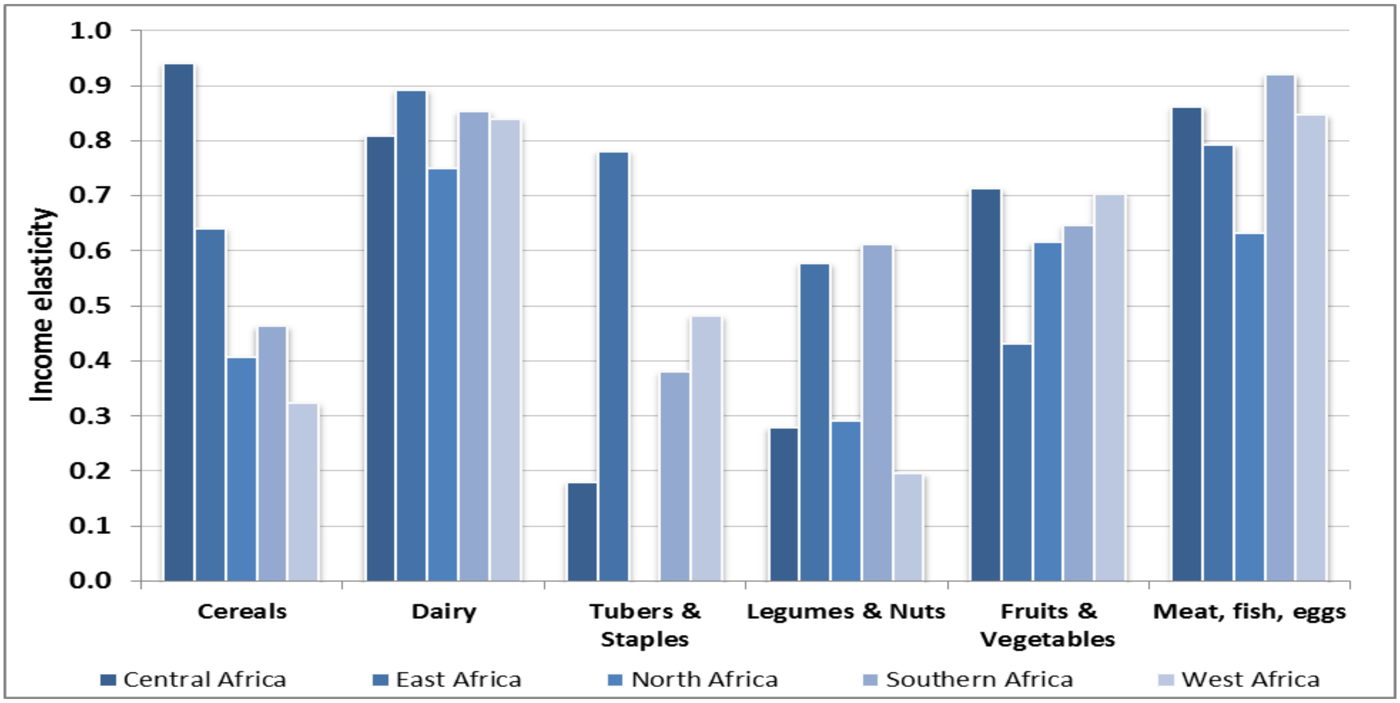

Figure 3. Predicted food-income elasticities for different groups by African region.

Sources of heterogeneity relating to primary study characteristics

Finally, we provide a brief summary of what appear to be the main sources of heterogeneity (i.e. variability) in the income elasticities as a result of differences in the data and methodologies used in the different primary studies. The summary refers only to the calorie-income elasticities (Table 3) and focusses on comparisons with the results from previous meta-analyses.

In common with Ogundari and Abdulai (2013) and Zhou and Yu (2014), we find evidence of lower calorie-income elasticities when studies use household expenditure as a proxy for income. Likewise we also find, like Bouis and Haddad (1992), that calorie-income elasticities tend to be smaller when based on actual calorie consumption as compared to expenditure on food (i.e. expenditure surveys). This effect was not tested by Ogundari and Abdulai (2013), and was not statistically significant in the meta-analysis carried out by Zhou and Yu (2014). Like Ogundari and Abdulai (2013) we do not find significant differences in the magnitude of the calorie-income elasticity between journals and 'grey' literature. This contrasts with Zhou and Yu (2014) who find that the elasticities tend to be higher for journals, followed by working papers, and lowest for reports and/or book chapters. The structure of the data (i.e. cross section, panel data, time series) has previously been found to be associated with differences in the size of the calorie-income elasticity (Ogundari and Abdulai, (2013); Zhou and Yu, (2014) but is generally insignificant in our analysis. Similarly, there are no significant differences in our study on the effect of using different estimators.

Unlike the previous meta-analysis, our study tested for changes in the magnitude of the calorie-income elasticity over time by comparing the estimates produced using data for the following periods: pre-1990, 1991-1995, 1996-2000, 2001-2005, and 2006-2015, and between type of area (i.e. rural, urban, whole country/region). The results suggest that overall the magnitude of the calorie-income elasticity appears to have remained fairly stable up to 2005, while it seems to have experienced a considerably increase in the latest period (i.e. 2006-2015). However, the increase in 2006-2015 may be unrepresentative because this specific period accounts only for 3% of the observations in the sample of calorie-income elasticities. As for the effect of type of area, the results suggest that the elasticities produced using data for rural areas, or urban areas, separately tend to be higher than those produced using aggregate data for regions or the whole country without discriminating between types of areas. The size of the calorie-income elasticity seems to be slightly higher for urban areas than rural, which is somewhat unexpected, but this difference could result in part from differences in the income segment (i.e. low, middle, high) of the households covered in the respective primary studies.

Table 3: Results from the meta-regression of income elasticities for calories

Reference	**Variable**	**Model (1)**		**Model (2)**	
		OLS	**RE**	**OLS**	**RE**
Type of publication (ref: journal)	Report	-0.0905	-0.0905	-0.2734**	-0.2436**
	Working paper	0.0834	0.0834	0.0249	0.0423
Structure of data (ref: cross-sectional)	Panel	0.1433	0.1433*	-0.0017	0.0186
Time period (ref: 1991/95)	1996/00	0.5400**	0.5400***	0.4493*	0.3439
	2001/05	0.4902***	0.4902***	0.4774**	0.4360**
	2006/15	0.8541***	0.8541***	0.6753**	0.6187**
	Pre-1990	0.5098**	0.5098**	0.6146**	0.5715**
Type of area/region (ref: rural/urban)	Rural	0.3375***	0.3375***	0.1825	0.1432
	Urban	0.3884***	0.3884***	0.1939	0.1495
Income measure (ref: expenditure)	Income	-0.5713***	-0.5713***	-0.3992***	-0.4173***
Consumption measure (ref: expenditure)	Quantity	-0.2066**	-0.2066***	-0.2783***	-0.2554***
Demand model (ref: Single equation)	Demand system	-0.0827	-0.0827	0.1309	0.1399*
Estimator (ref: IV)	FD/FE/GMM	0.0048	0.0048	0.1567**	0.1169**
	LS/ML	0.024	0.024	0.0938	0.0576
Region (ref: North Africa)	Central Africa	-0.8234***	-0.8234***		
	East Africa	-1.0385***	-1.0385***		
	Southern Africa	-0.9981***	-0.9981***		
	West Africa	-0.9613***	-0.9613***		
Country is in Sahelian region				0.1382	0.1303
Country is landlocked				-0.0714	-0.0403
Country's income level (i.e. logarithm of GDP pc)		-0.2187	-0.2187	-0.2886	-0.2666
Country's urbanisation level (% people in cities)		-0.0112**	-0.0112**	-0.0005	0.0002
Constant		2.5185***	2.5185***	1.7915*	1.7277*
Number of observations		98	98	98	98
Number of studies		24	24	24	24
Number of countries		12	12	12	12
Breusch-Pagan LM test		0.000 (1.000)		0.21 (0.3236)	
R^2 – overall		0.61	0.61	0.53	0.52
R^2 – between			0.91		0.83
R^2 – within			0.01		0.01
sigma_u			0.00		0.10

*- level of significance at 10%; **- level of significance at 5%; ***- level of significance at 1%. Standard errors are corrected for heteroskedasticity and clustering at the study level.

Table 4: Results from the meta-regression of income elasticities for nutrients

Reference	Variable	Model (1)		Model (2)	
		OLS	RE	OLS	RE
Type of publication (ref: journal)	Report	-0.0274	0.3050***	0.3984***	-0.6047***
Carbohydrates	Fats	0.1764**	0.1764***	0.1764**	0.1764***
	Minerals	0.0688**	0.0688***	0.0688**	0.0688***
	Proteins	0.0657**	0.0657**	0.0657**	0.0657**
	Vitamins	0.0868**	0.0868***	0.0868**	0.0868***
Structure of data (ref: cross-sectional)	Panel		-0.6648***		
Time period (ref: 1996/00)	Pre-1990				
	2001/05	0.7738***	0.4414***	-0.0517	-0.0819
Type of area/region (ref: rural/urban)	Rural	-0.0131	-0.0131	-0.0131	-0.0131
	Urban				
Income measure (ref: expenditure)	Income			-1.4009***	-1.5353***
Consumption measure (ref: expenditure)	Quantity				-1.2415***
Demand model (ref: Single equation)	Demand system	0.9029***	-0.0943	0.2588**	-0.0486
Estimator (ref: IV)	LS/ML	0.1273	-0.5376***		
Region (ref: West Africa)	East Africa	0.2951	-0.3697***		
	Southern Africa	-0.6914***	-0.3590***		
Country is in Sahelian region				0.1147	1.1390***
Country is landlocked				0.6425***	0.0656***
Country's income level (i.e. logarithm of GDP pc)		0.2937***	0.2937***	1.5654***	0.4236***
Country's urbanisation level (% people in cities)		-0.0275***	-0.0275***	0.0120***	-0.0235***
Constant		-1.6620***		-8.8112***	
Number of observations		324	324	324	324
Number of studies		7	7	7	7
Number of countries		8	8	8	8
Breusch-Pagan LM test		0.000 (1.000)		0.000 (1.000)	
R^2 – overall		0.36	0.36	0.36	0.36
R^2 – between			1.00		1.00
R^2 – within			0.03		0.03
sigma_u			0.00		0.00

*- level of significance at 10%; **- level of significance at 5%; ***- level of significance at 1%. Standard errors are corrected for heteroskedasticity and clustering at the study level.

Table 5: Results from the meta-regression of income elasticities for all foods

Variables		Model (1)		Model (2)	
		OLS	RE	OLS	RE
Type of publication (ref: journal)	Report	0.0739	0.0488	0.0613	0.0502
	Working paper	0.2827***	0.3206***	0.2159***	0.2987***
Food group (ref: meat, fish and eggs)	Beverages	0.4362***	0.4305***	0.4375***	0.4309***
	Cereals	-0.2792***	-0.2857***	-0.2835***	-0.2837***
	Dairy	-0.0051	-0.0067	-0.0047	-0.0059
	Fat and oil	-0.2374***	-0.2573***	-0.2331***	-0.2560***
	Fruits and vegetables	-0.2387***	-0.2566***	-0.2355***	-0.2551***
	Legumes and nuts	-0.3569***	-0.3555***	-0.3580***	-0.3545***
	Other	-0.0007	-0.0287	0.0049	-0.0269
	Tubers	-0.2271*	-0.2358*	-0.2258*	-0.2341*
Structure of data (ref: cross-sectional)	Panel	-0.1806*	-0.0126	-0.1197	-0.0061
	Time series	-0.6728***	-0.5091***	-0.6303***	-0.5315***
Structure of data (ref: aggregate)	Micro	0.0233	-0.0462	0.0263	-0.0323
Time period (ref: 1991/95)	Pre-1990	-0.4599*	-0.4411	-0.3599	
	1996/00	-0.3821***	-0.2292*	-0.4032***	-0.2638**
	2001/05	-0.3072***	-0.1963	-0.2960***	-0.1889
	2006/15	0.0065	0.1388	-0.0625	0.1072
Type of area/region (ref: rural/urban)	Rural	0.0437	0.0347	0.0707	0.0268
	Urban	-0.1532	-0.1409**	-0.121	-0.1502**
Income measure (ref: expenditure)	Income	-0.1277**	-0.0386	-0.1627***	-0.0424
Consumption measure (ref: expenditure)	Quantity	0.0449	0.0479	0.0192	0.025
Demand model (ref: Single equation)	Demand system	-0.0743	0.1487	-0.0225	0.1353
Estimator (ref: IV)	FD/FE/GMM				0.4292
	LS/ML	-0.4920***	-0.4580***	-0.4457***	-0.052
Region (ref: North Africa)	Central Africa	0.1865***	0.1014***		
	East Africa	0.0232	0.0340**		
	Southern Africa	0.1555**	0.0689***		
	West Africa	0.0586	0.0451***		
Country is in Sahelian region				-0.0881	-0.0412***
Country is landlocked				0.0068	0.0352***
Country's income level (i.e. logarithm of GDP pc)		-0.0895***	-0.0667***	-0.0677***	-0.0613***
Country's urbanisation level (% people in cities)		0.001	-0.0008**	0.0002	-0.0006**
Constant		2.0991***	1.7003***	2.0075***	1.3258***
Number of observations		1754	1754	1754	1754
Number of studies		34	34	34	34
Number of countries		47	47	47	47
Breusch-Pagan LM test		1.62 (0.18)		12.93 (0.0010)	
R^2 – overall		0.32	0.29	0.32	0.29
R^2 – between			0.50		0.49
R^2 – within			0.18		0.18
sigma_u			0.37		0.30

*- level of significance at 10%; **- level of significance at 5%; ***- level of significance at 1%. Standard errors are corrected for heteroskedasticity and clustering at the study level.

3.2. Sensitivity analysis

This section explores the robustness of the results by assessing (i) the degree to which they are affected by study-related heteroskedasticity (due to differences in the accuracy of the elasticity estimates) and (ii) possible publication bias. For space reasons, we discuss only the main findings, but the full set of results can be obtained from the authors upon request. One way of addressing the first problem is to give greater weight to more reliable elasticity estimates using their respective variances (e.g. standard errors) in a weighted least squares (WLS) regression model. However, because there are only 120 income elasticity estimates with data available for respective standard errors, we adopted an inferior approach which consists of weighting each individual income elasticity by the (square root) of the sample size used to estimate it. The idea is that the statistical power increases with sample size, that is, the t-statistic (absolute) value increases with sample size and is proportional to the square root of the degrees of freedom (e.g. Card and Krueger, 1995). The weighted least squares (WLS) regression indicates that overall the results replicate those reported in section 4.1.

Publication bias arises when the publication of research depends on its findings, particularly on whether they are in agreement with a certain (expected or preferred) theory or hypothesis (e.g. Florax, 2001, Stanley, 2005). Including studies from grey literature may help reduce the risk of publication bias, but does not guarantee a representative meta-sample since researchers may also chose to report only some of their 'preferable' results for non-scientific reasons (i.e. file drawer effect). One simple sensitivity test can be to consider the impact of including separate categories for type of publication (e.g. peer reviewed studies vs. 'grey' literature) or type of research sponsor (e.g. academic institution vs. international organisation). The presence of significant differences between groups may be indicative of publication bias. A more systematic test of publication bias is to include the standard error of the income elasticity in the meta-regression (e.g. Knell and Stix, 2005, Rose and Stanley, 2005). As noted above, only 120 estimates of the income elasticities included in the meta-sample also had a standard error associated with it, making it unfeasible to test for possible publication bias. Therefore, we carried out two simple tests, the first considered the relation between the elasticity estimate and its standard error for both peer reviewed journals and working papers simultaneously, while the second allowed the relation between income elasticity estimate and standard error to vary according to the type of publication. The results from both tests found no evidence that publication bias is an issue in the empirical literature.

4. Conclusion

The aim of this paper was to provide a better understanding of the relationship between income and the demand of different types of food, nutrients, and calories in Africa, focussing in particular on whether the relationship differs across regions. This will help in understanding the effectiveness of domestic policies in the fight against undernourishment and malnutrition. A major contribution of the study is the creation of a database of income elasticities which can be used (and improved) by other researchers. The meta-sample database contains 2,195 unique elasticity estimates drawn from 66 studies, covering 48 out of 54 African countries: 1,768 food-income elasticity estimates for different categories of food, 324 nutrient-income elasticity estimates, and 103 calorie-income elasticity estimates. In addition to variables capturing differences in the data and methodology in each of the primary studies, the analysis also includes several country-specific variables thought to potentially explain the heterogeneity across income elasticities. In particular, in addition to income level, which was also used by Zhou and Yu (2014), we include the country's urbanisation rate and three geographical indicators

One of the key contributions of this study, compared to the two previous meta-analyses of income elasticities, is that it considers nutrient- and food-income elasticities besides calorie-income elasticities. Focusing solely on calorie-income elasticities is limiting because it does not provide insights on the potential for substitution between nutrients and foods - as described in the form of, for example, the "nutrition transition" and "nutrition paradox" - as a result of changes in income levels. Furthermore, as development policies move from simply targeting calorie (i.e. energy) intake to improving the quality of diets,it becomes crucial to have a better understanding of the response of nutrient(s) and food(s) consumption to changes in income.

Meta-regression models were developed using the meta-sample for calorie-, nutrient-, and food-income elasticities (for all foods and separate types of food). The results show that the heterogeneity in the income elasticities can be explained both by differences in primary study characteristics (e.g. data, methodology) and differences in the characteristics of the countries for which the income elasticities were estimated. Like previous review studies of calorie-income elasticities, we also find that some features of the primary studies help explain variability, particularly with respect to the definition of 'income' (i.e. actual income or household expenditure) and 'consumption' (i.e. based on actual consumption or derived from food expenditure). On the other hand, we do not find significant differences in the calorie-income elasticities relating to type of publication, data structure, or type of estimator.

The relation between economic growth (measured in terms of country's GDP per capita) and the magnitude of the income elasticities is not clear and seems to differ depending on whether we are looking at calories, nutrients or different foods. While the calorie-income elasticities are not statistically significant, there appears to be a significant relation between country's economic development and the food- and nutrient-income elasticities. The overall food-income elasticity appears to decline with income growth, and the relation holds for cereals, dairy and fruit and vegetables, although it is weaker for the other main food groups. Interestingly, we find a positive relation between country's economic growth and the magnitude of the nutrient-income elasticity, indicating that unlike for calorie consumption the demand for nutrients may become more responsive to changes in income. One possible explanation is that the saturation point predicted for calorie intake, as a result of increased incomes, may not have a one-to-one translation to nutrients. Increased incomes may shift consumption towards more diversified, and often more expensive, foods with greater nutrient content but fewer, or no additional, calories. Moreover, this effect seems to play out differently across nutrient macro-components. The effect of increased GDP per capita on the income elasticity is stronger for the demand for vitamins, followed by minerals, proteins and carbohydrates (all with similar values). These results suggest that economic growth may in fact be associated with a beneficial shift in the nutritional status of diets.

We find that differences between African regions (captured by the geographical indicator) also help explain the variability in the income elasticities of types of foods. In some cases, for example for cereals, these differences can be related to regional differences in food consumption and production across Africa, but there is no clear or straightforward correspondence for other food groups. It is difficult to know exactly what aspects are being captured by the geographical indicator. Some of the aspects covered relate to differences in climate and soil, with possible implications for food production and consumption structures. However, there may be other influences captured by the regional dummies that are influencing the findings, including differences in the nature of agriculture across different regions (e.g. the share of subsistence farmers versus farm labourers in rural areas), cultural differences which influence food demand patterns (including religion), and critically differences in the governance of agricultural markets across African countries. Further analysis including more country-specific variables hypothesised as influencing the relationship between changing incomes and food demand would be useful. follow up to the findings presented. Nevertheless, and even though it is not possible to distinguish between the effects (if any) of these factors on the income elasticities, the results confirm that a similar policy intervention targeting income augmentation is likely to have varying results on food demand depending on the country in which it is introduced.

As for the country-level characteristics, we find that differences in a country's economic growth (measured by GDP per capita), degree of urbanisation and regional geographic affiliation also help explain the variability in the income elasticities, but the results can vary according to the type of income elasticity (i.e. calorie, nutrient, foodstuffs) and the relations are generally more complex for nutrients and foodstuffs. We find that the response of consumption of calories, nutrients, and food to changes in income decline with increased urbanisation levels, although the effect is not statistically significant for all types of foods. This finding is reasonable because households in urban areas tend to have more diversified diets, while rural households in Africa tend to be more dependent on a narrower range of foods obtained through subsistence agriculture. Differences in the mix of household income segments between rural and urban areas may also help explain the result: assuming higher income households sort spatially in favour of urban areas, increased urbanisation is also associated with a greater than proportional concentration of higher income households in urban areas, which in turn is associated with lower income elasticities (because the share of income spent on food is smaller for richer households than for poorer households). While recognising the need for further research, the results confirm that the impact of income-based policy mechanisms on the consumption of calories, nutrients and foodstuffs, will vary across Africa. It thus provides a useful basis for the design of future policies targeted at reducing undernourishment and malnutrition in the context of growing populations, urbanisation and climate uncertainty.

References

BABU, S., GAJANAN, S. N. & SANYAL, P. 2014. *Food security, poverty and nutrition policy analysis: statistical methods and applications*, Academic Press.

BOUIS, H. E. & HADDAD, L. J. 1992. Are estimates of calorie-income elasticities too high?: A recalibration of the plausible range. *Journal of Development Economics,* 39**,** 333-364.

CABALLERO, B. 2005. A Nutrition Paradox — Underweight and Obesity in Developing Countries. *New England Journal of Medicine,* 352**,** 1514-1516.

CARD, D. & KRUEGER, A. B. 1995. Time-Series Minimum-Wage Studies: A Meta-Analysis. *The American Economic Review,* 85**,** 238-243.

FAO IFAD AND WFP 2015. The State of Food Insecurity in the World 2015.Meeting the 2015 international hunger targets: taking stock of uneven progress. . Rome: FAO.

FLORAX, R. J. C. M. 2001. Methodological Pitfalls in Meta-Analysis: Publication Bias. *Research Memorandum 2001-28.* Free University Amsterdam.

GARCIA, M. & MOORE, C. M. T. 2012. The Cash Dividend -The Rise of Cash Transfer Programs in Sub-Saharan Africa. *Direction in Development - Human Development.* Washington, D.C.: The World Bank.

GREEN, R., CORNELSEN, L., DANGOUR, A. D., TURNER, R., SHANKAR, B., MAZZOCCHI, M. & SMITH, R. D. 2013. The effect of rising food prices on food consumption: systematic review with meta-regression. *BMJ: British Medical Journal,* 346.

KNELL, M. & STIX, H. 2005. The Income Elasticity of Money Demand: A Meta Analysis of Empirical Results. *Journal of Economic Surveys,* 19**,** 513-533.

LOGAN, T. D. 2006. Nutrition and Well-Being in the Late Nineteenth Century *Journal of Economic History,* 66**,** 313-341.
MACDIARMID, J. I., DOUGLAS, F. & CAMPBELL, J. 2016. Eating like there's no tomorrow: Public awareness of the environmental impact of food and reluctance to eat less meat as part of a sustainable diet. *Appetite,* 96**,** 487-493.
MUHAMMAD, A., SEALE, J. L., MEADE, B. & REGMI, A. 2011. International evidence on food consumption patterns: an update using 2005 international comparison program data. *Technical Bulletin 1929, Economic Research Service, United States Department of Agriculture, Washington, D.C.*
MURCOTT, A., BELASCO, W. & JACKSON, P. 2013. *The handbook of food research.* , Bloomsbury Publishing.
OGUNDARI, K. & ABDULAI, A. 2013. Examining the heterogeneity in calorie–income elasticities: A meta-analysis. *Food Policy,* 40**,** 119-128.
POPKIN, B. M. 1994. The nutrition transition in low-income countries: an emerging crisis. *Nutrition Reviews,* 52**,** 285-298.
REGMI, A. & DYCK, J. 2001. Effects of urbanization on global food demand. *In:* WRS-01-1 (ed.) *Changing structure of global food consumption and trade.* Economic Research Service/USDA.
ROSE, A. K. & STANLEY, T. D. 2005. A Meta Analysis of the Effect of Common Currencies on International Trade. *Journal of Economic Surveys,* 19**,** 347-365.
SALOIS, M. J., TIFFIN, R. & BALCOMBE, K. G. 2012. Impact of income on nutrient intakes: implications for undernourishment and obesity. *The Journal of Development Studies,* 48**,** 1716-1730.
SKOUFIAS, E., DI MARO, V., GONZÁLEZ-COSSÍO, T. & RAMIREZ, S. R. 2011. Food quality, calories and household income. *Applied Economics,* 43**,** 4331-4342.
STANLEY, T. D. 2005. Beyond Publication Bias. *Journal of Economic Surveys,* 19**,** 309-345.
UNPD 2015. World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. *Working Paper No., ESA/P/WP/241.* United Nations, Department of Economic and Social Affaires, Population Division.
ZHOU, D. & YU, X. 2014. Calorie Elasticities with Income Dynamics: Evidence from the Literature. *Applied Economic Perspectives and Policy***,** first published online December 10, 2014.

Appendix A

Table A.1. Previous review studies of calorie-income elasticities

Study	**Bouis and Haddad (1992)** [1]	**Salois et al. (2012)**[1]	**Ogundari and Abdulai (2013)**	**Zhou and Yu (2014)**
No. primary studies	26	15[2]	40	90
No. elasticity estimates	Not reported	171[3]	99	387
Range	[0.01,1.18][2]	<0-0.59 (based on study-level data)	[0.004,0.97]	[-0.23,0.99] (approximately)
Average	Not reported	Not reported	0.31	0.35
Time period	Not reported	1990-1992;2003-2005	Not reported	Not reported
Spatial coverage	Developing countries	Developing and developed countries	Developing and developed countries	Developing and developed countries

[1] These studies do not conduct a meta-analysis but provide an overview of the empirical literature.
[2] This value is inferred from the list of primary studies reported on Table 1 of the review study.
[3] Based on the information that the study uses "A cross-sectional sample of 171 developing and developed countries…"

Appendix B: List of primary studies included in the meta-sample

ABDULAI, A. & AUBERT, D. 2002. Does Income Really Matter? Nonparametric and Parametric Estimates of the Demand for Calories in Tanzania. Xth EAAE Congress, Zaragoza (Spain), 28, 31.

ABDULAI, A. & AUBERT, D. 2004a. A cross-section analysis of household demand for food and nutrients in Tanzania. Agricultural Economics, 31, 67-79.

ABDULAI, A. & AUBERT, D. 2004b. Nonparametric and parametric analysis of calorie consumption in Tanzania. Food Policy, 29, 113-129.

ACKAH, C. & APPLETON, S. 2007. Food price changes and consumer welfare in Ghana in the 1990s. CREDIT Research Paper.

AGBOLA, F. W. 2003. Estimation of food demand patterns in South Africa based on a survey of households. Journal of Agricultural and Applied Economics, 35, 663-670.

AKINLEYE, S. 2007. Nutritional implications of food demand in rural Nigeria. Pakistan Journal of Social Sciences, 4, 147-152.

AKINLEYE, S. 2009. Food demand in Northern Nigeria: Implications for food policy. Journal of Social Science, 18, 209-215.

AKINLEYE, S. & RAHJI, M. 2007a. Nutritional implications of the demand for food in Nigeria. Agrosearch, 8, 35-46.

AKINLEYE, S. & RAHJI, M. A. 2007b. Nutrient elasticities among Nigerian households differentiated by income. Agrekon, 46, 274-288.

ALBOGHDADY, M. A. & ALASHRY, M. K. 2010. The demand for meat in Egypt: An almost ideal estimation. African Journal of Agriculture and Resource Economics, 4, 70-81.

ALDERMAN, H. & DEL NINNO, C. 1999. Poverty issues for zero rating VAT in South Africa. Journal of African Economies, 8, 182-208.

AMAO, J., OLUWATAYO, I. & OSUNTOPE, F. 2006. Economics of fish demands in Lagos State, Nigeria. J. Hum. Ecol, 19, 25-30.

AROMOLARAN, A. B. 2004a. Household income, women's income share and food calorie intake in South Western Nigeria. Food Policy, 29, 507-530.

AROMOLARAN, A. B. 2004b. Intra-household redistribution of income and calorie consumption in south-western Nigeria. Yale University Economic Growth Center Discussion Paper.

AROMOLARAN, A. B. 2010. Does increase in women's income relative to men's income increase food calorie intake in poor households? Evidence from Nigeria. Agricultural Economics, 41, 239-249.

AYALEW, T. 2000. Liquidity constraint and the demand for food: Income elasticity of calorie in rural Ethiopia, Kath. Univ., Department Economie, Center for Economic Studies.

BABATUNDE, R. 2008. Empirical Analysis of the Impact of Income on Dietary Calorie Intake in Nigeria. European Journal of Social Science, 5, 173-180.

BABATUNDE, R. O., ADEJOBI, A. O. & FAKAYODE, S. B. 2010. Income and calorie intake among farming households in rural Nigeria: results of parametric and nonparametric analysis. Journal of Agricultural Science, 2, P135.

BALARABE, A., AHMED, B. & CHIKWENDU, D. 2007. Analysis of price and income elasticities for cereals food crops in an Urban Town of Kaduna, Nigeria. Agrosearch, 8, 59-66.

BOCOUM, I. & DURY, S. 2009. Non parametric and parametric analysis of Engel function for calorie, dietary diversity and food shares in the calories, in rural and urban Mali. Journées Jeunes Chercheurs, INRA SAE2, Montpellier. Montpellier.

BOPAPE, L. & MYERS, R. Analysis of household demand for food in South Africa: Model selection, expenditure endogeneity, and the influence of socio-demographic effects. African econometrics society annual conference, 2007 Cape Town, South Africa.

BOUIS, H., HADDAD, L. & KENNEDY, E. 1992. Does it matter how we survey demand for food?: Evidence from Kenya and the Philippines. Food Policy, 17, 349-360.

CAMARA, O. M. 2013. Seasonal price variability and the effective demand for nutrients: Evidence from cereals markets in Mali. African Journal of Food, Agriculture, Nutrition and Development, 13.

CONTE, A. 2006. A Food Demand Analysis For Egypt. Economia, Societa', e Istituzioni, 18.

DALHATU, M. & ALA, A. 2010. Analysis of Fish Demand in Sokoto Metropolis, Sokoto, Nigeria. Nigerian Journal of Basic and Applied Sciences, 18.

DAWOUD, S. 2005. An analysis of food consumption patterns in Egypt.

DAWSON, P. J. 1997. The demand for calories in developing countries. Oxford Development Studies, 25, 361-369.
DILLON B.M. & BARRETT, C.B. (2015) Global oil prices and local food prices: Evidence from east Africa. *American Journal of Agricultural Economics*, p.aav040Global Oil
ECKER, O. & QAIM, M. 2011. Analyzing Nutritional Impacts of Policies: An Empirical Study for Malawi. World Development, 39, 412-428.
ECKER, O., WEINBERGER, K. & QAIM, M. 2010. Patterns and determinants of dietary micronutrient deficiencies in rural areas of East Africa. AfJARE, 4.
ELIJAH OBAYELU, A., OKORUWA, V. & AJANI, O. 2009. Cross-sectional analysis of food demand in the North Central, Nigeria: The quadratic almost ideal demand system (QUAIDS) approach. China agricultural economic review, 1, 173-193.
FASHOGBON, A. E. & ONI, O. A. 2013. Heterogeneity in rural household food demand and its determinants in Ondo State, Nigeria: An application of quadratic almost ideal demand system. Journal of Agricultural Science, 5, p169.
GBAKOU, M. & SOUSA-POZA, A. 2011. Engel curves, spatial variation in prices and demand for commodities in Côte d'Ivoire.
GREER, J. & THORBECKE, E. 1986. A methodology for measuring food poverty applied to Kenya. Journal of Development Economics, 24, 59-74.
HANCOCK, P., NIEUWOUDT, W. & LYNE, M. 1984. Demand analysis of meats in South Africa. Agrekon, 23, 26-29.
HENDRIKS, S. L. & LYNE, M. C. 2003. Expenditure patterns and elasticities of rural households sampled in two communal areas of KwaZulu-Natal. Development Southern Africa, 20, 105-127.
HONFOGA, B. & VAN DEN BOOM, G. 2003. Food-consumption patterns in central West Africa, 1961 to 2000, and challenges to combating malnutrition. Food & Nutrition Bulletin, 24, 167-182.
IYANGBE, C. & OREWA, S. 2009. Determinants of daily protein intake among rural and low-income urban households in Nigeria. Am-Eurasian J Sci Res, 4, 290-301.
KENNEDY, E. & PAYONGAYONG, E. 1992. Patterns of Macronutrient and Micronutrient Consumption and Implications for Monitoring and Evaluation. Final Report Submitted to AID. International Food Policy Research Institute, Washington, DC.
KENNEDY, E. T. 1989. The effects of sugarcane production on food security, health, and nutrition in Kenya: A longitudinal analysis, Intl Food Policy Res Inst.
KENNEDY, E. T. & COGILL, B. 1987. Income and nutritional effects of the commercialization of agriculture in southwestern Kenya, Intl Food Policy Res Inst.
KNUDSEN, O. K. & SCANDIZZO, P. L. 1982. The demand for calories in developing countries. American Journal of Agricultural Economics, 64, 80-86.
MAXWELL, D., LEVIN, C., ARMAR-KLEMESU, M., RUEL, M., MORRIS, S. & AHIADEKE, C. 2000. Urban livelihoods and food and nutrition security in Greater Accra, Ghana, International Food Policy Research Institute Washington, DC.
MCKENZIE, C. & NIEUWOUDT, W. 1985. Estimation of demand and supply functions for fresh and industrial milk in South Africa. Agrekon, 24, 27-33.
MUHAMMAD, A., SEALE, J. L., MEADE, B. & REGMI, A. 2011. International evidence on food consumption patterns: an update using 2005 international comparison program data. Technical Bulletin 1929, Economic Research Service, United States Department of Agriculture, Washington, D.C.
OGUNDARI, K. Convergence in nutrient intakes and examination of nutrition-income elasticities in sub Saharan Africa: Implications on Health and welfare. 2014 Annual Meeting, July 27-29, 2014, Minneapolis, Minnesota, 2014. Agricultural and Applied Economics Association.
OGUNNIYI, L., AJAO, A. & OLADEJO, J. 2012. Food Consumption Pattern in Ogbomoso Metropolis of Oyo State, Nigeria. Journal of Agriculture and Social Research (JASR), 12, 74-83.
OHAJIANYA, D. 2005. Econometric Analysis Of Aggregate Demand For Meat In Imo State, Nigeria. Journal of Agriculture and Social Research (JASR), 5, 62-66.
OJOGHO, O. 2010. Determinants of Food Insecurity among Arable Farmers in Edo State, Nigeria. Agricultural Journal, 5, 151-156.
OJOGHO, O. & ALUFOHAI, G. 2010. Impact of price and total expenditure on food demand in South-Western Nigeria. African Journal of Food, Agriculture, Nutrition and Development, 10.
OMOJOLA, J., EFFIONG, J. & PEPPLE, I. 2008. Analysis of the demand for locally processed rice in Niger State, Nigeria. Journal of Agriculture and Social Research (JASR), 6, 22-26.

OMONON, B., NKANG, N. & AJAO, F. 2009. Household food demand analysis: a survey of semiurban and rural households in south-west Nigeria. Global Journal of Pure and Applied Sciences, 15.

PHILLIP, B. & ASHAOLU, O. 2013. Demand for non-alcoholic beverages among urban households in southwest, Nigeria. African journal of food, agriculture, nutrition and development, 13.

SARRIS, A. H. & TINIOS, P. 1994. Structural Changes inTanzanian Poverty Over 15 Years: 1976 to 1991. Cornell Food and Nutrition Policy Program.

SARTORIUS VON BACH, H. & VAN ZYL, J. 1994. HUMAN CARBOHYDRATE DEMAND IN SOUTH AFRICA/Die menslike vraag na koolhidrate in Suid-Afrika. Agrekon, 33, 145-150.

SEALE, J. L., REGMI, A. & BERNSTEIN, J. 2003. International evidence on food consumption patterns, Economic Research Service, US Department of Agriculture.

STRAUSS, J. 1984. Joint determination of food consumption and production in rural Sierra Leone: Estimates of a household-firm model. Journal of Development Economics, 14, 77-103.

TIFFIN, R. & DAWSON, P. J. 2002. The Demand for Calories: Some Further Estimates from Zimbabwe. Journal of Agricultural Economics, 53, 221-232.

TITILOLA, O. L., AJIBOYE, A. & SANUSI, W. 2012. Analysis of urban household demand for poultry products in Ogbomoso North and South Local Government Area Oyo State, Nigeria. Tropical and Subtropical Agroecosystems, 15.

ULIMWENGU, J., ROBERTS, C. & RANDRIAMAMONJY, J. 2012. Resource-Rich Yet Malnourished: Analysis of the Demand for Food Nutrients in the Democratic Republic of Congo. IFPRI Discussion Paper 01154.

ULIMWENGU, J. M. & RAMADAN, R. 2009. How does food price increase affect Ugandan households?: An augmented multimarket approach. International Food Policy Research Institute (IFPRI).

ULIMWENGU, J. M., WORKNEH, S. & PAULOS, Z. 2009. Impact of soaring food price in Ethiopia: Does location matter?, Intl Food Policy Res Inst.

VAN ZYL, J. 1986. A statistical analysis of the demand for maize in South Africa. Agrekon, 25, 45-51.

VON BRAUN, J., DE HAEN, H. & BLANKEN, J. 1991. Commercialization of agriculture under population pressure: Effects on production, consumption, and nutrition in Rwanda [Online]. Intl Food Policy Res Inst. 85].

VON BRAUN, J., PUETZ, D. & WEBB, P. 1989. Irrigation Technology and Commercialization of Rice in The Gambia, Effects on Income and Nutrition, Intl Food Policy Res Inst.

WELIWITA, A., NYANGE, D. & TSUJII, H. 2003. Food demand patterns in Tanzania: A censored regression analysis of microdata. Sri Lankan Journal of Agricultural Economics, 5, 9-34.

YUSUF, O. 2012. A system analysis of the demand for animal protein in rural and urban Nigeria: A case study of Ibadan metropolis. Journal of Research in National Development, 10, 208-213.

Appendix C

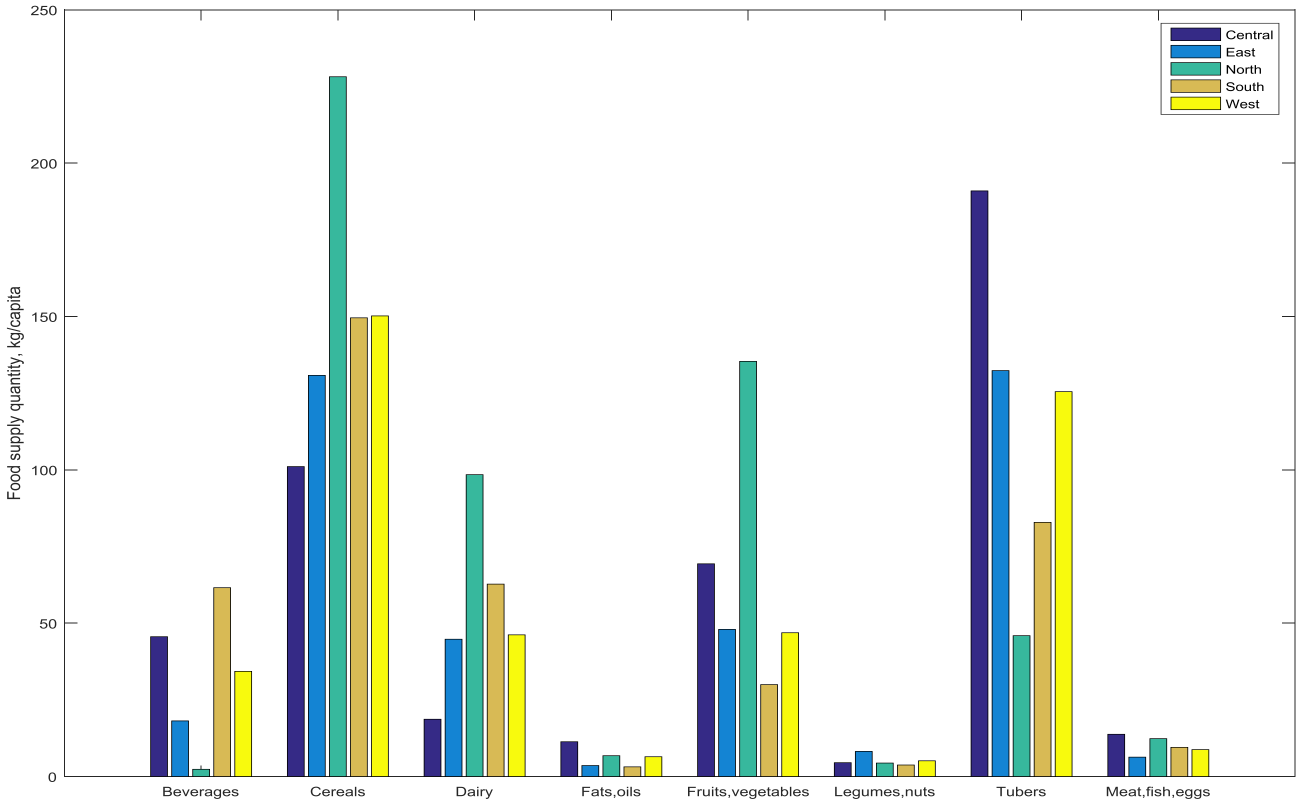

Figure C.1. 2011 food supply quantity by region, FAO.

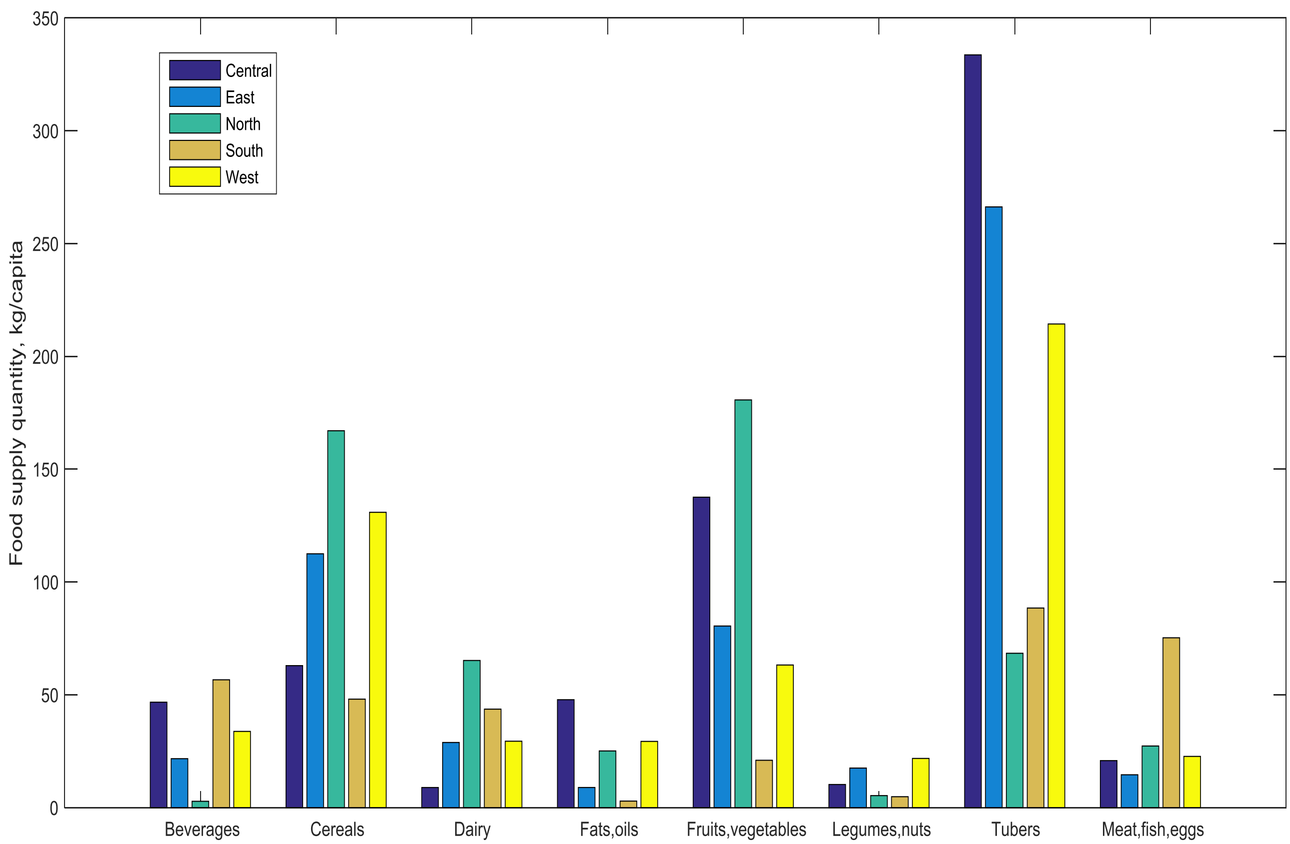

Figure C.2. 2011 food production per capita by region, FAO.

Appendix D

Table D.1. Results from the meta-regression of income elasticities for main groups of foods

Food groups / Variables		**Cereals**				**Dairy**			
		Model (1)		**Model (2)**		**Model (1)**		**Model (2)**	
		OLS	**RE**	**OLS**	**RE**	**OLS**	**RE**	**OLS**	**RE**
North Africa	Central Africa	0.1781***	0.1413***			0.0696***	0.0696***		
	East Africa	-0.1854*	-0.0138			0.0414***	0.0414***		
	Southern Africa	0.0560**	0.0706***			0.0417***	0.0417***		
	West Africa	-0.1063	0.0116			0.0499***	0.0499***		
Country is in Sahelian region				-0.0719	-0.0422			-0.0508	-0.0508
Country is landlocked				-0.0471	-0.0105			-0.0322	-0.0322
Country's income level (i.e. logarithm of GDP pc)		-0.1163***	-0.0786***	-0.0588***	-0.0544***	-0.0340**	-0.0340***	-0.0363**	-0.0363**
Country's urbanisation rate		0.0016	0.0006	0.0005	-0.0002	-0.0003	-0.0003	-0.0010**	-0.0010**
Number of observations		284	284	284	284	112	112	112	112
Number of studies		26	26	26	26	13	13	13	13
Number of countries		47	47	47	47	46	46	46	46
Breusch-Pagan LM test		0.000 (1.000)		0.000 (0.4763)		0.000 (1.000)		0.000 (1.000)	
R^2 - overall		0.46	0.44	0.44	0.42	0.48	0.48	0.49	0.49
R^2 - between			0.63		0.60		0.54		0.53
R^2 - within			0.01		0.01		0.10		0.08
sigma_u			0.26		0.31		0.00		0.00
Food groups / Variables		**Tubers & staple foods**				**Legumes and nuts**			
		Model (1)		**Model (2)**		**Model (1)**		**Model (2)**	
		OLS	**RE**	**OLS**	**RE**	**OLS**	**RE**	**OLS**	**RE**
North Africa	Central Africa	-4.3378***	-2.7394**			-	-		
	East Africa	-	-			-1.8416	-1.8769		
	Southern Africa	-0.2363	-0.0776			-0.9069**	-0.9429**		
	West Africa	*reference				0.4899**	0.5786***		
Country is in Sahelian region				0.3766	0.106			3.7178***	3.7178***
Country is landlocked				1.7441***	1.2224***			-4.4559***	-4.4559***
Country's income level (i.e. logarithm of GDP pc)		0.0379	0.0793*	0.0459	0.0822*	0.2489**	0.2056	0.3394***	0.3394***
Country's urbanisation rate		0.0647***	0.0397**	0.0525***	0.0353***	-0.0544	-0.0523	-0.1474***	-0.1474***

Number of observations		139	139	139	139	121	121	121	121
Number of studies		14	14	14	14	15	15	15	15
Number of countries		7	7	7	7	8	8	8	8
Breusch-Pagan LM test		1.47 (0.1128)		0.000 (1.000)		0.000 (1.000)		0.000 (1.000)	
R^2 - overall		0.28	0.25	0.28	0.25	0.51	0.51	0.52	0.52
R^2 - between			0.85		0.85		0.90		0.94
R^2 - within			0.01		0.02		0.12		0.12
sigma_u			0.33		0.33		0.51		0.00
Food groups / Variables		**Fruit and vegetables**				**Meat, fish, and eggs**			
		Model (1)		**Model (2)**		**Model (1)**		**Model (2)**	
		OLS	**RE**	**OLS**	**RE**	**OLS**	**RE**	**OLS**	**RE**
North Africa	Central Africa	0.2564*	0.0835***			0.2486*	0.0774***		
	East Africa	0.0389	0.0303***			0.001	0.0477***		
	Southern Africa	0.1502	0.0402***			0.1731	0.0403***		
	West Africa	0.1048	0.0385***			0.0798	0.0543***		
Country is in Sahelian region				-0.0717	-0.0168***			-0.0817	-0.0072*
Country is landlocked				-0.0453	0.0055			-0.0624	-0.0001
Country's income level (i.e. logarithm of GDP pc)		-0.0941**	-0.0466***	-0.0722**	-0.0429***	-0.0972	-0.0328***	-0.0678	-0.0342***
Country's urbanisation rate		0.0032	-0.0001	0.0019	-0.0002	0.0032	-0.0006	0.0013	-0.0008
Number of observations		206	206	206	206	316	316	316	316
Number of studies		21	21	21	21	26	26	26	26
Number of countries		47	47	47	47	47	47	47	47
Breusch-Pagan LM test		0.020 (0.4509)		0.090 (0.3816)		1.58 (0.1044)		3.35 (0.0335)	
R^2 - overall		0.38	0.27	0.36	0.26	0.24	0.03	0.22	0.02
R^2 - between			0.45		0.43		0.16		0.15
R^2 - within			0.16		0.16		0.05		0.04
sigma_u			0.49		0.43		0.66		0.80

* - level of significance at 10%; ** - level of significance at 5%; *** - level of significance at 1%.