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The effects of smallholder agricultural involvement on household food consumption and dietary diversity

Evidence from Malawi

by
Rui Benfica
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World Bank

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Abstract

This paper investigates how household agricultural involvement affects food consumption and dietary diversity in rural Malawi. Ceteris paribus, a 10 per cent increase in on-farm income share increases food consumption per capita by 2.9 per cent, calorie intake per capita per day by 1.7 per cent, and leads to small improvements in dietary diversity. There are significant differences in the relationship between on-farm income shares and caloric shares: a positive and significant relationship with the shares from energy-dense and low-protein cereals and grains, but not significant with shares from nuts/pulses and sugars. Negative relationships are found with shares from roots/tubers, vegetables/fruits, oils/fats and meat/fish/milk. While food consumption and dietary diversity increase with agricultural involvement, the quality of diets is an issue. As purchased calories are associated with richer/high-quality diets, particularly rich in protein, households with lower dependency on agriculture access those diets more easily. This highlights the importance of income diversification to dietary diversity. It also calls for the development and support of nutrition-sensitive agricultural value chains, nutrition education and crop diversification programmes to improve household food and nutrition security.

Introduction

Malawi is a predominantly rural economy, with agriculture accounting for 30 per cent of the gross domestic product (GDP). Around 84 per cent of households own and/or cultivate land, and the overwhelming majority of farming households practise subsistence agriculture. In spite of significant public spending on agricultural development programmes in recent years, rural poverty and food security remain high, with over half of the population living below the poverty line. Over the period 2004/05 to 2010/11, income growth has been significantly regressive, the poverty headcount has remained relatively stagnant, and income inequality has risen (World Bank 2014).[1]

There have been significant increases in the levels of intensification in recent years, with more households using productivity-enhancing inputs. Indications are, however, that that has been accompanied by increased crop specialization, especially towards maize grain. In fact, except for maize, pigeon peas and tobacco, the proportion of households growing all other crops has fallen between 2004/05 and 2010/11. Research indicates that, overall, income diversification away from own-farm income has also fallen over the same period. Except for paid farm work (a relatively low-return activity), off-farm income diversification fell significantly over the period (World Bank 2014).

As a result of this dynamic, the importance of crop income in total household income has increased in recent years. The growth in crop income has, however, less than compensated for the loss in income from non-farm sources, which resulted in stagnant consumption poverty in rural areas. Those patterns can have important implications for food security and nutrition. Depending on how households source their calories, including from their own production and market purchases, there can be implications for overall levels and, more importantly, dietary diversity patterns. In terms of nutritional outcomes, while there have been improvements in recent years, nutrition insecurity remains high at the household level and among children in particular. By 2010/11, 23 per cent of Malawian households had inadequate food consumption (poor and borderline, by the standards of the World Food Programme [WFP]), with woman-headed and poorer rural households exhibiting higher incidence of food inadequacy.

1. Recent survey data (2013) shows that crop and income diversification has somewhat improved in subsequent years, but agriculture continues to be the most predominant source of household income.

In terms of child nutritional outcomes, according to the Demographic and Health Survey (DHS), there is a high prevalence of stunting (47.8 per cent in 2010, down from 53.1 per cent in 2004), a modest underweight rate (14.1 per cent in 2010, down from 18.6 per cent in 2004) and a relatively low wasting rate (4.1 per cent in 2010, down from 6.2 per cent in 2004).[2]

The links between agriculture and nutrition are potentially significant in the context of the continued importance of income derived from agriculture relative to non-farm sources, the persistent and high levels of poverty, and food and nutrition insecurity. However, those links have not received adequate attention to date, mainly due to data limitations. This paper uses data from the Malawi Integrated Household Survey III (IHS3), undertaken during 2010/11, to start filling that gap by investigating the effect of agricultural involvement – defined as the share of on-farm income in total income – on household consumption and dietary diversity.

2. According to DHS data, between 2004/5 and 2010/11, Malawi's stunting prevalence declined 10 per cent. As compared to neighboring countries, the magnitude of this decline was average to high, falling below that of Rwanda (-14 per cent) and Uganda (-12 per cent), but above the progress achieved by Mozambique (-9 per cent), Zimbabwe (-8 per cent), Tanzania (-5 per cent) and Kenya (-1 per cent).

Analytical framework and research questions

The term "nutrition-agriculture linkages" refers to a set of relationships that describe the mutual dependence of nutrition, health and agriculture. The nutrition-agriculture framework features looping relationships that illustrate the bi-directional causality, and thus interdependence, among their key components (Chung 2012). Changes in nutrition or health status are expected to affect agricultural production; conversely, changes in the agricultural sector can have significant effects on health and nutritional status (Sahn 2010). Figure 1 summarizes a basic framework for analyzing agriculture-nutrition linkages. It focuses on rural households and highlights the interdependent relationships that connect nutrition, agriculture and health at the household and individual levels.

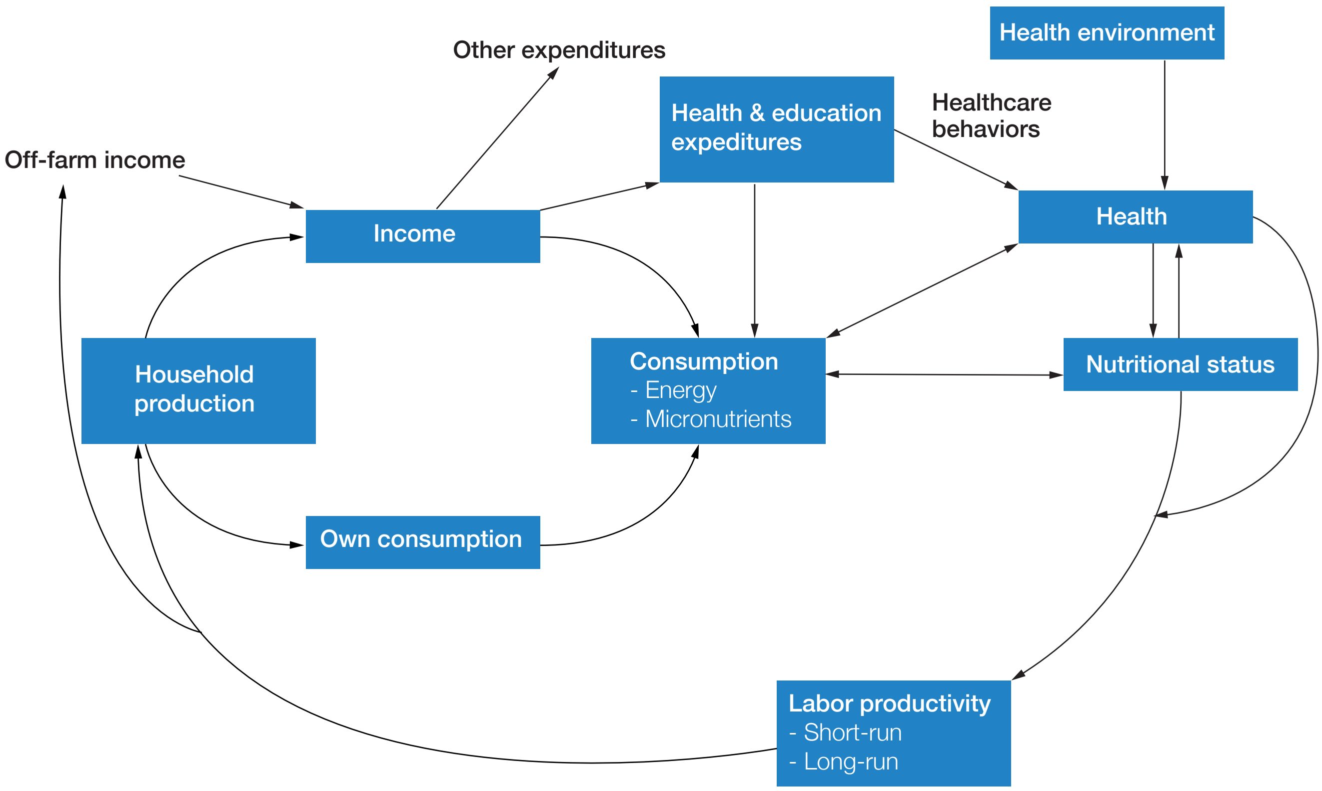
Given the question in hand, this paper takes a more simplified approach. Our focus is on consumption and nutritional outcomes and, as a result, we do not detail the ways in which agriculture affects health status and, indirectly, nutritional status. Hoddinott (2011) describes in detail that more complete loop. Here, we start with the trickle-down approach, which assumes that an increase in output will elicit changes in a household's nutritional status (Chung 2012). Nutritional status is presumed to improve as a result of increases in own consumption or income. The trickle-down strategy can also benefit consumers who are net buyers if aggregate production changes are large enough to reduce the price of crops that are nutritionally important.

The left-hand side of figure 1 shows that household food production is expected to improve individual food intake by either (a) increasing consumption from own production or (b) contributing to household income for the purchase of food. In turn, improved food intake provides energy that is needed for bodily growth, maintenance and activity. A high-quality diet also provides protein and various micronutrients (vitamins and minerals) that are essential for optimum growth and functioning (Chung 2012; TFCSD 1991).

Since agricultural activity determines, to a great extent, the amount, type, stability, control and distribution of income, the linkages between agriculture and consumption are expected to be strong and direct for agricultural households (Chung 2012). Furthermore, agriculture affects the food available for consumption by the household, including its diversity, quality and price (von Braun et al. 2010; Chung 2012).

Whether increases in output or in the relative importance of agricultural income results in increased consumption and improved nutritional outcomes is an empirical question that needs to be tested in each particular context. Thus, we ask and seek to answer the question: What are the effects of rural agricultural involvement of rural Malawian households on consumption, calorie intake and dietary diversity?

Figure 1: Agriculture-nutrition linkages framework



Source: Chung (2012)

Data

The analysis uses household-level data from the IHS3. The survey was conducted by the National Statistical Office (NSO), supported by the Living Standards Measurement Surveys – Integrated Surveys in Agriculture (LSMS-ISA) project of the World Bank, from March 2010 through March 2011. The sample included 12,271 households (10,038 from rural areas and 2,233 from urban areas). The sampling design was representative at the national and district level, as well as for rural and urban areas, enabling the survey to provide reliable estimates for each of these areas. It covered a wide range of topics, including household demographics, consumption patterns and expenditure levels, agricultural, livestock and fisheries production and marketing, and child anthropometry, among other variables (NSO 2011).

For the purposes of this analysis, we used a sample of around 9,000 rural agricultural households, corresponding to approximately 92 per cent of the overall rural sample. The analysis used survey data to generate variables related to the level of agricultural involvement (reliance on agricultural income), food consumption and nutritional outcomes at the household level.

Defining agricultural involvement, food consumption and nutritional outcomes

Agricultural involvement is defined as household on-farm (crop and livestock) income represented as a share of total gross household income. This measure captures the relative weight of returns to household agricultural involvement. The higher the share of on-farm income, the lower the level of household income diversification [i.e. the share of income generated from off-farm sources]. Data from IHS2 and IHS3 indicate that, between 2004/5 and 2010/11, household agricultural involvement increased, remaining at relatively high levels, with both the share of households engaging in on-farm activities and the share of net income from those sources increasing significantly (table 1).[3]

Table 1: Trends in income diversification, 2004/5-2010/11

Selected indicators	Rural areas		
	2004/2005	2010/2011	Difference
Income sources (% of HHs)			
AGRICULTURAL			
Crop and livestock production	83.4	92.2	+8.8**
Agricultural wage	54.4	48.7	-5.7**
Farm rents	2.2	0.5	-1.7**
NON-AGRICULTURAL			
Self-employment	29.8	16.5	-13.3**
Non-farm wage	16.2	13.2	-3.0**
Non-farm rents	2.3	1.9	-0.4
Net income shares (% of income)			
AGRICULTURAL			
Crop and livestock production	65.4	71.3	+5.9**
Agricultural wage	11.3	15.8	+4.5**
Farm rents	0.1	0.0	-0.1**
NON-AGRICULTURAL			
Self-employment	8.8	5.0	-3.8**
Non-farm wage	7.5	7.6	+0.1**
Non-farm rents	0.1	0.4	+0.3**

Note: Significance level of the difference: 1% (**), 5% (*) and 10% (+).
Source: World Bank (2014), using Malawi IHS2 and IHS3.

3. The rural sample here includes all rural households. The analysis in this paper only considers rural agricultural households.

The range of outcome variables that inform our analysis includes: (a) household annual food consumption expenditures per capita; (b) household caloric intake per capita per day; (c) household food consumption score; (d) household Simpson Index of dietary diversity; and (e) shares of caloric intake attributed to (i) cereals and grains, (ii) roots and tubers, (iii) nuts and pulses, (iv) vegetables and fruits, (v) meat, fish, milk and other animal products, (vi) oils and fats, (vii) sugar products, and (viii) other food items. The following is a basic definition of each of these outcomes.

Food consumption is measured both in terms of the total value of food consumed per person per year and the corresponding caloric levels consumed per person per day.

Food consumption per capita ($FCpc_h$) is defined as the total value of food consumed in the household annually divided by household size. It can be represented as:

(1) $$FCpc_h \approx \frac{1}{N_h} \sum_{i=1}^{n} C_{hi}$$

where C_{hi} is the value of household h annual consumption of commodity i, and N_h is the size of household h. This measure is expressed in monetary terms.

Calorie intake per capita per day ($Calpcpd_h$) is computed by converting the annual quantities of individual food items consumed to calories using standard conversion factors. The sum of calories across all food items is then divided by household size and 365 days to get the daily level of calorie consumption per capita.

(2) $$Calpcpd_h \approx \frac{1}{365 * N_h} \sum_{i=1}^{n} Cal_{hi}$$

where Cal_{hi} is calorie consumption of food item i by household h, and N_h is the size of household h. This measure is expressed in number of calories.

Dietary diversity is measured using the *Food Consumption Score*, the *Simpson Diversity Index* and the *share of calories from food groups*. The definitions of these follow.

The Food Consumption Score (FCS_h) is a composite score based on dietary diversity, food frequency and relative nutritional importance of different food groups. Food items consumed in the 7 days prior to the interview are grouped into 8 groups. The consumption frequency (maximum of 7 days/week) of each food group by the household is then multiplied by group-assigned nutrient-based weights. Those values are then summed up to generate the FCS of household h.

(3) $$FCS_h \approx \sum_{i=1}^{8} f_{hi} * w_i$$

where F_{hi} is the frequency of consumption of food commodity group i by household h, and w_i is the weight attributed to each food commodity group i. This indicator was proposed by WFP (World Food Programme).[4]

4. The score thresholds range from 0 – 35 and allow for the classification of households into the following categories of food consumption: (1) poor (FCS between 0 -21); (2) borderline (FCS between 21 and 35); and (3) acceptable food consumption (FCS above 35). WFP considers inadequate consumption to be the combination of poor and borderline [i.e. FCS less than 35].

The Simpson Diversity Index (SDI_h) is a member of a class of diversity indexes that take into account not only whether or not each food item is consumed, but also the relative importance of each type of food consumed, as expressed by consumption shares. It can be expressed as

(4) $$SDI_h = 1 - \sum_{i=1}^{n} ShCal_{hi}^2$$

where $ShCal_{hi}$ is the calorie consumption share of food item i in total calorie consumption of household h, and n is the total number of food items considered. A consideration of the shares of calorie consumption implicitly gives more weight to food types that have higher shares. Food items with equal shares are weighted equally.[5] This index ranges from 0 to 1. If a household consumes only one type of food item (i.e. its share is equal to unity), the index will be zero (no diversity). As more items are consumed, the index value increases to indicate more dietary diversity.

The food groups defined in this analysis are formed in line with the structure suggested by WFP for the FCS. **Table A1 of the annex** lists the crops and products comprising the groups, and provides a description of their nutritional attributes.

The analysis uses shares of calorie consumption from these groups as outcomes in the Three-Stage Least Squares (3SLS) model to assess how agricultural involvement affects the relative levels of those shares. The share of calorie consumption from each food group i ($ShCal_{hi}$) can be expressed as

(5) $$ShCal_{hi} \approx \frac{Cal_{hi}}{\sum_{i=1}^{n} Cal_{hi}}$$

where Cal_{hi} is the calorie consumption of food item i of household h, and n is the total number of food items considered to arrive at the total number of calories consumed (denominator). By definition, the sum of the shares will be equal to unity.

5. In a more elaborate scheme, one may want to give bigger weights to items such as vegetables, meat and fish (and very small weights to items such as sodas, cookies and alcohol) as opposed to staple foods.

Descriptive statistics of agricultural involvement, food consumption and nutritional outcomes

This section looks at some descriptive statistics for the variables of interest. Using IHS3 data, we look at: (a) levels of agricultural involvement; and (b) household level of food consumption, calorie intake and dietary diversity outcomes, by selected household characteristics, such as gender of the household head, consumption expenditure quintiles, poverty status and rural region of residence. Results are presented in **table 2**.

Overall, in rural Malawi, where about 92 per cent of households engage in crop and livestock production, the share of on-farm income in the total gross household income is about 60 per cent [i.e. for every Malawi Kwacha generated, about 60 cents originate from that source]. The following results stand out. First, agricultural involvement, as defined by this measure, is higher (at 66 per cent) in the Central Region and lowest (at 53 per cent) in the Southern Region. Second, while differences are relatively small, woman-headed and poor households have relatively higher levels of agricultural involvement (63 per cent) than man-headed households (59 per cent) and their non-poor counterparts (57 per cent). On average, households in the top 20 per cent of the income distribution have shares of on-farm income of only about 50 per cent, compared to about 61 per cent among the poorest 20 per cent.

Descriptive analyses of the consumption and dietary diversity outcomes indicate several important results. First, food consumption per capita is higher in the Central Region and lowest in the Southern Region, pretty much in line with the patterns of agricultural involvement. Second – and contrary to the first finding – when looking at consumption per capita across gender and wealth, we find that man-headed and non-poor households (that exhibit lower levels of agricultural involvement) enjoy relatively higher levels of consumption per capita.

Third, calorie intake and dietary diversity – measured using the food consumption score and the Simpson Index – are higher in the Northern Region among man-headed and relatively wealthier households. One exception is calorie consumption per capita per day, which is slightly higher among woman-headed households when compared to their man-headed counterparts. Table 2 of the annex provides a more detailed analysis of food consumption adequacy for all rural households (disaggregated by gender of headship and poverty status), derived from the food consumption score. By 2010/11, 23 per cent of Malawian households had inadequate food consumption (poor and borderline, by WFP standards), with woman-headed and poorer rural households exhibiting a higher incidence of food consumption inadequacy.

Finally, when looking at disaggregated calorie consumption, we note that households in the Central and Southern Regions have a structure essentially dominated by cereals (72 per cent and 68 per cent, respectively), and significantly small shares from non-crop protein sources such as meat/fish/milk (just about 3 per cent) and roots/tubers (less than 6 per cent).

Households in the Northern Region appear to have a relatively more balanced diet, deriving about 13 per cent of calories from meat/fish/milk, just below 60 per cent from cereals/grains and 12 per cent from roots/tubers. While differences are not significant, man-headed households and those that are classified as non-poor enjoy relatively more balanced diets, consuming relatively less calories from non-cereal sources. A look at the structure of calorie consumption by wealth quintile reveals that the poorest 20 per cent derive about 80 per cent of their calorie consumption from cereals, against only 61 per cent among the richest 20 per cent. The latter have a relatively more diversified diet, where the share of fruits and vegetables and meat/fish/milk is about double that of the poorest 20 per cent.

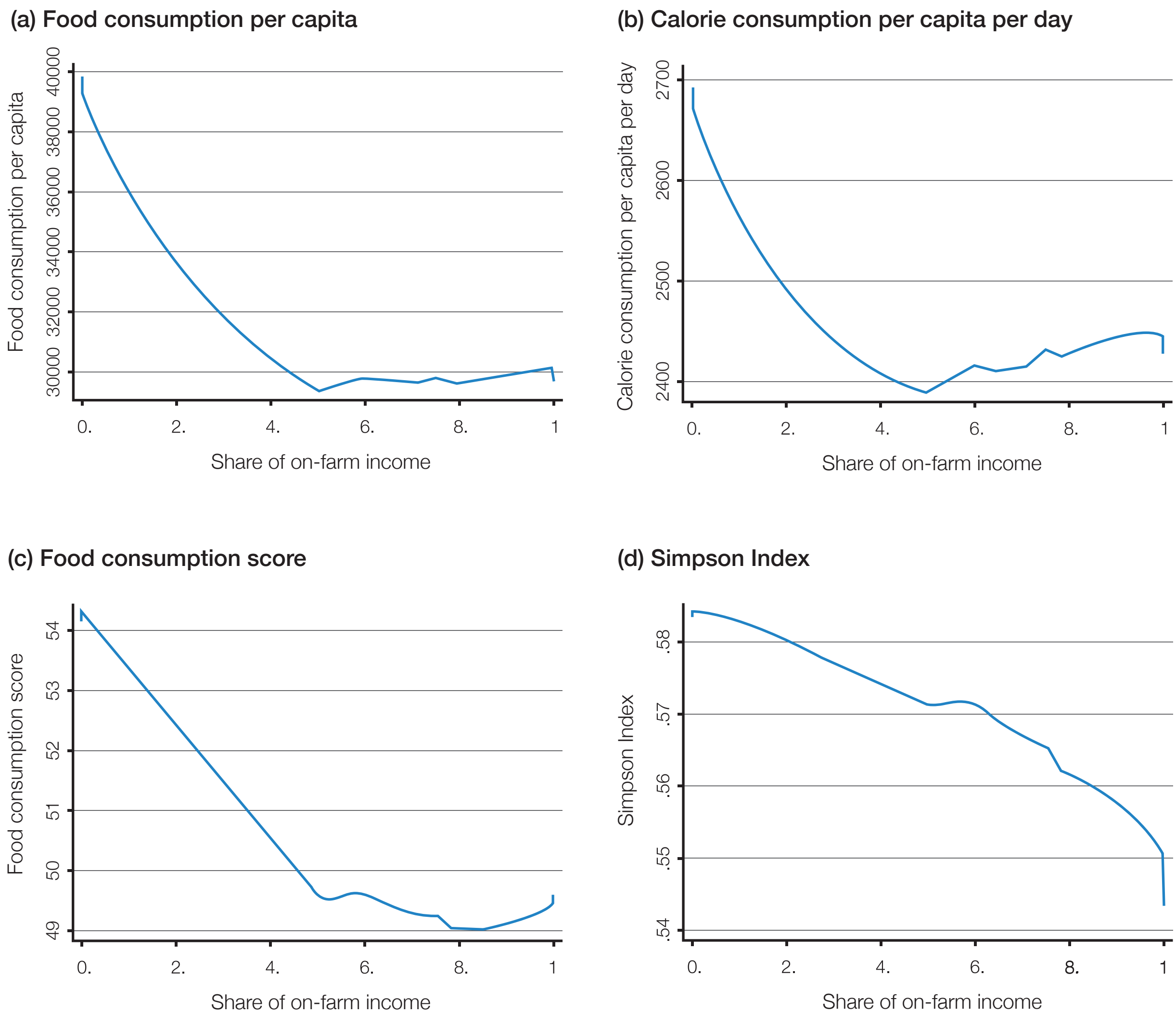
In terms of food consumption and dietary diversity outcomes across different levels of agricultural involvement, several patterns can be highlighted. First, in a strictly bivariate sense (i.e. without controlling for a wealth of factors), higher levels of agricultural involvement almost invariably result in lower levels of the various aggregate outcomes. While this seems to represent an apparent paradox, an analysis of a more detailed continuum shows that, beyond a certain involvement threshold, a positive relationship holds beyond shares of over 50 per cent – i.e. levels at which over 60 per cent of the sample falls (**figure 2**). This is particularly the case for food consumption per capita, calories per capita per day and, to some extent, the food consumption score for which a mirrored J-shaped curve emerges.

Table 2: Agricultural involvement and household-level outcomes, by selected characteristics, 2010/11

Household characteristics	Agricultural involvement (share of on-farm income)	Household-level consumption and dietary diversity outcomes (rural agricultural households)											
		Food and calorie consumption		Dietary diversity		Disaggregated calorie consumption: share of calorie consumption per person per day by food groups (%)							
		Food cons. per capita	Calories/ person/ day	Food cons. score	Simpson Index	Cereals/ grains	Roots/ tubers	Pulses/ nuts	Fruits/ vegetables	Meat/fish and milk	Oils/ fats	Sugars	Others
Rural Malawi	0.60	31 044	2 425	49.6	0.56	68.5	6.5	5.3	2.5	4.6	5.7	5.4	1.6
BY REGION													
Northern	0.64	31 041	2 595	51.2	0.57	56.4	12.8	3.7	1.7	14.0	5.0	5.2	1.2
Central	0.66	32 748	2 361	49.5	0.55	72.4	5.0	5.4	2.1	3.1	5.1	5.1	1.8
Southern	0.53	29 560	2 433	49.3	0.57	68.4	6.2	5.5	3.1	3.3	6.4	5.6	1.6
BY SEX													
Male	0.59	31 369	2 396	50.0	0.58	67.7	6.4	5.3	2.4	4.9	6.0	5.5	1.7
Female	0.63	30 053	2 513	45.4	0.52	70.7	6.9	5.1	2.7	3.7	4.7	4.9	1.3
CONSUMPTION QUINTILES													
1st quintile	0.61	11 404	1 360	36.9	0.39	78.4	5.3	3.3	2.4	2.9	4.2	2.9	0.6
2nd	0.64	18 346	1 906	43.3	0.50	72.0	6.5	4.5	2.1	3.8	5.7	4.3	1.1
3rd	0.64	25 392	2 299	49.0	0.58	67.9	6.5	5.4	2.6	4.2	6.0	5.7	1.7
4th	0.60	35 423	2 760	55.3	0.64	63.9	7.1	6.2	2.7	5.2	6.4	6.5	2.0
5th quintile	0.50	64 885	3 814	63.8	0.71	60.0	7.4	7.0	2.7	6.9	6.0	7.4	2.7
POVERTY STATUS													
Poor	0.63	16 458	1 734	41.4	0.46	74.5	6.0	4.1	2.3	3.5	5.2	3.9	1.0
Non-poor	0.57	45 329	3 001	57.7	0.66	62.9	7.1	6.4	2.7	5.7	6.1	6.8	2.2

Source: Malawi IHS3.

Figure 2: Aggregate food consumption and household nutritional outcomes by share of on-farm income, 2010/11



Source: Author's computations with IHS3.

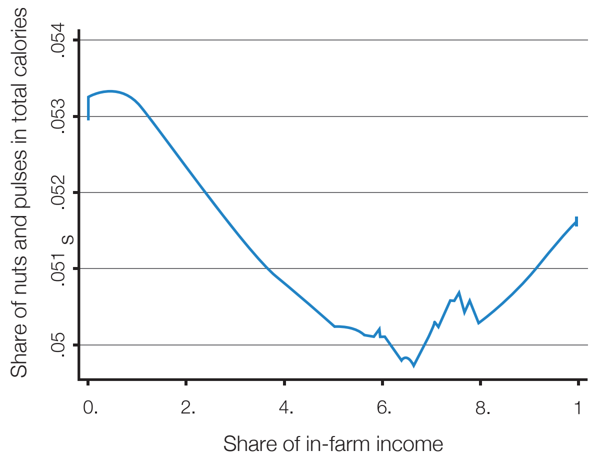
Second, when looking at the different calorie sources, we find that the share of cereals/grains (mostly sourced from own production) increases with the levels of agricultural involvement, while the shares of calories from most of the other sources fall, particularly for food groups that are mostly sourced from the market. This reflects the degree of difficulty that households increasingly specialized in agriculture have to acquire calories from market sources, especially non-crop protein sources such as meat/fish/milk and oils/fats (table 3 and figure 3).

An assessment of the true average effect of agricultural involvement can only be done by controlling for household and location factors, while addressing the potential endogeneity of agricultural involvement. The section that follows accomplishes that.

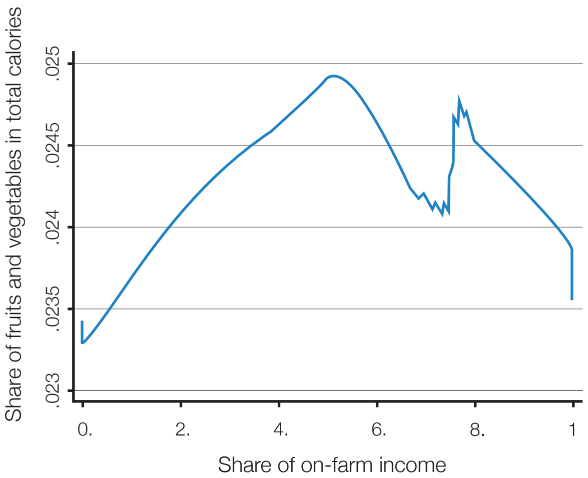
Figure 3: Share of food group calorie consumption, by household share of on-farm income, 2010/11

(a) Share of cereals and tubers

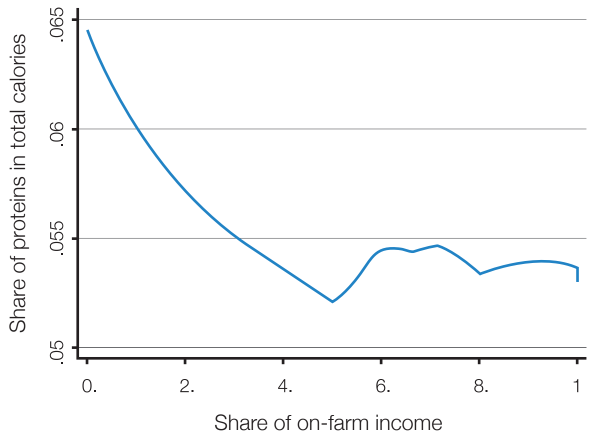
(b) Share of nuts and pulses



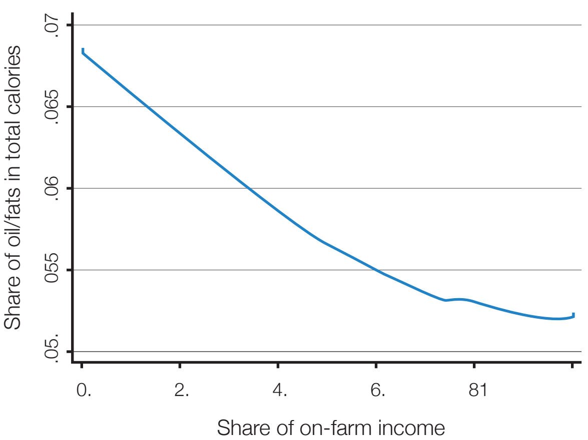
(c) Share of fruits and vegetables



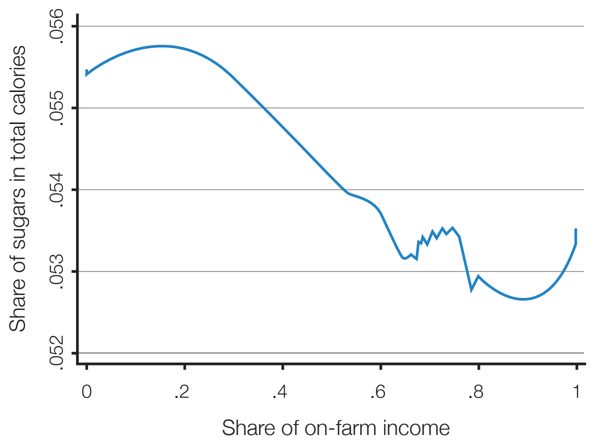
(d) Share of meat, fish and milk



(e) Share of oils and fats



(f) Sugars



Source: Author's computations with IHS3.

Table 3: Household-level outcomes by agricultural involvement, 2010/11

Household-level consumption and dietary diversity outcomes	Levels of agricultural involvement (terciles of share of on-farm income)			All households
	Low	Middle	High	
	0.15	0.64	0.98	0.60
CONSUMPTION AND DIVERSITY MEASURES				
Food and calorie consumption				
Food consumption per capita	35 077	29 080	29 037	31 044
Total calories per person per day	2 513	2 402	2 362	2 425
Dietary diversity measures				
Food consumption score	52.7	48.1	48.2	49.6
Simpson Diversity Index	0.58	0.57	0.54	0.56
SHARE OF CALORIE CONSUMPTION BY FOOD GROUPS (%)				
Grains	67.0	68.4	69.7	68.5
Roots	6.4	6.9	6.4	6.5
Pulses	5.4	5.1	5.2	5.3
Fruits/vegetables	2.5	2.7	2.4	2.5
Meat/fish/milk	4.9	4.3	4.5	4.6
Oils/fats	6.5	5.5	5.1	5.7
Sugars	5.6	5.3	5.2	5.4
Others	1.8	1.8	1.3	1.6

Source: Malawi IHS3.

Econometric methods

Given the presence of unobserved heterogeneity that may jointly determine the dependent variables and the explanatory variable of interest, we rely on Two-Stage Least Squares (**2SLS**) regressions for the analysis of the effects of agricultural involvement on consumption and nutritional outcomes, and a simultaneous system of equations in a Three-Stage Least Squares (**3SLS**) framework for the analysis of the effects of agricultural involvement on caloric shares from the different food groups. The regressions control for a rich set of household and community characteristics, combined with geospatial variables that broadly capture climatological conditions, soil characteristics and agricultural productivity potential obtained by linking geo-referenced household locations to publicly available geographical information systems. The two models are presented in the sections below.

Two-stage least squares model (2SLS)

This model is used to estimate the effects of agricultural involvement on household food consumption levels, and nutritional and dietary diversity outcomes, while controlling for a wealth of household- and district-level characteristics.

Equations (6) and (7) represent the 2SLS model for each outcome variable (Y_h^j).

(6) $$Y_h^j = \alpha_0 + \alpha_1 X_{1h} + \alpha_2 A_h + \varepsilon_h$$

(7) $$A_h = \beta_0 + \beta_1 X_{1h} + \beta_2 X_{2h} + \eta_h$$

Outcome indicators $\in$ *j* ={food consumption per capita; calorie consumption per person per day; food consumption score; the Simpson Diversity Index}

where Y_h^j is the food consumption or nutritional outcome *j* of household *h*, as described in the previous section (expressed in logarithmic form); A_h is the endogenous variable, i.e. the share of on-farm income representing agricultural involvement of household *h* (expressed in logarithmic form); X_{1h} is a vector of exogenous variables assumed to be associated with consumption or nutritional outcomes and agricultural involvement. The latter include household characteristics, such as the gender of the household head, age and education, household size, income diversification, access/use of services, farm characteristics and location-specific fixed-effects factors. X_{2h} is a vector of instrumental variables for agricultural involvement. ε_h and η_h are error terms: $E(\varepsilon_h) = 0$, $E(\eta_h) = 0$, and cov $(\varepsilon_h;\eta_h) = 0$. The analysis runs the model separately for each individual consumption and nutritional outcome *j*.

The instrumental variable (IV), used to capture the random variation in the share of household on-farm income that is not directly related to the dependent variables, is the number of agricultural officers per household at the district level. A key requirement for the validity of such instruments is that they are sufficiently strongly correlated with the endogenous variable and uncorrelated with the error term. In other words, they do not affect consumption or nutritional outcomes directly, but only through agricultural involvement.

Three-stage least squares (simultaneous equations) model (3SLS)

The 3SLS simultaneous equations system of the share of on-farm income and the food group shares of calorie intake is used to assess the effects of agricultural involvement on the structure of calorie intake by looking at individual food groups (grains, roots, pulses, fruits and vegetables, oils/fats and sugars).[6] The 3SLS model can be represented as:

(8) $\quad ShCal_{hi} = \alpha_{0i} + \alpha_{1i} X_{1h} + \alpha_{2i} A_h + \varepsilon_{hi}$, for each food group i

(9) $\quad A_h = \beta_0 + \beta_1 X_{1h} + \beta_2 X_{2h} + \eta_h$

(10) $$\sum_{i=1}^{n} ShCal_{hi} = 1$$

Food groups ∈ A*i* ={cereals, roots, fruits/vegetables, meats/fish/milk, oils/fats, sugars and other}

where $ShCal_{hi}$ is household *h* share of calories from food group *i* (*i equations*), A_h is the endogenous variable (share of on-farm income representing agricultural involvement of household h), X_{1h} is a vector of exogenous variables, and X_{2h} is a vector of instrumental variables for agricultural involvement. ε_h and η_h are error terms, as defined earlier. The equations are estimated as a system of *i* share equations (8) and an agricultural involvement equation (9), subject to a share adding up requirement (10). The estimate of interest is α_2 for each food group *i*.

6. As described in **table 2**, these groups are differentiated by relative energy density, protein content and absorbability of micronutrient content.

Results

As discussed in section 3, we use 2SLS and 3SLS techniques to address the endogeneity of our variable of interest [i.e. the unobserved heterogeneity that may jointly determine consumption and dietary diversity outcomes and agricultural involvement]. The 2SLS model is used to analyze the effects of agricultural involvement on the levels of consumption and dietary diversity outcomes, while the 3SLS system of equations analyses the effects of agricultural involvement on the shares of calories consumed from the various food groups.

Choice of instruments

Several potential instruments were considered. A key question we tried to answer in order to come up with appropriate instruments was whether it was reasonable to consider a set of instruments at the district level, i.e., if the unobserved heterogeneity was not at the district level, but rather at lower levels (e.g. enumeration area or household level). To test that, we run regressions of selected outcomes on on-farm income share, a wide range of household-level factors and district dummies. Essentially, we run two models – a model with district fixed effects (FE) and another with district random effects (RE) – followed by a Hausman test to conclude if the difference in coefficients was systematic (FE) or not (RE).

The test results (**table 4**) indicate a rejection of district fixed effects [i.e. there is no unobserved, time-invariant heterogeneity found at the district level]. Thus, unobserved heterogeneity is more likely to be found at finer levels such as the enumeration area or household level. District-level IVs are therefore appropriate for use in our models.

The final models chosen are *just identified*. The Instrumental Variable (IV) used to capture the random variation in the share of household on-farm income that is not directly related to the dependent variables is the district-level number of agricultural extension officers per household. These data are obtained from the IHS3 and records of the Ministry of Agriculture and Food Security, respectively.[7] To verify the appropriateness of our models in addressing endogeneity through IV (i.e. adequacy of the chosen instruments), we run post-estimation diagnostic tests, such as Wu-Hausman for endogeneity and Cragg-Donald for weak identification, in addition to checking the magnitude and the statistical significance of the correlation with the endogenous variable.

7. We chose the just-identified model after attempting to use multiple district-level instruments (e.g. covariance of average precipitation in rainy season, inputs distributed per household, number of lead farmers per household, among others). Tests of over-identifying restrictions (Sargan Chi2) have systematically not supported the validity of additional instruments.

Table 4: Testing district random effects versus fixed effects

Outcome variables	Null hypothesis (Ho): difference in coefficients not systematic (RE)		
	Chi2 (1)	Prob > Chi2	Unobserved, time-invariant heterogeneity at district level?
HOUSEHOLD LEVEL			
Food consumption per capita	8.78	0.845	No
Calories per capita per day	3.63	0.993	No
Food consumption score	6.13	0.963	No

Source: Malawi IHS3.

2SLS model results

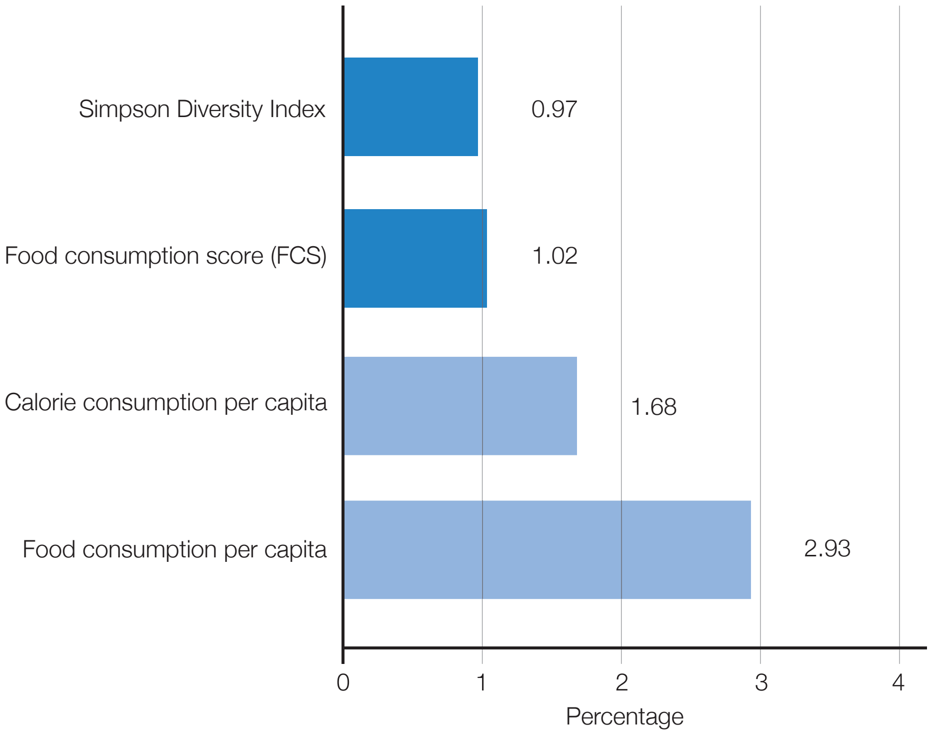
The 2SLS model indicates several results (table 5). First, first-stage regression results indicate that there is a strong positive and statistically significant correlation between the share of on-farm income and the chosen instrument (i.e. the district-level number of agricultural extension officers per household), which is a necessary requirement for its adequacy as an instrument.

Second, there are several other factors strongly associated with the share of on-farm income. Households have lower levels of agricultural involvement if they are man-headed, have achieved relatively high levels of education, have more diversified sources of off-farm income, and are relatively wealthier overall. Higher levels of agricultural involvement are associated with the number of female adults in a household, use of agricultural extension and inputs, high levels of agricultural asset ownership (agricultural asset index), and prevalence of severe nutrient availability constraints.

Finally, and more importantly, the results from the second-stage 2SLS estimations indicate (while controlling for household head characteristics, household composition, agricultural technology, income diversification and region-specific fixed effects) that, on average, a 10 per cent increase in the share of on-farm income leads to: (a) an increase in food consumption per capita of 2.9 per cent (900 Kwachas per capita) and in total calorie intake per capita per day of 1.7 per cent (or 41 calories per person per day); and (b) small improvements in dietary diversity, resulting in an increase of 1.02 per cent in the food consumption score and 0.97 per cent in the Simpson Index. These positive effects are statistically significant at least at the 5 per cent level. The results are fully presented in table 5, and summarized in figure 4.

In each of the 2SLS estimations, we reject the exogeneity of the on-farm income share (the main explanatory variable), justifying therefore the use of the IV approach. In each case, we also find evidence that counteracts potential concerns regarding weak instrumental variable bias (**table 5**).

Figure 4: Effects on food consumption and dietary diversity of a 10% increase in agricultural involvement



Source: Author's computations.

Table 5: Effects of agricultural involvement on food consumption and dietary diversity

Explanatory variables	Effects of share of on-farm income on consumption and dietary diversity (two-stage least square estimates)				
	1st stage: log share of on-farm income	**2nd stage:** log of household-level outcomes			
		Food and calorie consumption		Dietary diversity	
		Per capita food consumption	Consumption of calories	Food consumption score (FCS)	Simpson Index
Log share of on-farm income		0.293**	0.168**	0.102**	0.097*
HEAD CHARACTERISTICS					
Sex of head (1 = male)	-0.113+	0.073**	0.030+	0.055**	0.062**
Age of head	-0.002	-0.002	0.003	-0.006**	-0.013**
Age of head squared	0.000	0.000	0.000	0.000**	0.000**
Highest education	-0.023**	0.013**	0.007**	0.008**	0.011**
HOUSEHOLD COMPOSITION					
# of kids 0-14 years	0.054**	-0.171**	-0.129**	-0.012**	-0.021**
# of male adults 15-64 years	0.073*	-0.144**	-0.101**	-0.016*	-0.021*
# of female adults 15-64 years	0.119**	-0.158**	-0.120**	-0.013+	-0.013
# of individuals 65+ years	0.107	-0.214**	-0.156**	-0.046**	-0.080**
AGRICULTURAL TECHNOLOGY					
Use seeds (D)	-0.145**	0.093**	0.050**	0.038**	0.043**
Use inorganic fertilizer (D)	1.086**	-0.221**	-0.098+	-0.077*	-0.017
Use extension (D)	0.130*	0.032	0.056**	0.030**	0.021
DIVERSIFICATION AND CREDIT ACCESS					
Self-employed (D)	-0.718**	0.326**	0.181**	0.134**	0.173**
Non-farm waged (D)	-0.910**	0.359**	0.207**	0.136**	0.178**
Farm waged (D)	-0.839**	0.168**	0.129**	0.032	0.035
Received credit (D)	-0.050	0.059*	0.013	0.032*	0.024
REGION FIXED-EFFECTS					
Rural Central Region (D)	-0.074	0.154**	0.021	0.002	-0.065**
Rural Southern Region (D)	0.006	-0.032	-0.022	-0.004	-0.009
WEALTH AND PRODUCTIVITY FACTORS					
Log agro-ecological potential	-0.016	0.005	-0.002	0.009*	0.009+
Household wealth index	-0.083**	0.133**	0.060**	0.065**	0.060**
Household agricultural asset index	0.101**	0.029**	0.023**	0.026**	0.051**
Share of adults chronically sick	0.021	0.048	0.047	-0.046*	0.046+
Mean temperature: wettest quarter	-0.032**	0.008**	0.005**	0.003**	0.002
Household land holdings	-0.016	0.028**	0.016**	0.009**	0.004
Moderate nutrient avail. const. (D)	0.054	-0.044+	-0.016	-0.006	-0.034*
Severe nutrient avail. const. (D)	0.319**	0.000	-0.006	0.024	0.025
INSTRUMENTS					
Log # Dist. Ag. Officers/household	0.235**				
Constant	7.154**	9.081**	7.050**	3.223**	-0.812**
Observations	8 872	8 872	8 872	8 872	8,872
R-Squared	0.173				
Endogeneity test (a)					
Wu-Hausman F (1;8844)		53.63	20.08	18.12	4.50
[p-value]		[0.000]	[0.000]	[0.000]	[0.000]
Weak-identification test (b)					
Gragg-Donald Min. eigenvalue stat	31.05				
Crit. Val.:10% max IV size	16.38				

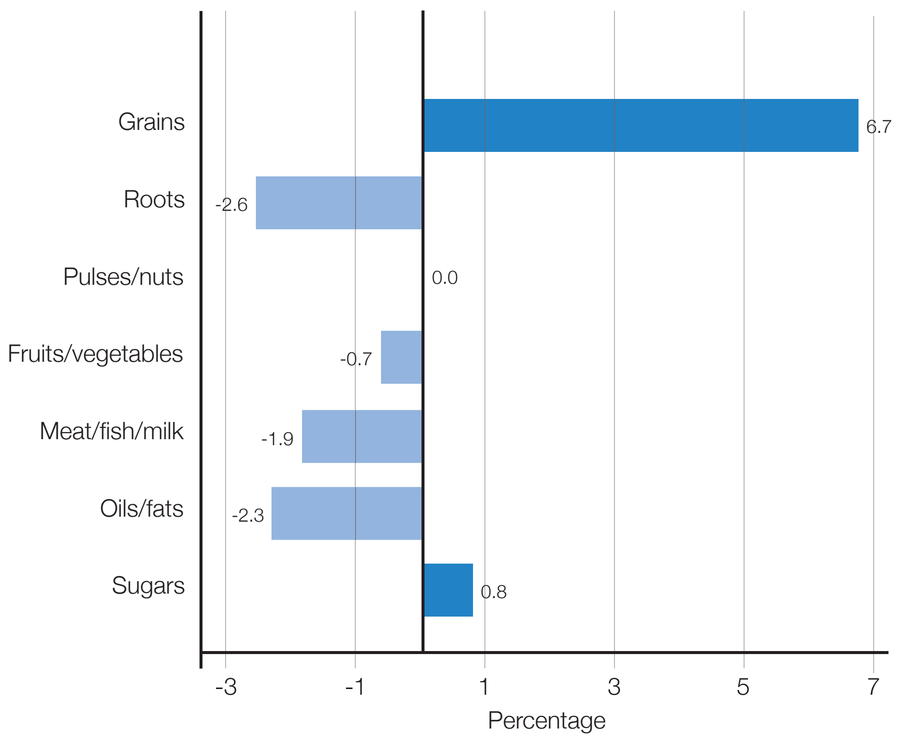
Note: (a) Ho: Share of on-farm income is exogenous; (b) Ho: Instruments are weak. Significance levels are: 1% (**), 5% (*) and 10% (+). Source: Malawi IHS3.

3SLS simultaneous equation model results

The 3SLS simultaneous equations model is aimed at assessing the extent to which agricultural involvement relates to the structure of household consumption. More specifically, we evaluate how increased share of on-farm income affects the shares of calories consumed from the defined food groups (grains, roots, pulses, fruits and vegetables, oils/fats and sugars) whose nutrition attributes are described in **table 1 of the annex**.

The 3SLS estimations reveal fundamental differences in the relationship between the caloric shares and the share of household on-farm income. First, there is a positive and statistically significant relationship between the share of household on-farm income and the shares of calories from energy-dense and low-protein grains and cereals. A positive effect is also observed in relation to sugars, but it is not statistically significant. Second, there is a negligible and not statistically significant impact on the share of caloric intake associated with nuts and pulses. Finally, we find negative and statistically significant relationships between the share of household on-farm income and the shares of calories from (a) roots and tubers, (b) vegetables and fruits, (c) oils and fat, and (d) meat, fish and milk products (high-quality protein/easily absorbable micronutrient foods). These results are fully presented in table 6, and summarized in figure 5.

Figure 5: Effects on food group shares of a 10% increase in agricultural involvement



Source: Author's computations.

Table 6: Results of 3SLS system of equations estimation: effects of agricultural involvement (share of on-farm income) on share of calorie consumption per food group

Explanatory variables	3SLS system of equations: share of on-farm income and share of calories of food groups in total calories consumed (all shares ranging from 0 – 1)							
	Share of on-farm income	Share of calories from food groups (shares across groups sum up to 1)						
		Grains	Roots	Pulses/ nuts	Fruits/ vegetables	Meat/fish and milk	Oils/fats	Sugars
ENDOGENOUS:								
Share of on-farm income		0.670**	-0.258**	0.001	-0.065*	-0.187**	-0.234**	0.076
EXOGENOUS:								
HEAD CHARACTERISTICS								
Sex of head (1 = male)	0.002	-0.009	-0.005+	0.001	-0.001	0.006*	0.007**	0.000
Age of head	0.002	0.003**	0.000	-0.001**	0.000	0.000	0.000	-0.001**
Age of head squared	0.000	0.000*	0.000	0.000**	0.000	0.000	0.000	0.000*
Highest education	-0.005**	0.001	-0.001*	0.000	0.000	-0.001**	0.000	0.001*
HOUSEHOLD COMPOSITION								
# of kids 0-14 years	0.004*	0.005**	0.000	-0.001**	0.000	-0.002**	0.002*	-0.003**
# of male adults 15-64 years	0.006	-0.001	0.003	-0.001	-0.001	0.001	0.000	-0.001
# of female adults 15-64	0.014**	-0.012*	0.005*	0.000	0.001	0.004*	0.003	0.000
# of individuals 65+ years	0.006	0.009	-0.006	0.000	0.002	-0.005	0.002	-0.002
AGRICULTURAL TECHNOLOGY								
Use seeds (D)	-0.012*	-0.009+	0.001	0.004**	0.001	-0.002*	0.002	0.002
Use inorganic fertilizer (D)	0.081**	-0.054**	0.015*	0.002	0.006*	0.011**	0.023**	-0.004
Use extension (D)	0.027**	-0.037**	0.016**	0.002	0.004**	0.007**	0.009	-0.001
DIVERSIFICATION AND CREDIT								
Self-employed (D)	-0.373**	0.227**	-0.099**	0.003	-0.024*	-0.067**	-0.080**	0.037*
Non-farm waged (D)	-0.382**	0.242**	-0.105**	0.009	-0.023*	-0.072**	-0.088**	0.037*
Farm waged (D)	-0.247	0.191**	-0.066**	-0.003	-0.016*	-0.055**	-0.062**	0.010
Received credit (D)	-0.006	0.005	-0.002	0.000	0.000	-0.002	-0.003	0.001
REGION FIXED-EFFECTS								
Rural Central (D)	-0.003	0.168**	-0.077**	0.017**	0.004**	-0.117**	-0.005	0.004+
Rural South (D)	-0.047**	0.173**	-0.086**	0.020**	0.010**	-0.142**	-0.002	0.021**
WEALTH AND PRODUCTIVITY FACTORS								
Log agro-ecological potential	0.000	0.000	0.000*	0.000	0.000	0.000	0.000	0.000
Household wealth index	-0.024**	0.002	-0.005*	0.001	-0.002**	0.001	-0.003+	0.005**
Household agr. asset index	0.018**	-0.020**	0.007**	0.001	0.001	0.004**	0.004**	0.002+
Share adults chronically sick	-0.011	0.005	-0.002	0.005	0.005**	-0.005	-0.007*	-0.001
Mean temp: wettest quarter	-0.001**	0.000	0.000	0.000**	0.000**	0.001**	0.000	0.000
Household land holdings	0.015**	-0.004	-0.001	0.001	0.001	0.001	0.003*	-0.001
Moderate nutrient avail. (D)	-0.007	0.014*	-0.012**	0.001	-0.001	-0.004+	-0.003	0.006**
Severe nutrient avail (D)	0.001	-0.030**	0.023**	-0.007**	0.000	0.007**	-0.007*	0.015**
INSTRUMENTS								
Log # Dist. Ag. Officers/household	0.338**							
Constant	0.982**	-0.085	0.367**	0.097+	0.114**	0.169**	0.258**	0.041
Observations	8 684	8 684	8 684	8 684	8 684	8 684	8 684	8 684
Parameters	26	26	26	26	26	26	26	26
RMSE	0.234	0.248	0.116	0.068	0.039	0.080	0.091	0.066
R-Squared	0.500	-0.489	-0.275	0.023	-0.181	0.068	-0.488	-0.001
Chi-2	8 668.550	917.370	643.540	204.790	190.240	3 329.060	252.080	468.600
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: Significance levels are: 1% (**), 5% (*) and 10% (+). Source: Malawi IHS3.

Conclusions and policy implications

In the context of persistent and high levels of poverty and food insecurity in Malawi, the links between agriculture and nutrition are potentially important, but have not received adequate attention. In part, that has been due to data limitations. Taking advantage of data recently collected in Malawi through the IHS3, which allows household consumption to be linked to the structure of economic activity and income sources, this paper starts to fill that gap by investigating the effect of agricultural involvement on household consumption and dietary diversity.

The analysis uses a rural agricultural household sample of over 9,000 households [i.e. 92 per cent of the overall rural survey sample]. The range of outcome variables that inform our analysis include: (*a*) household annual food consumption expenditures per capita; (*b*) household caloric intake per capita per day; (*c*) household food consumption score; (*d*) household Simpson Index of dietary diversity; and (*e*) shares of caloric intake attributed to (i) cereals and grains, (ii) roots and tubers, (iii) nuts and pulses, (iv) vegetables and fruits, (v) meat, fish, milk and other animal products, (vi) oils, (vii) sugar products, and (viii) other food items. The main explanatory variable is household income from crop and livestock activities as a share of total household income – a measure that captures the relative weight of household agricultural involvement.

Given the presence of unobserved heterogeneity that may jointly determine the dependent variables and the explanatory variable of interest, we rely on 2SLS regressions for the analysis of outcomes (*a*) through (*d*), and a simultaneous system of equations in a 3SLS framework for the analysis of caloric shares (*e*), as defined above. The regressions control for a rich set of household and community characteristics, combined with geospatial variables that broadly capture climatological conditions, soil characteristics and agricultural productivity potential, and that are obtained by linking geo-referenced household locations to publicly available geographical information systems.

Conditional on observable attributes that are part of our models, we provide results from diagnostic tests that reject the presence of unobserved district-level heterogeneity, in support of district-level Instrumental Variables (IVs). The models are just identified, and the IV used is the district-level number of agricultural extension officers per household. This variable is strongly correlated with the share of on-farm income. Through post-estimation tests, we reject the exogeneity of the main explanatory variable (justifying the need for the 2SLS approach), and provide evidence that counteracts potential concerns regarding weak instrumental variable bias.

Controlling for a wealth of household and region-specific factors, 2SLS estimations indicate that, on average, a 10 per cent increase in the share of on-farm income leads to: (a) an increase in food consumption per capita of 2.9 per cent and in total calorie intake per capita per day of

1.7 per cent; and (b) only small improvements in dietary diversity, resulting in an increase of 1.02 per cent in the food consumption score and 0.97 per cent in the Simpson Index. These positive effects are statistically significant at least at the 5 per cent level.

The 3SLS estimations reveal fundamental differences in the relationship between the caloric shares and the share of household on-farm income. While there is a positive and statistically significant relationship between the share of household on-farm income and the shares of calories from energy-dense low-protein cereals and grains, there is no statistically significant impact on the caloric intake associated with nuts, pulses and sugars. Furthermore, we find negative and statistically significant relationships between the share of household on-farm income and the shares of calories consumed from (a) roots and tubers, (b) vegetables and fruits, (c) oils and fat, and (d) meat, fish and milk products (high-quality protein/easily absorbable micronutrient foods), which normally define more diversified diets that are predominantly purchased.

These results indicate that although household food consumption and dietary diversity increases with agricultural involvement, there are issues related to the quality of diets, as energy-dense diets increase with agricultural involvement. As purchased calories are associated with richer high-quality diets (particularly protein-rich diets), households with lower degrees of dependence on agriculture seem to be able to access those diets more easily, highlighting the importance of overall income diversification to rural livelihoods.

In order to increase and sustain the caloric requirements and balanced diets, improvements are needed in the supply (crop composition) and in the demand side (purchasing power and consumer knowledge). These call for policies/programmes focused on three key areas. First, promoting crop diversification at the farm level using nutrition sensitive agricultural extension and crop support programmes. Second, strengthening agricultural market participation and income diversification to increase liquidity (cash availability) and achieve poverty reduction while improving household food and nutrition security. Finally, promoting household-level nutrition education/awareness and strengthen nutrition education in school curricula, as stand-alone or in the context of school feeding programmes.

Annex tables

Annex Table 1. Definition of food groups used in the analysis

Food groups	Food items	Nutritional attributes
Main staples (cereals and tubers)	Cereals: Maize grain/flour; green maize; rice; finger millet; pearl millet; sorghum; wheat flour; bread; pasta; other cereals. Roots/tubers: Cassava tuber/ flour; sweet potato; Irish potato; other tubers/plantain.	Energy dense, protein contents of lower and poorer quality than in legumes, micronutrients (bound by phytates).
Nuts and pulses	Beans; pigeon pea; macadamia nuts; groundnuts; ground beans; cow pea; other nuts/pulses.	Energy dense, high amounts of protein but of lower quality than in meats, micronutrients (inhibited by phytates), low fat.
Vegetables	Onion; cabbage; *tanaposi*; *nkhwani*; wild green leaves; tomato; cucumber; other vegetables/leaves.	Low energy, low protein, no fat, micronutrients.
Fruits	Mango; banana; citrus; pineapple; papaya; guava; avocado; apple; other fruits.	Low energy, low protein, no fat, micronutrients.
Meat, fish and animal products	Egg; dried/fresh/smoked fish (excluding fish sauce/powder); beef; goat meat; pork; poultry; other meat.	Highest quality protein, easily absorbable micronutrients (no phytates), energy dense, fat. Even in small quantities, improvements to the quality of diet are large.
Milk and milk products	Fresh/powdered/soured milk; yogurt; cheese; other milk products (excluding margarine/ butter or small amounts of milk for tea/coffee).	Highest quality protein, micronutrients, vitamin A, energy. However, milk could be consumed only in very small amounts and should then be treated as a condiment. In such cases, a reclassification is needed.
Sugar, sugar products and honey	Sugar; sugar cane; honey; jam; jelly; sweets/candy/chocolate; other sugar products.	Empty calories. Usually consumed in small quantities.
Oil and fats	Cooking oil; butter; margarine; other fat/oils.	Energy dense, but usually no other micronutrients. Usually consumed in small quantities.

Source: Adapted from WFP (2007), adjusted for Malawi IHS3.

Annex Table 2. Food consumption inadequacy in Malawi

	Proportion of households with inadequate food consumption (%)[1]						
	All households	Sex of the household head			Poverty status		
		Male	Female	Difference	Non-poor	Poor	Difference
RURAL MALAWI	22.7	20.3	29.9	9.6**	9.2	36.7	27.5**
RURAL REGION							
Northern	20.2	9.3	23.7	4.4	9.5	30.0	20.5 **
Central	24.7	21.6	35.6	14.0**	10.1	43.6	33.5**
Southern	21.8	19.5	27.4	7.9**	8.1	33.7	25.6**

Notes: (1) Inadequate food consumption is defined as poor or borderline, i.e. a food consumption score <35.
Significance level of the difference: 1% (**), 5% (*) and 10% (+).
Source: Malawi IHS3.

References

Chung, K. 2012. Introduction to agriculture nutrition linkages. Working Paper No. 72E, Directorate of Economics, Ministry of Agriculture, Maputo, Mozambique.

Hoddinott, J. 2011. Agriculture, health, and nutrition: Toward conceptualizing the linkages. 2020 Conference Paper 2 presented at the International Conference on Leveraging Agriculture for Improving Nutrition and Health, 10-12 February, Delhi, India.

National Statistics Office (NSO-Malawi). 2011. Integrated Household Survey 2010-2011. Zomba, Malawi.

Sahn, D. 2010. The impact of poor health and nutrition on labor productivity, poverty and economic growth in Sub-Saharan Africa. In *The African food system and its interaction with human health and nutrition*, ed. P. Pinstrup-Andersen. Ithaca, New York: Cornell University Press in cooperation with the United Nations University.

Task Force for Child Survival and Development. 1991. Proceedings of Ending Hidden Hunger. Policy Conference on Micronutrient Malnutrition, 10-12 October, Montreal, Quebec.

Von Braun, J., M. Ruel, and S. Gillespie. 2010. Bridging the gap: Linking agriculture and health to achieve the Millennium Development Goals. In *The African food system and its interaction with human health and nutrition*, ed. P. Pinstrup-Andersen. Ithaca, New York: Cornell University Press in cooperation with the United Nations University.

World Bank. 2014. *Trends and determinants of household welfare in Malawi: Implications for policy*. Washington, D.C.: World Bank.

World Food Programme (WFP). 2007. Food consumption analysis: Calculation and use of the Food Consumption Score in food consumption and food security analysis. Draft. Rome: WFP.

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