The influence of household farming systems on dietary diversity and caloric intake: the case of Uganda

Vincent Linderhofa

Jeffrey Powella,b

Romain Vignesc

Ruerd Rubena,d

LEI Wageningen University Research Centre, the Netherlands

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# Abstract

The relationship between farm production diversity at the plot level and diversity of household consumption and caloric intake are econometrically estimated. Our results confirm previous findings that an increase in production diversity increases consumption diversity and thereby, presumably, household nutritional levels. In addition, we find a positive relationship between diversity of farm production and caloric intake. Three waves of the World Bank LSMS-ISA database for Uganda were used to create a panel data set. Both fixed effects and limited dependent variable panel models, including time, were estimated. Results indicate that households that produce a greater diversity of crops, have higher food expenditures, have larger farms, and consume more from their own production have higher consumption diversity and caloric intake. Policy implications are that strategies aimed at increasing household production diversity may have positive effects on household nutritional levels and caloric intake.

**Keywords:** dietary diversity, panel data, farm production diversity, caloric intakes, Uganda

**JEL Code:**

# 1. Introduction

According to FAO, “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO, 1996).Given this definition of food security, the definition of a single indicator a or a reasonable set of indicators for security is a complex task. Indicators suggested in the literature can be categorised into four categories: caloric deprivation indicators; monetary poverty indicators; dietary diversity indicators, and; subjective indicators (Headey and Ecker 2013). Carletto, Zezza, and Banerjee (2013a) compiled the following list of the most common indicators of food security: measures of undernourishment, food consumption scores, household food security access scales, coping strategy indices, food adequacy factors and non-food factors.

The overlap between food security and nutritional security is large, our emphasis in on the whether a household consumes the types of food items that will ensure an adequate intake of nutrients. ADD WHETHER OR NOT THESE TWO LINK; BETTER RELATE PRODUCTION AND FOODCONSUMPTION/NUTRITION VALUE AND DISCUSS THIS LINK IN THE LITERATURE REVIEW; ANY REFERENCES; WHY UGANDA THE MOTIVATION AND RESEARCH QUESTION SHOULD FOLLOW FROM THIS DISCUSSION

Results from (Kumar 1994) showed that the promotion of hybrid seed use by maize growing smallholders in Eastern Province of Zambia has increased their productivity of maize, increased their reliance on maize products in their food consumption, and declined their dietary diversity. This latter result was surprising, because it contradicted with the historical development in the region where maize growing smallholders maintained to grow local maize varieties due to local preferences for those varieties. In a recent study (Smale, Moursi, and Birol 2015) reinvestigated the impact of hybrid seeds on dietary diversity and they concluded that women in maize growing households have more diverse diets. There is some evidence that diversity of food production at the farm level positively affects diversity of the diet. In particular, recent work by Jones et al. (2014a) showed that there is a positive relationship between farm production and the health of household members.

For Uganda, there has not been an investigation on the link between the use of hybrid seeds, crop production diversity (or productivity) and dietary diversity. This paper links food security, particularly nutritional security at the level of the household, with household farm production. We examine the effects of the diversity of farm production for households in Uganda on their dietary diversity, a measure that has previously been linked to a household’s nutrient adequacy, and caloric intake (Hoddinott and Yohannes 2002). As will be argued further below, establishing a direct link between a measure of household’s nutrient level and its constituents is difficult and we are apply a second-best technique. Ideally we would have conducted our analysis at the level of the individuals however such diary level data is not available in the data set (Arimond and Ruel 2004). The principle advantages of the data we analyse over individual, diary level data are its breadth and length.

This paper will explore the impact of production diversity when explaining the determinants of dietary diversity. We will base our analyses on the work of Jones, Shrinivas, and Bezner-Kerr (2014) for Malawi and we will extend their work in two ways. Firstly, we use panel data on farmers households instead of cross-section data. Panel data allows us to utilize econometric techniques which statistically control for potential problems related to unobserved heterogeneity which can bias results when cross-sections data are used. In addition, we control for a set of household characteristics (e.g. non-agricultural income, investments and transfers).

The last technical addition concerns the use of a count model in place of the continuous models used in Jones et al.

Secondly, Jones, Shrinivas, and Bezner-Kerr (2014) use two dietary diversity indicators in their analyses namely Household Dietary Diversity Score (HDDS), and the Food Consumption Score (FCS). We add another dietary diversity indicator that links household caloric intake to farm production diversity. Our hypothesis is that an index which combines both nutrient diversity and caloric content will provide a better indication of health than either a nutrient diversity or caloric content index alone. By doing so, we hope to provide a convenient, first approximation of the level of household food security and allow policy makers to better target potential policies.

The remainder of the paper is organized as follows, the next section describes the data and methods used, emphasizing the process of selecting the variables eventually used in the analysis and the panel techniques employed. Thereafter follows the results and discussion sections. Finally, the conclusions section describes general conclusions and suggests policy implications.

# 2. Methodology

For smallholders, production and consumption decisions are non-separable. This means that production decisions are affected by household preferences (consumption decisions). Therefore, we analyse the relationship between production diversity, food consumption and dietary diversity within the theory of agricultural household models (Singh et al. 1986; Sadoulet and De Janvry 1995). In this theory, household members organize their labor and farm resources with the objective of maximizing utility over consumption goods and leisure in an economic environment defined by market failures, such as controlled prices and overt subsidies, and market uncertainties inherent in rain-fed agriculture where market infrastructure is inadequate. Small holders produce goods for consumption and for sale (at local markets). Access to credit markets is still limited for them, and to overcome cash constraints primarily through farm sales family members take on off-farm jobs. In the case of cash constraints for (food) consumption, farmers also sell livestock or farm equipment.

food

of time(Hatluy, Torheim, and Oshaug 1998; Torheim et al. 2004; Kennedy et al. 2007) (Arimond and Ruel 2004; Steyn et al. 2006).Steyn et al. (2006) dS(Kennedy et al. 2007).explored the nutrient adequacy indicators Torheim et al. (2004)

Ideally, the nutrient adequacy is measured for individuals. Unfortunately individual consumption data is not available in the LSMS-ISA surveys in Uganda. Therefore, we and whousehold distribute (Thorne-Lyman et al. 2010; Jones, Shrinivas, and Bezner-Kerr 2014)AThorne-Lyman et al. (2010)dietary diversity scores are increasingly used as measures of food security and as proxies for nutrient adequacy because data rather. (Pitt et al.(1990)

Measurement of dietary diversity

We aim to link production diversity and the diversity of household consumption in Uganda similar to (Jones, Shrinivas, and Bezner-Kerr 2014) with their analysis for Malawi. In keeping with the literature on this topic and to provide a rough crosscheck of outcomes, we use several measures of dietary diversity. In order to compare our work with previous results we test two commonly accepted measures of dietary diversity which have been linked to a healthy nutrient diet, namely, the FVS and DDS measures previously presented (Hatluy, Torheim, and Oshaug 1998; Arimond and Ruel 2004; Torheim et al. 2004; Steyn et al. 2006; Kennedy et al. 2007).

The DDS is the count of the number of nutritional food groups consumed by a household in a reference period (Swindale and Bilinsky 2006). The maximum score for a household is 12 as there are 12 nutritional food groups: *i*. cereals, *ii*. roots and tubers, *iii*. pulses and nuts, *iv*. vegetables, *v*. fruit, *vi*. meat, *vii*. eggs, *viii*. fish and seafood, *ix*. milk and dairy products, *x*. oil and fats, *xi*. condiments, and *xii*. sugar. The advantages of the DDS indicator are:

* It shows dietary diversity as it distinguishes 12 food groups;
* It is associated to improved outcomes in areas such as birth weight, child anthropometric status, and improved hemoglobin concentrations;
* It is highly correlated with such factors as caloric and protein adequacy, percentage of protein from animal sources (high quality protein), and household income;
* It can be asked at household or individual level; and
* The data for the DDS are relatively easy to collect.

The Food Variety Score counts individual food items (Torheim et al. 2004) in a given reference period. Each food groups consists of a number of food items, see Torheim et al. The calculation of the FVS score requires more detailed data on food items. As the DDS, the FVS score does not take into account the frequency of consumption of food items given a reference period.

However, in order to approximate the results in (Jones, Shrinivas, and Bezner-Kerr 2014), we use a derivate of the FVS known as the Food Consumption Score (FCS). The FCS uses weighted food groups, the Dietary Diversity Score uses also uses food groups but with weights set to one and the Food Variety Score counts individual food items. Therefore, while both the FVS and FCS measure the number of different food items consumed over a defined period, the FCS weights

each food item according to its nutritional contribution to the diet (United Nations World Food Programme 2008). Households were interviewed in regards to their consumption of 69 food items over the last 7 days before the interview date.

Measurement of farm production diversity

In addition to the three measures of dietary diversity, three indicators were used to estimate farm production diversity; recall that farm production diversity is an exogenous variable in our model. All three production diversity indicators are postulated to be positively linked to our measures of dietary diversity and two of them have been previously used (Jones, Shrinivas, and Bezner-Kerr 2014).

The first measure of farm production diversity is the count of the number of different crops harvested by the household farm. It only takes into account crops which have been harvested at the time the household was interviewed. Current crops on the plots were not taken into account, because we cannot be certain that those crops will eventually be consumed or sold due to health concerns of the farmer, and the threats of insects, rodents, droughts, floods, other pests and thefts.

The second measure of production diversity is the Simpson’s index which was initially used in ecology to define the diversity of a given population (Simpson 1949).

with

Where and is the share of cultivated land with crop *j* in the total area cultivated by the household *i*. The Simpson’s index was estimated for a household for each of the three years of the panel. The index is bounded by 0 and 1 and allows us to measure the diversity of farm production. If a household cultivated one single crop, the value of the Simpson’s index is zero. Values approaching zero indicate that a household cultivates one main crop with small plots with other crops. has an unequal distribution of crops, while a value approaching one reflects an equal crop distribution across cultivated area. Areas were calculated by GPS data recorded in the surveys, when the GPS data was not available, the farmer plot size estimation was considered, estimations available in the LSMS-ISA survey. In cases of intercropping, each crop was taken separately. Given that there is no information on the proportion of an intercropped crop on a plot, we assume that each crop encompasses the entire plot. The two seasons, dry and rainy, were taken in consideration for the Simpson’s index as for the other variables. Both seasons correspond to different varieties and amount of production, consider them together reduce possible errors.

The third production indicator has not previously been used in the literature. It is designed to reflect the effects of farm production diversity on the number of nutritional food groups grown by a household. In an analogous relationship to that between the FVS and DDS measures, our third indicator counts the number of food items *from different nutritional groups* produced by a household. In short, it distinguishes between crops based on their contribution to nutritional diversity. All three production diversity measures are designed to estimate the effect of production diversity on consumption diversity. The same nutritional matching and groups are considered as in the DDS and as a result a score is calculated between 0 and 12 inclusive. This new indicator is easy to calculate and could provide policy makers with an additional indicator of health. This variable seems important especially for households consuming their own production and we expect that a production of various nutritional food group should improve the diet quality. A separate exogenous variable indicating whether households raise animals such as chickens or cattle was included in the regressions to test their effect on household consumption diversity.

ADD MOTIVATION WHY 3 PRODUCTION INDICATORS AND 3 NUTRITION INDICATORS

CONCEPTUAL FRAMEWORK

# 3. Data

see Boysen et al. (2014)(The Uganda Bureau of Statistics 2015)

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*Variables description*

In addition to the three measures of production diversity discussed above, many other variables were considered for inclusion into our model to explain household dietary diversity. The number of potential variables in the World Bank survey meant that we were able to test many potential variables. In practice, our task was to choose a subset of variables that best explains dietary diversity. The variable selection criteria we used was first to consult the literature to get an overview of the set of variables commonly used with the addition of other variables which are commonly used in the micro-economics. Finally, a third condition for deciding whether a variable was chosen for inclusion in the model was the condition of parsimony. The following paragraphs discuss potential variables considered for inclusion into out model and our hypotheses concerning its potential effect on dietary diversity. To ease the flow of the discussion, each variable was placed into one of the following four categories: household characteristics, economics characteristics, agricultural characteristics and location.

*Household characteristics*

Household characteristics clearly have significant effects on the diversity of food consumption. For instance, the number of household members has previously been hypothesized to directly influence the household dietary diversity and caloric intakes by, for example, influencing the number of members who are potentially able to work. Following previous studies, we believe that this variable will be positively related to the diversity of consumption and the quantity of caloric intakes (Weiss and Briglauer 2000; Benin et al. 2004; Jones, Shrinivas, and Bezner-Kerr 2014). The gender of the head of the household has been argued to be positively related to dietary diversity. For instance, Abay et al. (2009) found a positive correlation with a male household head in Ethiopia link to their contribution to certain tasks associated with strong physical labour such as ploughing. The age of the household head has also been hypothesized to be positively correlated with dietary diversity because it is seen as a proxy for experience. However, while Abay et al. (2009) found a positive relationship between age and diversity, (Jones, Shrinivas, and Bezner-Kerr 2014) found a negative correlation. The argument behind the relationship between age and diversity is not entirely clear. The underlying assumption which we make is that heads of households desire to increase dietary diversity because they assume that it increases health, greater age, which is a proxy for experience, allows better, healthier production decisions to be made. Similarly, the education level of the household head and person primarily responsible for food preparation is presumed to be positively related to the dietary diversity of the household and their caloric intake. A better education level should influence the knowledge about the importance of a good diet. Positive influence of this parameter have been stressed by (Benin et al. 2004; Jones, Shrinivas, and Bezner-Kerr 2014).

*Economics characteristics*

Clearly, the economic characteristics of a household affect food consumption diversity. Total income is an important indicator of the general economic well-being of households, consequently a positive relationship is expected between consumption diversity and total income. A high level of income may permit to the purchase of more food and food of higher nutritional quality. The econometric techniques used will allow us to distinguish between the effects of income on household net of the effects of, for example, household size. In a separate model, we examine the importance of sources of household income on diversity by categorizing income along the following lines: agricultural income, non-agricultural income, property income, investments and transfers. Agricultural and non-agricultural income are expected to be positively related to diversity because they are the main sources of income for the households in our sample. In regards to the expenditures of households, we expect food expenditures to be positively correlated with diet diversity because of its direct link to the quantity and the diversity of the food products consumed. Non-food expenditures are assumed to reflect the socio-economic situation of a household. According to Thorne-Lyman et al. (2010), non-food expenditures have a positive effect on the household dietary diversity, however, surprisingly (Jones, Shrinivas, and Bezner-Kerr 2014) found a negative relationship. All money values have been deflated by taking 2010 as index.

*Agricultural characteristics*

With 66% of the Ugandan population employed in the agricultural sector in 2009 (Boysen et al., 2014), agricultural characteristics are an essential component of Ugandan households. The number of household members who have worked in sector other than agriculture is hypothesized to be positively related to dietary diversity because of its positive influence on income. Such jobs are could represent a significant source of income for households and make them economically more independent of the agricultural sector. In addition, the proportion of food items consumed from a household’s own farm production is expected to be positively correlated with dietary diversity of consumption. We hypothesize that a family with a farm has potentially greater access to a diversity of food items not otherwise available through the market or elsewhere. Whether the head of the household primarily makes economic farm decisions was evaluated. Jones et al. (2014), argue dietary diversity increases when the head of the household controls agricultural earnings decisions. The underlying assumption, presumably, is that the head of the household has as an aim high dietary diversity. Finally, we test whether a household’s total crop area has an influence on the income of the family and on own farm production consumption. More land and maybe more plots can encourage and allow households to produce a greater diversity of crops. Accordingly, this variable is presumed to be positively correlated with food diversity and caloric intakes of the household.

Location

Finally, the location, in terms of western, eastern, northern or central Uganda, of a household was assumed to be an important determinant of dietary diversity. We argue that being in the central region, where Kampala is located, gives a household greater market access for it products and other products and, in addition, increases access to non-agricultural jobs, both of which imply that a household can potentially increase the diversity of the crops it consumes.

Data characteristics

Two data analyses are presented in this paragraph, first household data are described for each of the three waves, and secondly, they are split according to their location to stress differences within the country which might then be used to set assistance priorities.

Table 1 presents the characteristics of households variables previously described disaggregated by wave year. Most important changes were observed for the household size which increased from 2009 to 2012 and the cultivated area which decreased over the same period. Table 2 presents the sample variables split by region. Both dietary diversity scores were greater in the central region while the lowest scores were observed in the northern region for the FCS and western region for the DDS. Households from western region spent less for food and consumed more products from their own farm. Their farms were the smallest of the country; the biggest were located in northern region. The central region, which includes the Ugandan capital Kampala and surrounding regions, had the highest incomes per household.. Standard deviations are large and stress the existence of large gaps between the poorest and richest households. These large differences were observed after removing outliers. But standard deviations for income and expenditures remained still significantly elevated.

*Table 1: Variable characteristics by year*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 2009/2010 | | 2010/2011 | | 2011/2012 | |
| Characteristics | mean | SD | mean | SD | mean | SD |
| *Household characteristics* |  |  |  |  |  |  |
| Household size | 6.87 | 3.23 | 7.53 | 3.49 | 8.15 | 3.80 |
| Age head household | 47.15 | 15.01 | 47.82 | 15.01 | 48.67 | 14.77 |
| Education level head household | 20.64 | 10.78 | 21.10 | 11.86 | 20.61 | 11.22 |
| *Production indicators* |  |  |  |  |  |  |
| Number of different crops produced by household | 5.15 | 2.10 | 5.12 | 2.09 | 4.83 | 1.97 |
| Total cropped area | 5.09 | 21.74 | 5.56 | 29.79 | 4.02 | 7.65 |
| *Nutrition diversity* |  |  |  |  |  |  |
| FCS | 56.84 | 21.72 | 55.50 | 21.92 | 59.34 | 21.34 |
| DDS | 7.35 | 1.97 | 7.33 | 2.04 | 7.48 | 2.05 |
| Food expenditure | 250.17 | 365.06 | 272.95 | 428.82 | 297.00 | 464.61 |
| Non-food expenditure | 201.66 | 537.33 | 144.47 | 363.42 | 148.38 | 701.27 |
| Proportion food consumed from household production | 0.37 | 0.19 | 0.34 | 0.20 | 0.39 | 0.20 |
| Calories by HH | 73,131.29 | 57,374.23 | 67,420.06 | 75,311.22 | 70,892.96 | 73,086.24 |
| *Income sources* |  |  |  |  |  |  |
| Total household income | 1,754.87 | 6,484.85 | 1,739.88 | 7,515.30 | 1,807.59 | 5,011.38 |
| Number different non-agricultural income sources | 0.10 | 0.35 | 0.31 | 0.66 | 0.29 | 0.60 |
| Agricultural income | 730.40 | 4752.38 | 633.75 | 1624.64 | 781.30 | 1919.23 |
| Non-agricultural income | 3.09 | 116.84 | 0.23 | 5.37 | 3.54 | 92.63 |
| Property income | 451.59 | 2044.57 | 648.27 | 6791.09 | 558.45 | 3321.52 |
| Investments | 66.09 | 514.69 | 126.59 | 1463.42 | 99.06 | 1199.97 |
| Transfers | 189.55 | 810.36 | 253.97 | 1202.16 | 276.19 | 1538.28 |

SD = Standard Deviation

*Table 2: Variables characteristics by region over all three waves*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Eastern |  | Western |  | Northern |  | Central |  |
| Characteristics | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Household size | 7.71 | 3.61 | 7.15 | 3.15 | 7.13 | 3.16 | 8.17 | 4.21 |
| FCS | 58.23 | 22.78 | 58.60 | 20.39 | 52.27 | 20.18 | 60.63 | 22.54 |
| Number of different crops produced by the household | 4.65 | 1.85 | 5.35 | 1.96 | 4.73 | 2.09 | 5.55 | 2.22 |
| Age of the household head | 48.43 | 14.16 | 47.81 | 15.07 | 46.14 | 14.75 | 49.40 | 15.80 |
| Education level of the household head | 20.86 | 11.39 | 20.18 | 10.82 | 21.45 | 11.91 | 20.57 | 10.95 |
| Total cropped area | 4.17 | 22.41 | 3.69 | 7.76 | 7.42 | 33.11 | 4.07 | 11.09 |
| DDS | 7.64 | 1.94 | 6.53 | 1.97 | 7.46 | 1.96 | 7.94 | 1.97 |
| Food expenditure | 249.58 | 322.24 | 198.09 | 306.55 | 305.48 | 490.42 | 350.61 | 528.95 |
| Non-food expenditure | 129.05 | 231.86 | 122.77 | 243.21 | 181.64 | 474.18 | 238.55 | 1002.71 |
| Incomes | 1474.03 | 4591.61 | 1546.88 | 3272.15 | 1720.66 | 5025.95 | 2426.33 | 10908.34 |
| Number of different non-agricultural income sources | 0.20 | 0.49 | 0.25 | 0.63 | 0.22 | 0.55 | 0.27 | 0.58 |
| Proportion of food consumed in previous  One week from households own production | 0.35 | 0.18 | 0.46 | 0.21 | 0.31 | 0.18 | 0.36 | 0.20 |
| Calories by HH | 83338.23 | 86398.41 | 55883.82 | 55234.58 | 67441.70 | 54758.01 | 74008.97 | 69767.01 |
| Agricultural incomes | 672.65 | 3194.08 | 656.98 | 1244.83 | 699.52 | 983.48 | 856.60 | 5389.51 |
| Non-agricultural incomes | 4.24 | 100.29 | 0.00 | 0.00 | 4.06 | 131.84 | 0.09 | 1.84 |
| Property incomes | 332.54 | 1597.02 | 427.60 | 1736.77 | 614.79 | 3607.21 | 902.61 | 8490.77 |
| Investments | 81.80 | 1249.88 | 102.16 | 1232.88 | 101.73 | 1153.51 | 105.66 | 751.63 |
| Transfers | 166.23 | 765.75 | 236.38 | 1204.97 | 200.22 | 1357.20 | 389.17 | 1496.80 |

Other variables, of the hundreds available, were considered for inclusion in the regressions to explain dietary diversity but were left out due to poor quality due mainly missing values, and because they were highly correlated with variables included in the regressions For example, the number of farm plots could be linked to production diversity because it potentially encourages the production of a range of different crops. It was not included because it was found to be highly correlated with production diversity. A quantile measure of income, used in Jones et al. (2014), was replaced with the correlated measure of income types because these types include more information in terms of the sources of an income.

*Analytical methodology*

As mention in the introduction, we aim to complement and extend the work of Jones et al. (2014) in two ways. First, we use a panel set of data which allows us to measure dynamic effects, and we apply more appropriate econometric techniques given that some of the endogenous variable we test are count measures.

The panel data allows us to utilize econometric techniques which statistically control for potential problems related to omitted static endogenous variables which can bias results when only one year of data is available.

In addition to the classic Ordinary Least Square (OLS) regression technique used by Jones et al. (2014), we run panel Poisson regressions. In particular we estimate a Poisson Generalized Panel Linear Model with fixed effects. The fixed effects model assumes that individual household characteristics are important; an assumption which tests, see below, confirm are significant. Finally, a time-fixed effect model is used because it allows us to control for correlation of individual households over time.

We also incorporates a more complete set of household variables into the model to better account for household characteristics influencing dietary diversity. For example, as mentioned we include variables which measure income from different sources, specifically we include measures of income from agricultural, non-agricultural, property, investments and transfers. . We test the quadratic forms of the income and age of the household head to capture non-linear effects of these variables.

Finally, we test whether there is a relationship between farm production diversity and household caloric intake. This is our key exogenous variable in that it links household production and consumption. If that link is robust after having accounted for the other exogenous variables contained in the regressions, then policy implications follow. Our contention is that some combination of nutrient diversity and caloric intake indices provide a better indication of health than one or the other index alone. At a minimum, it would be worthwhile reporting both measures.

*Measurement of children anthropometric development*

Finally, data in the LSMS-ISA survey allow us to estimate household child development as a measure of child health. Many studies have tested and established a the link between children dietary diversity and the height for age Z-score (HAZ) (Arimond and Ruel 2004; Steyn et al. 2006; Rah et al. 2010). We use our exogenous variables to test their effect on the HAZ. Once again, we need to make the assumption that dietary diversity is equal across all members of the household. The World Health Organisation anthropometric children data were used as references (World Health Organization, 2006). Two thousand, nine hundred and thirty-two childhood anthropometric parameters from the Uganda LSMS-ISA surveys were used in the HAZ estimation. Weight for age Z-score (WAZ) and weight for height Z-score (WHZ) were estimated using the same method for 2,929 and 2,964 children respectively.

# 4. Results and discussion

Technique regression comparison.

Panel regression results are reported in Table 3. Each of the dependent variables, the Food Consumption Score (FCS), the Dietary Diversity Score (DDS), and Calories are discussed in order of their appearance in the table. For each of these dependent variables panel Ordinary Least Squares (OLS) and within transformed (PLM) regressions were calculated. In addition, for each model a Poisson model was run, although it is only appropriate for the DDS because it alone is a count measure.

Estimated coefficients for the OLS estimator for the FCS model are deceptively encouraging in the sense that nearly all are statistically significant and have the expected, hypothesized, signs as was argued in the variable description section of the paper. The estimates for household characteristics are discussed first followed by estimates for economic characteristics, agricultural and regional characteristics.

The coefficient for the size of the household, an indicator of potential labour, is positive indicating that more labour increases dietary diversity. A male head of household has been associated with higher diversity; however, in both the FCS and DDS models the coefficient is far from reaching a statistically significant level. The age of the household head, reflecting greater experience and thereby increasing, for examples, management skills, is negative and insignificant in the FCS model. This is a counter-intuitive result, but corresponds to the findings of Jones et al. (2014). The education level of the household head, hypothesized to reflect better knowledge of the benefits of consuming a nutritious diet, is positive and significant.

In general, the economic characteristic coefficients move as hypothesized, i.e., higher levels of income lead to greater quantity and quality of food consumption. Both the coefficients for food and non-food expenditures are positive and significant. Income, perhaps surprisingly, is insignificant. Its insignificance might be due in part to the fact that the expenditure coefficients are picking-up its correlation with dietary measures. However, regression diagnostics such as measures of correlation between the exogenous variables and variance in inflation factors indicate that excessive collinearity is not a problem for any of the variables selected for analysis.

The income of a household is further distinguished into income from agriculture sources and income from non-agricultural sources. As expected, the higher food expenditures, the higher measures of dietary diversity. Those households spending more on food buy items that increase diversity and thereby improve their health. Greater non-food expenditures, perhaps a further reflection of a households economic standing, increase dietary diversity, but the coefficient's magnitude is much smaller.

*Table 3: Comparison of different regression methods*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Dependent variable: | | | | | | | | | | | | | Dependent variable: | | | | | | | | | | | | Dependent variable: | | | | | | | | | | | | | | | | | | |
|  | FCS | | | | | | | | | | | | | DDS | | | | | | | | | | | | Calories by HH | | | | | | | | | | | | | | | | | | |
|  | OLS | | | | | PLM | | | | PGLM - Poisson | | | | OLS | | | | PLM | | | | PGLM - Poisson | | | | OLS | | PLM | | | | | | | | PGLM - Poisson | | | | | | | | |
| Number of different crops produced by the household farm | 0.683 | | \*\*\* | | 0.668 | | \*\*\* | | 9.63E-03 | | \*\*\* | | 0.112\*\*\* | |  | | 0.046\*\*\* | |  | | 5.32E-03 | |  | | 2,365.892\*\*\* | | 1,598.531\*\* | | | | | | | 1.90E-02 | | | | | | | \*\*\* | |
| (0.146) | |  | | (0.190) | |  | | 1.69E-03 | |  | | -1.30E-02 | |  | | (0.018) | |  | | 4.69E-03 | |  | | -5.22E+02 | | | |  | | (794.180) | | | | | |  | | 4.65E-05 | | | | |  | | |
| Household size | 0.396 | | \*\*\* | | 0.113 | |  | | 6.04E-03 | | \*\* | | 0.019\*\* | |  | | 0.008 | |  | | 3.37E-03 | |  | | 5,767.801\*\*\* | | 3,549.252\*\*\* | | | | | | | 2.10E-02 | | | | | | | \*\*\* | |
| (0.088) | |  | | (0.319) | |  | | 2.33E-03 | |  | | -8.00E-03 | |  | | (0.029) | |  | | 6.64E-03 | |  | | -3.15E+02 | | | |  | | (1,328.393) | | | | | | | | 6.27E-05 | | | | |  | | |
| Sex of household head - Male | -0.429 | |  | | -1.435 | |  | | -3.32E-02 | |  | | -4.40E-02 | |  | | -0.316 | |  | | -4.09E-02 | |  | | 5,518.678\*\* | | 12,033.980 | | | | | | | 2.38E-01 | | | | | | | \*\*\* | |
| (0.706) | |  | | (2.414) | |  | | 2.15E-02 | |  | | -6.40E-02 | |  | | (0.223) | |  | | 5.95E-02 | |  | | -2.52E+03 | | | |  | | (10,055.910) | | | | | | | | 6.19E-04 | | | | |  | | |
| Age of the household head | -0.030 | |  | | 0.032 | |  | | 2.63E-03 | | \* | | -0.011\*\*\* | |  | | -0.006 | |  | | 1.52E-04 | |  | | -164.193\*\* | | -932.338\* | | | | | |  | -1.76E-02 | | | | | | | \*\*\* | |
| (0.021) | |  | | (0.133) | |  | | 1.14E-03 | |  | | -2.00E-03 | |  | | (0.012) | |  | | 3.09E-03 | |  | | -7.58E+01 | | | |  | | (549.497) | | | | | |  | | 3.30E-05 | | | | |  | | |
| Education level of the household head | 0.115 | | \*\*\* | | 0.076 | |  | | 6.32E-04 | |  | | 0.013\*\*\* | |  | | 0.004 | |  | | 9.21E-05 | |  | | -175.642\* | | | |  | | 588.644\*\* | | | | | | | | 6.44E-03 | | | | | \*\*\* | | |
| (0.027) | |  | | (0.062) | |  | | 5.41E-04 | |  | | -2.00E-03 | |  | | (0.006) | |  | | 1.51E-03 | |  | | -9.79E+01 | | | |  | | (258.916) | | | | | |  | | 1.53E-05 | | | | |  | | |
| Food expenditure | 0.023 | | \*\*\* | | 0.021 | | \*\*\* | | 2.71E-04 | | \*\*\* | | 0.002\*\*\* | |  | | 0.001\*\*\* | |  | | 1.58E-04 | | \*\*\* | | 42.078\*\*\* | | 53.863\*\*\* | | | | | | | 4.98E-04 | | | | | | | \*\*\* | |
| (0.001) | |  | | (0.001) | |  | | 7.60E-06 | |  | | -1.00E-04 | |  | | (0.0001) | |  | | 2.15E-05 | |  | | -2.64E+00 | | | |  | | (3.992) | | | | | |  | | 2.14E-07 | | | | |  | | |
| Non-food expenditure | 0.001 | | \*\*\* | | 0.00005 | |  | | 1.16E-06 | |  | | 4.00E-05 | |  | | -0.00001 | |  | | -6.12E-07 | |  | | 8.94E-01 | | | |  | | 0.718 | | | | | |  | | 1.72E-05 | | | | | \*\*\* | | |
| (0.0005) | |  | | (0.001) | |  | | 4.62E-06 | |  | | -5.00E-05 | |  | | -1.00E-04 | |  | | 1.45E-05 | |  | | -1.77E+00 | | | |  | | (2.592) | | | | | |  | | 1.46E-07 | | | | |  | | |
| Incomes | 0.00004 | |  | | -0.00003 | |  | | -1.69E-07 | |  | | 0.00001\* | |  | | 0.00001 | |  | | 9.55E-07 | |  | | -2.19E-01 | | | |  | | 0.110 | | | | | |  | | 1.22E-06 | | | | | \*\*\* | | |
| (0.0001) | | |  | | (0.0001) | |  | | 4.88E-07 | |  | | 0.00E+00 | |  | | (0.00001) | |  | | 1.32E-06 | |  | | -1.91E-01 | | | |  | | (0.240) | | | | | |  | | 1.50E-08 | | | | | |  | |
| Total cropped area | 0.053 | | | \*\*\* | | 0.024 | | \* | | 3.35E-04 | | \*\* | | 0.003\*\*\* | |  | | 0.001 | |  | | 1.50E-04 | |  | | 98.469\*\* | | | |  | | 101.137\* | | | | | |  | | 1.02E-03 | | | | | | \*\*\* | |
| (0.012) | | |  | | (0.013) | |  | | 1.09E-04 | |  | | (0.001) | |  | | (0.001) | |  | | 3.09E-04 | |  | | -4.40E+01 | | | |  | | (55.244) | | | | | |  | | 2.93E-06 | | | | | |  | |
| Proportion of food consumed in previous one week from households own production | 9.903 | | | \*\*\* | | 10.624 | | \*\*\* | | 1.93E-01 | | \*\*\* | | -0.566\*\*\* | |  | | -0.303 | |  | | -4.09E-02 | |  | | 42,313.690\*\*\* | | 39,811.510\*\*\* | | | | | | | | 6.33E-01 | | | | | | \*\*\* | | |
| (1.706) | | |  | | (2.135) | |  | | 1.99E-02 | |  | | (0.155) | |  | | (0.197) | |  | | 5.51E-02 | |  | | (6,105.464) | | (8,923.219) | | | | | | | | 5.86E-04 | | | | | |  | | |
| Number of different non-agricultural income sources | 1.488 | | | \*\*\* | | -0.838 | |  | | -1.51E-02 | | \*\* | | 0.112\*\* | |  | | 0.011 | |  | | -1.79E-03 | |  | | -4,095.348\*\* | | -156.530 | | | | | | |  | -1.60E-02 | | | | | | \*\*\* | | |
| (0.512) | | |  | | (0.593) | |  | | 4.80E-03 | |  | | (0.047) | |  | | (0.055) | |  | | 1.39E-02 | |  | | (1,829.032) | | (2,471.428) | | | | | | | | 1.42E-04 | | | | | |  | | |
| Agriculture Decision - Household Head | 0.711 | | |  | | 1.066 | |  | | -3.62E-03 | |  | | 0.100 | |  | | 0.048 | |  | | -6.18E-03 | |  | | 2,285.700 | | | |  | | 558.623 | | | | | |  | | 1.18E-02 | | | | | | \*\*\* | |
| (1.095) | | |  | | (1.276) | |  | | 1.13E-02 | |  | | (0.100) | |  | | (0.118) | |  | | 3.15E-02 | |  | | (3,909.422) | | (5,318.208) | | | | | | | | 3.33E-04 | | | | | |  | | |
| Region - Eastern | 2.228 | | | \*\*\* | |  | |  | |  | |  | | 0.086 | |  | |  | |  | |  | |  | | 17,358.570\*\*\* | |  | | | | | | |  |  | | | | | |  | | |
| -0.825 | | |  | |  | |  | |  | |  | | (0.075) | |  | |  | |  | |  | |  | | (2,944.524) | |  | | | | | | |  |  | | | | | |  | | |
| Region - Northern | -6.366 | | | \*\*\* | |  | |  | |  | |  | | -0.363\*\*\* | |  | |  | |  | |  | |  | | 1,573.681 | | | |  | |  | | | | | |  | |  | | | | | |  | |
| -0.829 | | |  | |  | |  | |  | |  | | (0.075) | |  | |  | |  | |  | |  | | (2,959.331) | |  | | | | | | |  |  | | | | | |  | | |
| Region - Western | 1.903 | | | \*\* | |  | |  | |  | |  | | -0.983\*\*\* | |  | |  | |  | |  | |  | | -13,380.570\*\*\* | |  | | | | | | |  |  | | | | | |  | | |
| -0.869 | | |  | |  | |  | |  | |  | | (0.079) | |  | |  | |  | |  | |  | | (3,102.356) | |  | | | | | | |  |  | | | | | |  | | |
| Constant | 40.282 | \*\*\* | | | |  | |  | |  | |  | | 7.006\*\*\* | |  | |  | |  | |  | |  | | -7,751.641 | |  | | | | | | |  |  | | | | | |  | | |
| -1.784 | | |  | |  | |  | |  | |  | | (0.162) | |  | |  | |  | |  | |  | | (6,368.986) | |  | | | | | | |  |  | | | | | |  | | |
|  |  | | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | | | |  | |  | | | | | |  | |  | | | | | |  | |
| Observations | 3,941 | | |  | | 3,941 | |  | |  | |  | | 3,941 | |  | | 3,941 | |  | |  | |  | | 3939 | | | |  | | 3939 | | | | | |  | |  | | | | | |  | |
| R2 | 0.33 | | |  | | 0.18 | |  | |  | |  | | 0.32 | |  | | 0.12 | |  | |  | |  | | 0.22 | | | |  | | 0.09 | | | | | |  | |  | | | | | |  | |
| AdjustedR2 | 0.33 | | |  | | 0.11 | |  | |  | |  | | 0.32 | |  | | 0.07 | |  | |  | |  | | 0.22 | | | |  | | 0.05 | | | | | |  | |  | | | | | |  | |
| F Statistic | 131.225\*\*\* | | | | | 43.238\*\*\* | | | |  | |  | | 122.381\*\*\* | | | | 27.588\*\*\* | | | |  | |  | | 75.621\*\*\* | | 19.080\*\*\* | | | | | | | |  | | | | | |  | | |
|  | (df=15; 3925) | | | | | (df=12; 2430) | | | |  | |  | | (df = 15; 3925) | | | | (df = 12; 2430) | | | |  | |  | | (df=15; 3923) | | (df=12;2428) | | | | | | | |  | | | | | |  | | |
| Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01 |  | | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | |  | | | |  | |  | | | | | |  | |  | | | | | |  | |

The household's total land area devoted to agricultural production is positively associated with dietary diversity. More available land improves diversity. Similarly, the greater the proportion of food consumed from a household's own production, the great the dietary diversity. Given more land, Ugandan households appear to choose a greater diversity of production and consumption. However, in contrast to Jones et al. (2014), our results do not indicate that control of agricultural decisions by the head of a household increases diversity; the coefficient is insignificant in our model. Finally, the Northern region appears to be strongly associated with decreased dietary diversity. This might be due to violence in that part of the country.

Results for the DDS measure closely resemble those of the FCS with the exception of the age of the head of the household, the proportion of food consumed from a household's own production and the significance of the Eastern Region. Differences in the signs and magnitudes of the coefficients might be due to the fact that the DDS measure is a rougher measure than the FCS in the sense that it simply counts the number of items consumed in a time period rather than adjusting the consumption of those items to reflect their nutrient contribution to the diet. The DDS measure imposes a stricter structure on the data which in some cases might distort coefficients. Another explanation is that OLS is an inappropriate technique for count measures such as the DDS because it will lead to inconsistent estimates (Greene, 2012 chapter 17).

Following this reasoning, it is best to compare the Calories model with the FCS model because both are continuous variables. Again, the coefficients of the two models are similar. In contrast to the FCS model, the gender of the head of household is significant in the Calories models. Furthermore, its sign corresponds to its hypothesized sign. However, the coefficient for the education of the head of the household in the Calories model is negative. The more educated the head of the household, the few calories consumed, although this result should be read with caution given that it is just significant.

In general, the OLS estimates should read with caution to the extent that correlation is present between households and across time. The assumption of the OLS panel model is that this correlation is not affecting estimates and that there are no significant static missing variables. However, the null hypothesis of a common intercept is soundly rejected for both the FCS and Calories models implying that OLS is inappropriate in essence because there are significant differences between households. In addition, the within transformation removes the effects of both observed and unobserved static variables. Time dummies were added to the model in order to capture significant events not captured by the explanatory variables. Finally, a Hausman test rejected the random effects model in favour of the within model (results does not show).

Results for the FVS and Calories models are less impressive than their respective OLS models in that far fewer coefficients are significant.

A comparison of the results for the OLS and the within panel models for the FCS dependent variable indicates similar coefficients for the variables the number of different crops produced by the household, food expenditures, total crop area and the proportion of food consumed from own production. The signs of the coefficients are identical and their magnitudes similar. Results for the DDS model also show that the coefficient for the number of different crops produced by the household and food expenditures are positive and significant, but coefficients for total crop area and the proportion of food consumed from own production are no longer significant. However, as previously noted, DDS is a count measure so using a continuous measure is not recommended. Before discussing the panel Poisson model for DDS, panel results for the Calories model will be presented. The same four variables are significant in both the FCS and Calories models. Unsurprisingly, the magnitudes of the coefficients are different given the difference in scales of the two dependent variables. In addition, household size is positive and significant, as is the education of the household head. The age of the head of household negatively affects caloric intake, but is only just significant. In short, the results of the Caloric model correspond closely with the FCS measure, and the signs of most of the coefficients conform to hypotheses. Finally, a Poisson panel regression was estimated for the DDS dependent variable. In that regression only food expenditures were found to be significant. As mentioned, the DDS model is rough in that it is a step function.

Regressions with different production count variables

Table 4: Time-effect regression results with different production count variables

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Dependent variable: | | | Dependent variable: | | | Dependent variable: | | |
|  | FCS | DDS | Calories | FCS | DDS | Calories | FCS | DDS | Calories |
| Number of different crops produced by the household farm | 0.668\*\*\* | 0.046\*\*\* | 1.599\*\* |  |  |  |  |  |  |
| (0.190) | (0.018) | (0.794) |  |  |  |  |  |  |
| Number of different nutritional food group produced by the household farm |  |  |  | 0.844\*\* | 0.059\* | 0.971 |  |  |  |
|  |  |  | (0.353) | (0.033) | (1.470) |  |  |  |
| Simpson' s index |  |  |  |  |  |  | 3.585\*\* | 0.364\*\* | -2.688 |
|  |  |  |  |  |  | (1.582) | (0.147) | (6.877) |
| Household size | 0.113 | 0.008 | 3.549\*\*\* | 0.131 | 0.009 | 3.626\*\*\* | 0.281 | 0.016 | 3.985\*\*\* |
| (0.319) | (0.029) | (1.328) | (0.319) | (0.029) | (1.329) | (0.344) | (0.032) | (1.492) |
| Household head gender - Male | -1.435 | -0.316 | 12.034 | -1.664 | -0.332 | 11.396 | -4.451\* | -0.449\* | 15.448 |
| (2.414) | (0.223) | (10.056) | (2.416) | (0.223) | (10.058) | (2.517) | (0.235) | (10.934) |
| Age of the household head | 0.032 | -0.006 | -0.932\* | 0.038 | -0.005 | -0.919\* | 0.163 | -0.001 | -1.177\*\* |
| (0.133) | (0.012) | (0.549) | (0.133) | (0.012) | (0.550) | (0.138) | (0.013) | (0.598) |
| Education level of the household head | 0.076 | 0.004 | 0.589\*\* | 0.078 | 0.004 | 0.601\*\* | 0.123\* | 0.008 | 0.818\*\*\* |
| (0.062) | (0.006) | (0.259) | (0.062) | (0.006) | (0.259) | (0.067) | (0.006) | (0.291) |
| Food expenditure | 0.021\*\*\* | 0.001\*\*\* | 0.054\*\*\* | 0.021\*\*\* | 0.001\*\*\* | 0.054\*\*\* | 0.022\*\*\* | 0.002\*\*\* | 0.056\*\*\* |
| (0.001) | (0.000) | (0.004) | (0.001) | (0.000) | (0.004) | (0.001) | (0.000) | (0.004) |
| Non-food expenditure | 0.000 | -0.000 | 0.001 | 0.0001 | -0.000 | 0.001 | -0.001 | 0.000 | -0.003 |
| (0.001) | (0.000) | (0.003) | (0.001) | (0.000) | (0.003) | (0.002) | (0.000) | (0.007) |
| Incomes | -0.029 | 0.007 | 0.110 | -0.024 | 0.007 | 0.123 | -0.029 | 0.006 | -0.010 |
| (0.057) | (0.005) | (0.240) | (0.058) | (0.005) | (0.240) | (0.059) | (0.006) | (0.257) |
| Total cropped area | 0.024\* | 0.001 | 0.101\* | 0.023\* | 0.001 | 0.100\* | 0.025\* | 0.001 | 0.062 |
| (0.013) | (0.001) | (0.055) | (0.013) | (0.001) | (0.055) | (0.015) | (0.001) | (0.066) |
| Proportion of food consumed in previous one week from households own production | 10.624\*\*\* | -0.303 | 39.812\*\*\* | 11.037\*\*\* | -0.275 | 41.325\*\*\* | 11.244\*\*\* | -0.345 | 39.764\*\*\* |
| (2.135) | (0.197) | (8.923) | (2.132) | (0.197) | (8.903) | (2.253) | (0.210) | (9.822) |
| Number of different non-agricultural income sources | -0.838 | 0.011 | -0.157 | -0.842 | 0.011 | -0.129 | -0.986 | 0.008 | -1.147 |
| (0.593) | (0.055) | (2.471) | (0.594) | (0.055) | (2.474) | (0.630) | (0.059) | (2.736) |
| Agriculture Decision - Household Head | 1.066 | 0.048 | 0.559 | 1.183 | 0.056 | 0.978 | 1.516 | 0.154 | -0.086 |
| (1.276) | (0.118) | (5.318) | (1.277) | (0.118) | (5.319) | (1.451) | (0.135) | (6.305) |
| Year 2009-10 | 42.121\*\*\* | 7.414\*\*\* | 32.840 | 42.214\*\*\* | 7.416\*\*\* | 36.066 | 36.972\*\*\* | 7.069\*\*\* | 45.926 |
| (6.430) | (0.594) | (26.696) | (6.477) | (0.598) | (26.874) | (6.924) | (0.646) | (29.991) |
| Year 2010-11 | 39.955\*\*\* | 7.227\*\*\* | 23.489 | 40.049\*\*\* | 7.229\*\*\* | 26.620 | 34.672\*\*\* | 6.890\*\*\* | 36.314 |
| (6.560) | 0.606 | (27.243) | (6.604) | (0.610) | (27.406) | (7.039) | (0.656) | (30.495) |
| Year 2011-12 | 43.794\*\*\* | 7.494\*\*\* | 25.399 | 43.721\*\*\* | 7.484\*\*\* | 28.085 | 38.320\*\*\* | 7.136\*\*\* | 37.343 |
| (6.691) | (0.618) | (27.787) | (6.738) | (0.622) | (27.963) | (7.187) | (0.670) | (31.134) |
|  |  |  |  |  |  |  |  |  |  |
| Observations | 3,941 | 3,941 | 3,939 | 3,941 | 3,941 | 3,939 | 3,596 | 3,596 | 3,594 |
| R2 | 0.176 | 0.12 | 0.086 | 0.174 | 0.119 | 0.085 | 0.186 | 0.125 | 0.085 |
| AdjustedR2 | 0.108 | 0.074 | 0.053 | 0.107 | 0.073 | 0.052 | 0.111 | 0.075 | 5.10E-02 |
| F Statistic | 43.238\*\*\* | 27.588\*\*\* | 19.080\*\*\* | 42.575\*\*\* | 27.263\*\*\* | 18.751\*\*\* | 40.787\*\*\* | 25.578\*\*\* | 16.600\*\*\* |
|  | (df=12; 2430) | (df=12; 2430) | (df=12; 2428) | (df=12; 2430) | (df=12; 2430) | (df=12; 2428) | (df=12; 2139) | (df=12; 2139) | (df=12; 2137) |
| Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01 |  |  |  |  |  |  |  |  |  |
| Calories intakes are estimated by household |  |  |  |  |  |  |  |  |  |

Recall that one of the aims of the paper is to develop an easy to implement indicator that can be used to establish the nutritional health of an individual. So, in addition to testing several endogenous measures, three exogenous production count variables were tested as well to determine if they lead to significantly different overall model estimates. The number of different crops produced, the number of different *nutritional groups* produced, and the Simpson’s index were tested using the fixed-time effects (PLM) method (Table 4). These main variables were significant and positive for our three endogenous variables except for production by nutritional group and Simpson’s index, which were not significant in explaining caloric intakes. Results for the entire model were in line with previous results across the different production count variables and thereby suggest that the most parsimonious exogenous production count indicator in a given situation should be used

The first crop count model, the number of different crops produced, reproduces the results in table 3 and so will not be discussed in the this section. The three models run with different *nutritional groups* (second three columns in the table) as an exogenous variable produce similar results. Its estimate is highly significant in all three models. Two interesting points of comparison are the results for household size and the education level of the head of household. As opposed to the other two models, the estimate for household size is highly significant in the caloric model, indicating that a larger household significantly increases the number of calories consumed by the household. While not in itself surprising, it does raise the question of why a larger household size does not increase household nutritional levels. Similarly, the estimate for the educational level of the household head is also significant in explaining calories consumed by a household, but is not in either of the other two models. In general, the two indices, the number of crops produced and the number of different nutritional food groups produced, yield similar results.

Results for the model using the Simpson’s index were somewhat different than the previous two estimators. Its estimate was also significant for the FCS and DDS models, but insignificant in the Caloric model. The estimate for the variable male head of household for the FCS and DDS models was negative in contrast to the other model. Perhaps male household heads focus on food quantity instead of nutritional diversity.

In general, results across the three models testing different exogenous food count measures show similar results. The Caloric model consistently has more significant variables than the other two models. This might be due to the fact that calories are more closely linked to the quantity of food consumed which we suppose is easier to influence than the nutritional diversity of crops grown. In addition, in none of the models were the time estimates significant for the Calories model. Calories consumed appear to be unaffected through time, as opposed to nutritional intake. This surprising conclusion needs to be further investigated. Of the three exogenous variables tested, the number of different crops shows significant results for each model and similar results for the other exogenous variables in the model. We therefore recommend using it as a measure of the overall nutritional and caloric health of a household.

*Subdivided income and non-linear variables*

*Table 5: Time-effect regression results with subdivided income*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Dependent | variable: |  |
|  | FCS | DDS | Calories by HH |
| Number differerent crops produced by household | 0.698\*\*\* | 0.117\*\*\* | 2,292.087\*\*\* |
|  | (0.144) | (0.013) | (508.079) |
| Household size | 0.396\*\*\* | 0.020\*\* | 5,683.600\*\*\* |
|  | (0.087) | (0.008) | (308.673) |
| Gender head household | -0.151 | -0.039 | 6,156.332\*\* |
|  | (0.701) | (0.064) | (2,476.968) |
| Age household head | -0.037\* | -0.012\*\*\* | -176.294\*\* |
|  | (0.021) | (0.002) | (74.188) |
| Education household head | 0.103\*\*\* | 0.013\*\*\* | -167.754\* |
|  | (0.027) | (0.002) | (95.235) |
| Food expenditure | 0.024\*\*\* | 0.002\*\*\* | 43.480\*\*\* |
|  | (0.001) | (0.0001) | (2.622) |
| Nonfood expenditure | 0.002\*\*\* | 0.0001 | 1.512 |
|  | (0.0005) | (0.00005) | (1.750) |
| Agricultural income | 0.0002\*\* | 0.00002\*\*\* | 0.391 |
|  | (0.0001) | (0.00001) | (0.290) |
| NonAgricultural income | -0.002 | 0.0001 | -5.549 |
|  | (0.003) | (0.0003) | (10.792) |
| Property income | -0.0001 | -0.00000 | -0.843\*\* |
|  | (0.0001) | (0.00001) | (0.408) |
| Investments | -0.0005\*\* | -0.00003 | -3.105\*\*\* |
|  | (0.0002) | (0.00002) | (0.822) |
| Transfers | 0.0005\*\* | 0.00001 | 0.497 |
|  | (0.0002) | (0.00002) | (0.794) |
| Total cropped area | 0.057\*\*\* | 0.003\*\*\* | 115.182\*\*\* |
|  | (0.012) | (0.001) | (44.013) |
| Proportion food consumed own production | 10.392\*\*\* | -0.547\*\*\* | 39,848.070\*\*\* |
|  | (1.662) | (0.152) | (5,888.364) |
| Number different nonagricultural income sources | 1.534\*\*\* | 0.116\*\* | -3,689.048\*\* |
|  | (0.510) | (0.046) | (1,801.443) |
| Head Agriculture Decision | 0.849 | 0.106 | 3,298.061 |
|  | (1.061) | (0.097) | (3,752.212) |
| Region Eastern | 1.513\* | 0.020 | 16,995.220\*\*\* |
|  | (0.804) | (0.073) | (2,842.856) |
| Region Northern | -6.441\*\*\* | -0.373\*\*\* | 1,229.344 |
|  | (0.822) | (0.075) | (2,906.272) |
| Region Western | 1.627\* | -1.012\*\*\* | -12,909.160\*\*\* |
|  | (0.858) | (0.078) | (3,033.123) |
| Constant | 39.942\*\*\* | 6.972\*\*\* | -7,511.747 |
|  | (1.748) | (0.159) | (6,180.267) |
|  |  |  |  |
| Observations | 4,103 | 4,103 | 4,101 |
| R2 | 0.336 | 0.322 | 0.226 |
| Adjusted R2 | 0.334 | 0.321 | 0.225 |
| F Statistic | 108.566\*\*\* | 102.253\*\*\* | 62.775\*\*\* |
|  | (df=19; 4083) | (df=19; 4083) | (df=19; 4081) |

In our final set of regressions, we split the different sources of income available to a family in order to try to disentangle how sources of household income affect our three endogenous variables with the number of different crops as our main exogenous count of food diversity (Table 5). The five income variables we examine are agricultural income, non-agricultural income, property income, investments, and transfers. Results are mixed and inconsistent across models. Agricultural income is significant in both the FCS and DDS models, but its magnitude is small in comparison to the other estimates in the models. Non-agricultural income is insignificant in all three models, while income from property and income from investments have negative effects in the Calories model. More income from property and investments reduces calories after accounting for the effects of the other variables in the model. However, the magnitudes are small in comparison the many of the other significant variables in the mode. The effects of squaring the following variables was tested in order to check nonlinear effects: age of the household head, income, food and non-food expenditures. Results were insignificant.

*Child growth*

The children development indicators have a mean under the anthropometric children references database but they stay at a reasonable level. According to the WHO, the normal standard deviation window is [-2 to +2]. Respectively for HAZ, WAZ and WHZ the results are -1.58, -1.02 and -0.39. But extremes case of undernourishment are present when we look at the minimum HAZ, WAH and WHZ. The same problem is observed on the other side with unusual maximum Z-scores. According to the Uganda Bureau of Statistics (2012) 13.8% of children under five years old were still underweighted in 2011. Still work have to be done for the purpose of eradicate children anthropometric deficiencies which pass through healthy diet.

# 5. Conclusions and discussion

Our preliminary results aim at reproducing and extending the model found in Jones, et al. (2014), using more data and improved techniques. In addition, we test several measures of food counts and estimate a model which attempts to explain household variations in calories consumed

Our hypotheses were twofold: to test whether farm production diversity by households effects their consumption diversity using appropriate regression techniques, and; to test whether farm production diversity leads to higher household caloric intake. We were able to confirm both hypotheses. Both hypotheses were confirmed. The panel approach allows the reduction of correlation across time and within the same household. It is therefore preferable to a cross-sectional approach. The exogenous variable, number of different crops produced by a household, was found to outperform the other two variables tested and should be the preferred measure.

The analyses emphasize that farm production diversity increases consumption diversity and therefore nutrient intake and caloric intake. This result was robust across models. Therefore, policies aimed at increasing farm production diversity are likely to improve the overall health of farm households. Given more land, famers in Uganda choose to plant a greater diversity of crops and raise their nutritional health, indicating that they are aware that greater crop diversity leads to greater health. The same appears to be true for

# References

Abay, Fetien, Asmund Bjørnstad, and Melinda Smale. 2009. ‘Measuring on Farm Diversity and Determinants of Barley Diversity in Tigray, Northern Ethiopia’. *Momona Ethiopian Journal of Science* 1 (2). http://www.ajol.info/index.php/mejs/article/view/46048.

Arimond, Mary, and Marie T. Ruel. 2004. ‘Dietary Diversity Is Associated with Child Nutritional Status: Evidence from 11 Demographic and Health Surveys’. *The Journal of Nutrition* 134 (10): 2579–85.

Benin, S., M. Smale, J. Pender, B. Gebremedhin, and S. Ehui. 2004. ‘The Economic Determinants of Cereal Crop Diversity on Farms in the Ethiopian Highlands’. *Agricultural Economics*, Current Issues in the Economics of Agriculture, Food, and Resources: Reshaping Agriculture’s Contributions to Society, 31 (2–3): 197–208. doi:10.1016/j.agecon.2004.09.007.

Boysen, Ole, Hans Grinsted Jensen, and Alan Matthews. 2014. ‘Impact of EU Agricultural Policy on Developing Countries: A Uganda Case Study’. IIIS. https://www.gtap.agecon.purdue.edu/resources/download/7200.pdf.

Carletto, Calogero, Alberto Zezza, and Raka Banerjee. 2013. ‘Towards Better Measurement of Household Food Security: Harmonizing Indicators and the Role of Household Surveys’. *Global Food Security* 2 (1): 30–40. doi:10.1016/j.gfs.2012.11.006.

Hatluy, A., L. E. Torheim, and A. Oshaug. 1998. ‘Food Variety - a Good Indicator of Nutritional Adequacy of the Diet? A Case Study from an Urban Area in Mali, West Africa’. *European Journal of Clinical Nutrition* 52: 891–98.

Headey, Derek, and Olivier Ecker. 2013. ‘Rethinking the Measurement of Food Security: From First Principles to Best Practice’. *Food Security* 5 (3): 327–43. doi:10.1007/s12571-013-0253-0.

Hoddinott, John, and Yisehac Yohannes. 2002. ‘Dietary Diversity as a Food Security Indicator’. *Food Consumption and Nutrition Division Discussion Paper* 136: 2002.

Jones, Andrew D., Aditya Shrinivas, and Rachel Bezner-Kerr. 2014. ‘Farm Production Diversity Is Associated with Greater Household Dietary Diversity in Malawi: Findings from Nationally Representative Data’. *Food Policy* 46: 1–12. doi:10.1016/j.foodpol.2014.02.001.

Kennedy, Gina L., Maria Regina Pedro, Chiara Seghieri, Guy Nantel, and Inge Brouwer. 2007. ‘Dietary Diversity Score Is a Useful Indicator of Micronutrient Intake in Non-Breast-Feeding Filipino Children’. *The Journal of Nutrition* 137 (2): 472–77.

Kumar, Shubh K. 1994. *Adoption of Hybrid Maize in Zambia: Effects on Gender Roles, Food Consumption, and Nutrition*. Research Report 100. Washington, D.C: International Food Policy Research Institute.

Pitt, Mark M., Mark R. Rosenzweig, and Md. Nazmul Hassan. 1990. ‘Productivity, Health, and Inequality in the Intrahousehold Distribution of Food in Low-Income Countries’. *The American Economic Review* 80 (5): 1139–56.

Rah, J. H., N. Akhter, R. D. Semba, S. de Pee, M. W. Bloem, A. A. Campbell, R. Moench-Pfanner, K. Sun, J. Badham, and K. Kraemer. 2010. ‘Low Dietary Diversity Is a Predictor of Child Stunting in Rural Bangladesh’. *European Journal of Clinical Nutrition* 64 (12): 1393–98. doi:10.1038/ejcn.2010.171.

Sadoulet, Elisabeth, and Alain De Janvry. 1995. *Quantitative Development Policy Analysis*. Baltimore: Johns Hopkins University Press.

Simpson, E. H. 1949. ‘Measurement of Diversity’ 163: 688. doi:10.1038/163688a0.

Singh, Inderjit, Lyn Squire, John Strauss, and World Bank, eds. 1986. *Agricultural Household Models: Extensions, Applications, and Policy*. A World Bank Research Publication. Baltimore: Johns Hopkins University Press.

Smale, Melinda, Mourad Moursi, and Ekin Birol. 2015. ‘How Does Adopting Hybrid Maize Affect Dietary Diversity on Family Farms? Micro-Evidence from Zambia’. *Food Policy* 52 (April): 44–53. doi:10.1016/j.foodpol.2015.03.001.

Steyn, Np, Jh Nel, G Nantel, G Kennedy, and D Labadarios. 2006. ‘Food Variety and Dietary Diversity Scores in Children: Are They Good Indicators of Dietary Adequacy?’ *Public Health Nutrition* 9 (05): 644–50. doi:10.1079/PHN2005912.

Swindale, Anne, and Paula Bilinsky. 2006. ‘Development of a Universally Applicable Household Food Insecurity Measurement Tool: Process, Current Status, and Outstanding Issues’. *The Journal of Nutrition* 136 (5): 1449S – 1452S.

The Uganda Bureau of Statistics. 2015. ‘The Uganda National Panel Survey (UNPS) 2011/12’. Accessed March 23. http://siteresources.worldbank.org/INTLSMS/Resources/3358986-1233781970982/5800988-1265043582346/UNPS\_2009\_10\_BID\_rev\_2014.pdf.

Thorne-Lyman, Andrew L., Natalie Valpiani, Kai Sun, Richard D. Semba, Christine L. Klotz, Klaus Kraemer, Nasima Akhter, et al. 2010. ‘Household Dietary Diversity and Food Expenditures Are Closely Linked in Rural Bangladesh, Increasing the Risk of Malnutrition Due to the Financial Crisis’. *The Journal of Nutrition* 140 (1): 182S – 188S. doi:10.3945/jn.109.110809.

Torheim, L. E., F. Ouattara, M. M. Diarra, F. D. Thiam, I. Barikmo, A. Hatløy, and A. Oshaug. 2004. ‘Nutrient Adequacy and Dietary Diversity in Rural Mali: Association and Determinants’. *European Journal of Clinical Nutrition* 58 (4): 594–604. doi:10.1038/sj.ejcn.1601853.

United Nations World Food Programme. 2008. ‘Food Consumption Analysis: Calculation and Use of the Food Consumption Score in Food Security Analysis.’ Rome: United Nations World Food Programme. http://foodsecuritycluster.net/sites/default/files/WFP%20FCS%20Guideline%20%281%29.pdf.

Weiss, Christoph R., and Wolfgang Briglauer. 2000. ‘Determinants and Dynamics of Farm Diversification’. FE Working Paper 0002. Christian-Albrechts-University of Kiel, Department of Food Economics and Consumption Studies. http://econpapers.repec.org/paper/zbwcaufew/0002.htm.

# Appendix Glossary

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| --- | --- |
| **Acronym** | **Description** |
| DDS | Dietary Diversity Score |
| FAO | Food and Agriculture Organization of the United Nations |
| FCS | Food Consumption Score |
| FVS | Food Varity Score |
| GPS |  |
| HAZ | Height for age score |
| LSMS-ISA | The Living Standards Measurement Study - Integrated Surveys on Agriculture |
| MAR | Mean Adequacy Ratio |
| NAR | Nutrient Adequacy Ratio |
| OLS | Ordinary Least Square |
| UNPS | Uganda National Panel Survey |
| USDA | United States Department of Agriculture |
| WAZ | Weight for age score |
| WHO | World Health Organization |
| WHZ | Weight for height score |