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

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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. Fixed effects models were estimated. Preliminary 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 nutrition 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

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1. Introduction

According to Rome Declaration on World Food Security, “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” (World Food Summit in 1996). Given this definition of food security, the construction of a single indicator 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 et al. (2013) 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. Agriculture produces much of the world’s food (Hawkes and Ruel 2006), and nearly three-quarters of the poor people live in rural areas of developing countries where agricultural production and livelihoods may be especially influential on diets (Haddad 2000; Pinstrup-Andersen 2007). The positive relationship between farm diversity and dietary diversity was found for households in central Kenya and northern Tanzania (Herforth 2010). Similar finding were found for households in rural highlands of Ecuador (Oyarzun et al. 2013), in western Mali (Torheim et al. 2004), and in Malawi (Jones et al. 2014).

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 et al. (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.

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 nutrition diversity at the household level to farm production diversity. We examine the effects of the diversity of farm production for households in Uganda on their dietary diversity such as nutrition diversity and caloric intake (Hoddinott and Yohannes 2002). Ideally, the dietary diversity indicator would have been analysed at the individual level, but such data is not available in the data set used (Arimond and Ruel 2004). For children of 5 years or younger, anthropometric indicators are available for Uganda.

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 et al. (2014) for Malawi and we will extend their work in two ways. Firstly, we use panel data on farmer’s households instead of cross-section data. Panel data allows us to control for unobserved heterogeneity. Next to the two dietary diversity indicators used by Jones et al. (2014) namely Dietary

Diversity Score (DDS), and the Food Consumption Score (FCS), we add a 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

The link we draw between production diversity and nutritional adequacy rests on the link between food consumption diversity and nutritional adequacy. There are several papers arguing that there is a significant positive relationship between diet diversity and micro-nutrient intake (Katz 1994; Rose et al. 2002) and even between diet diversity and anthropometric outcomes for adults and children (Arimond and Ruel 2004; Rah et al. 2010; Hawkes and Ruel 2006).

Ideally, the nutrient adequacy is measured for individuals. Unfortunately, individual consumption data is not available in the LSMS-ISA surveys in Uganda. Therefore, we examine household dietary diversity and we assume that household distribute food equitably to optimize the diet of each member according to the total of foods available (Thorne-Lyman et al. 2010; Jones, Shrinivas, and Bezner-Kerr 2014). According to Thorne-Lyman et al. (2010), dietary diversity scores are increasingly used as measures of food security and as proxies for nutrient adequacy because the collection of reliable household expenditures data is relatively time consuming and rather complex. However, as argued in (Pitt et al.(1990), although intra-household calories allocation varies between members, especially in relationship to gender, the work and other activities of each household member can explain those differences. According to the authors, *“household are averse to inequality”*. Accordingly, as a second best solution we take household consumption as imperfectly reflecting the dietary condition of individual household members.

For smallholders in developing countries, 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 labour 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.

Measurement of dietary diversity

For nutrition diversity in Uganda, we use the same indicators as Jones et al. (2014) for Malawi. 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 et al. 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. It is highly correlated with factors such as caloric and protein adequacy, and household income. Furthermore, it is associated to improved outcomes in child anthropometric status.

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 et al. 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 et al. 2014).

The first farm production diversity indicator is the crop count, which is the count of the number of different crops harvested by the household farm:

$$Crop\ count_i = 1 - \sum I_{ij}$$

with *j* the different crops grown by household i. 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).

$$Simpson's\ index_i = 1 - \sum s_j^2 \text{ with } s_j = \frac{a_{ij}}{A_i}$$

Where a_{ij} is the area of the crop *j* used by household i, A_i is the total cropped area cultivated by the household *i* and s_j is the share of cultivated land with crop *j* in the total area cultivated by the household *i* with *j*=1,..,12. 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.

The third production indicator is the *own production ratio* which has not been used in the literature before.

$$Own\ production\ ratio_i = \frac{\sum I_{ij}}{12}$$

with *j* is the production of crops from different food groups. It is designed to reflect the direct link between farm production diversity on the number of nutritional food groups grown by a household. In an analogous relationship to that between the nutrition diversity indicators FVS and DDS, 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. 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 groups should improve the diet quality.

All three production diversity measures are designed to estimate the effect of production diversity on dietary diversity. A separate exogenous variable indicating whether a household is involved in livestock activities will be included in the regressions to test their effect on nutrition diversity.

Empirical strategy

We estimate linear models that regress production diversity indicators and other characteristics on nutrition diversity indicators similar to Jones et al. (2014). We use panel data sample for Uganda which allows us to control for unobserved heterogeneity at the household level. We distinguish three nutrition diversity indicators, namely DDS, FFS and caloric intake. For the production diversity indicators, we use crop count, Simpson's index, and the own production ratio.

We test whether there is a relationship between farm production diversity and household caloric intake. For convenience, we assume that production diversity indicators are exogenous. Since nutrient diversity indicators are complex and multidimensional, we choose to use a combination of nutrient diversity indicators to be explored. Either the analyses of multiple indicators might give us significant and robust results or it might give us insight in the relationship between nutrition diversity indicators.

Furthermore, we also incorporate socio-economic and demographic household variables into the model to control for household characteristics influencing dietary diversity, such as household size, age, gender and education of the household head as well as income-related variables. That income related variables include different sources of income, property, investments and transfers.

3. Data

For our analyses, we use three waves of the LSMS-ISA Uganda National Panel Survey (UNPS) implemented by the Ugandan Bureau of Statistics. The LSMS-ISA survey for Uganda combines information on socioeconomic information including food consumption and anthropometric characteristics, with agricultural characteristics. In our sample, we only take into account the rural households that claim to explore agricultural activities because we research the direct relationship between production diversity and nutrition diversity. For the agricultural part, households are visited twice to record the agricultural activities in both growing seasons (dry and rainy seasons). The food consumption information is based on registering the food consumption in one week.

The LSMS-ISA survey is a stratified survey of households in rural and urban districts. When using weights, it can produce representative results at the national level or the level of four regions. Our sample is based on three waves of the LSMS-ISA survey for Uganda. We constructed a balanced panel of 1,722 rural smallholders. Urban households were not considered, because we cannot establish a relationship between agricultural production diversity and nutrition diversity.

Nutrition diversity

For nutrition diversity we use three different indicators namely DDS, FCS and caloric intake. The latter indicator is constructed by multiplying the weights of food items consumed with the calorific coefficient data from the World Food Programme and the USDA's National Nutrient Database for Standard (References World Food Programme; USDA, 2013). For most food items, we were able to match the food products consumed in Uganda with the caloric coefficient of each product to make the link between quantity consumed by the household and its total caloric intake.

Cultivated 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 mixed cropping, each crop was taken separately. Given that there is no information on the proportion of crops on a mixed-cropping plot, we assume that each crop encompasses the entire plot. Both growing seasons within a year were included in the calculations of the productivity diversity indicators.

Household characteristics clearly have significant effects on the diversity of food consumption. For instance, household size 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 et al. 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 results on the relationship between age of the household head and nutrition diversity are mixed. While Abay et al. (2009) found a positive relationship (experience), (Jones et al. 2014) found a negative correlation (risk averse). Similarly, the education level of the household head. Benin et al. (2004) and Jones et al. (2014) found a positive relationship. Higher education of the household head, which is primarily responsible for food preparation in the household, take into account nutrition diversity and their caloric intake better.

Total income is an important indicator of the general economic well-being of a household, consequently a positive relationship is expected between consumption diversity and total income. A high level of income allows a household to the purchase of more food and food with higher nutritional quality. With respect 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. Note that food expenditures might be related to income, but they are not the same. According to Thorne-Lyman et al. (2010), non-food expenditures have a positive effect on the household dietary diversity, however, surprisingly Jones et al. (2014) found a negative relationship. All monetary income and expenditure variables are expressed in 2010 prices.

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. Most of them are smallholders. We test whether or not a household’s total cultivated area has an influence on dietary diversity through own production. More land can encourage households to grow more different crops. Jones et al. (2014) argued that 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.

Table 1 shows that the nutrition diversity indicators over time for the rural smallholders. For all nutrition diversity indicators, the values of the indicators are lowest for the period 2010-2011. They are highest for the period 2011-2012 except for caloric intake. On average, households consume food from more than 7 different food groups per week (DDS score). For food items, the average is more than 55 food items per week (FCS score). In caloric terms, households take 67,400 calories per week in 2010/2011, and 73,100 calories in 2009/2010. Given the increase in household size from 6.87 in 2009/2010 to 8.15, there is a clear decline in the amount of calories per household member per week from 10,600 calories in 2009/2010 to 8,700 calories in 2011/2012. For all dietary diversity indicators, their scores were largest in the central region, see Table 2. Both DDS and FCS were lowest in the northern region, but the caloric intake is lowest in the western region.

The crop count of smallholders in Uganda also slightly declines over time from 5.15 to 4.83, see Table 1. In addition, the cultivated area per household declined by 20% over time. In Central region, the crop count is highest, and in Eastern region lowest, see Table 2. The total cultivated area per smallholder is largest in Northern Uganda.

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. 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
Nutrition diversity						
DDS	7.35	1.97	7.33	2.04	7.48	2.05
FCS	56.84	21.72	55.50	21.92	59.34	21.34
Calories per HH (x 1,000)	73.1	57.4	67.4	75.,3	70.9	73.1
Calories per household member (x 1,000)	10.6		9.0		8.7	
Production diversity						
Crop count	5.15	2.10	5.12	2.09	4.83	1.97
Own production ratio	0.37	0.19	0.34	0.20	0.39	0.20
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
Food expenditure	250.2	365.1	273.0	428.8	297.0	464.6
Non-food expenditure	201.7	537.3	144.5	363.4	148.4	701.3
Income sources						
Total household income	1,754.9	6,484.9	1,739.9	7,515.3	1,807.6	5,011.4
# sources of non-agricultural income	0.10	0.35	0.31	0.66	0.29	0.60
Agricultural income	730.4	4752.4	633.8	1624.6	781.3	1919.2
Non-agricultural income	3.09	116.84	0.23	5.37	3.54	92.63
Property income	451. 6	2044.6	648.3	6791.1	558. 5	3321.5
Investments	66.1	514.7	126.6	1463.4	99.1	1200.0
Transfers	189.6	810.4	254.0	1202.2	276.2	1538.3
Total cropped area	5.09	21.74	5.56	29.79	4.02	7.65

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
Nutrition diversity								
DDS	7.64	1.94	6.53	1.97	7.46	1.96	7.94	1.97
FCS	58.23	22.78	58.60	20.39	52.27	20.18	60.63	22.54
Calories by HH (x 1,000)	83.34	86.40	55.88	55.23	67.44	54.76	74.01	69.77
Production diversity								
Crop count	4.65	1.85	5.35	1.96	4.73	2.09	5.55	2.22
Own proportion ratio	0.35	0.18	0.46	0.21	0.31	0.18	0.36	0.20
Household characteristics								
Household size	7.71	3.61	7.15	3.15	7.13	3.16	8.17	4.21
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
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
Income sources								
Incomes	1474.03	4591.61	1546.88	3272.15	1720.66	5025.95	2426.33	10908.34
# sources of non-agricultural income	0.20	0.49	0.25	0.63	0.22	0.55	0.27	0.58
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
Total cropped area	4.17	22.41	3.69	7.76	7.42	33.11	4.07	11.09

Other variables 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.

4. Preliminary results and discussion

Panel data models

Productivity diversity and other characteristics are regressed on nutrition diversity. Table 3 presents the panel data regression results (transformed PLM regressions). For each dependent variable, DDS, FCS and calories there are three regressions presented which differ across the indicator used for production diversity. For convenience, we assume that the production diversity is exogenous. Finally, a Hausman test for fixed effects was not rejected.

For the nutrition diversity indicators DDS (columns 1, 4 and 7 in Tables 3) and FCS (columns 2, 5 and 8), all production diversity indicators have significantly positive coefficients, see Table 3. The magnitude of the production diversity coefficients for the DDS and FCS equations ware largest for the Simpson’s index. In the case of calories (columns 3, 6 and 9), only the crop count variables (column 3) showed a significant positive coefficient. The Simpson’s index and own production ratio were not significant in the caloric intake equations. The result confirm the findings of Jones et al. (2014).

The results for the DDS models (columns 1, 4 and 7 in Tables 3) show that the coefficient for food expenditures are positive and significant. Also, three time period dummies are significantly positive as well. Note that we use three period dummies and ignore the intercept in the panel models. The switch between production diversity indicators did not affect the significance levels of the coefficients of the variables. Male household heads showed a significantly negative coefficient in the DDS with the Simpson’s index.

The panel models for the FCS indicator (column 2, 5 and 8) show significant coefficients for the number of different crops produced by the household, food expenditures, and total crop area. Also, three time period dummies are significantly positive as well. The signs and the magnitude of the significant coefficients were all in the same range. The coefficient of the variable education of household head is significantly positive when the Simpson’s index is used. Male household heads showed a significantly negative coefficient in the DDS with the Simpson’s index. The socioeconomic variables such as household size, age of the household head, education of the household head and the gender of the household head were insignificant. This might be due to the fixed effects estimation.

The results of the caloric intake models show that the same variables as the FCS model show significantly positive coefficients. Additionally, household size and education of the household head have also significantly positive while age of the household head has significantly negative coefficient. The total cultivated area is only significant is the count crop and own production ratio as proxies for production diversity were used. The time period dummies were not significant in the caloric intake models.

In general, the results across the three models nutrition diversity models which test for different exogenous food count measures showed 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.

Discussion

Our results for Uganda partly support the earlier findings of Jones et al. With our analyses we found a positive relationship between production diversity and nutrition diversity for different combinations.

The coefficient for the size of the household, an indicator of potential labour, is positive which indicates 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 counterintuitive 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 have the expected signs, 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.

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.

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.

Results for the DDS indicator showed less significant results. This might be due to the DDS indicator itself. It is a count variable with values ranging from 1 to 12. Moreover the distribution of the DDS variable is likely to be skewed. Linear model estimations like the panel data regression used in Table 3 might be inappropriate technique for count variables because it will lead to biased and/or inconsistent estimates see Chapter 17 in (Greene 2012). A Poisson Generalized Panel Linear Model with fixed effects would be a more appropriate estimation procedure for the DDS indicator.

Table 3: Fixed-effects regression results for three nutrition indicators and three production diversity indicators.

	DDS	FCS	Calories	DDS	FCS	Calories	DDS	FCS	Calories
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Crop count	Crop count	Crop count	Simpson' s index	Simpson' s index	Simpson' s index	Own production ratio	Own production ratio	Own production ratio
Production diversity	0.046 ***	0.668 ***	1.599 **	0.364 **	3.585 **	-2.688	0.059 *	0.844 **	0.971
Household size	0.008	0.113	3.549 ***	0.016	0.281	3.985 ***	0.009	0.131	3.626 ***
Household head gender - Male	-0.316	-1.435	12.034	-0.449 *	-4.451 *	15.448	-0.332	-1.664	11.396
Age of the household head	-0.006	0.032	-0.932 *	-0.001	0.163	-1.177 **	-0.005	0.038	-0.919 *
Education level of the household head	0.004	0.076	0.589 **	0.008	0.123 *	0.818 ***	0.004	0.078	0.601 **
Food expenditure	0.001 ***	0.021 ***	0.054 ***	0.002 ***	0.022 ***	0.056 ***	0.001 ***	0.021 ***	0.054 ***
Non-food expenditure	-0.000	0.000	0.001	0.000	-0.001	-0.003	-0.000	0.0001	0.001
Incomes	0.007	-0.029	0.110	0.006	-0.029	-0.010	0.007	-0.024	0.123
Total cropped area	0.001	0.024 *	0.101 *	0.001	0.025 *	0.062	0.001	0.023 *	0.100 *
Proportion of own production	-0.303	10.624 ***	39.812 ***	-0.345	11.244 ***	39.764 ***	-0.275	11.037 ***	41.325 ***
# non-agricultural income sources	0.011	-0.838	-0.157	0.008	-0.986	-1.147	0.011	-0.842	-0.129
Agriculture Decision - Household Head	0.048	1.066	0.559	0.154	1.516	-0.086	0.056	1.183	0.978
Year 2009-10	7.414 ***	42.121 ***	32.840	7.069 ***	36.972 ***	45.926	7.416 ***	42.214 ***	36.066
Year 2010-11	7.227 ***	39.955 ***	23.489	6.890 ***	34.672 ***	36.314	7.229 ***	40.049 ***	26.620
Year 2011-12	7.494 ***	43.794 ***	25.399	7.136 ***	38.320 ***	37.343	7.484 ***	43.721 ***	28.085
Observations	3,941	3,941	3,939	3,596	3,596	3,594	3,941	3,941	3,939
R^2	0.12	0.176	0.086	0.125	0.186	0.085	0.119	0.174	0.085
Adjusted R^2	0.074	0.108	0.053	0.075	0.111	0.051	0.073	0.107	0.052
F Statistic	27.59 ***	43.24 ***	19.080 ***	25.578 ***	40.787 ***	16.600 ***	27.263 ***	42.575 ***	18.751 ***

*Note: *p<0.1; **p<0.05; ***p<0.01, Calories intakes are estimated by household. Standard errors and t-values are available upon request with the corresponding author.*

5. Conclusions and discussion

Our preliminary results aim at estimating the link between production diversity and nutrition diversity for Uganda analogue to the analyses for Malawi by Jones et al. (2014). In addition to their paper, production diversity is also regressed on caloric intake. Moreover, we introduced a new indicator for the production diversity namely the own production ratio next to the crop count and Simpson's index. The own production ratio is the count of food items/groups produced by a household for own consumption purposes. All three production diversity indicators were regressed on all three nutrition diversity indicators. Since nutrition diversity indicators are complex and multidimensional, we chose to use a combination of nutrition diversity indicators to be explored.

For DDS and DCS, all three production diversity indicators positively affect nutrition diversity. With the Simpson's index the coefficients were largest. In the caloric intake models, only the crop count showed a significant positive effect. In addition, food expenditures has a positive impact on nutrition diversity as well. Furthermore, cultivated area education of household head and household size (labour) also had a positive impact but not for all models explored.

Based on the results, we can already indicate that promotion of production diversity in Uganda will lead to a larger diversity of nutrition. 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. Caloric intake might not necessarily increase in all cases but further research is necessary. Moreover, we have to test whether or not we can hold our assumption that the production diversity is an exogenous variable. Also, the DDS indicator is a count variable with a limited number of possible values and it is likely to have a skewed distribution. A Poisson type of regression would be more suitable. In addition, we could also test whether there is a link between production diversity and nutrition diversity over time.

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