**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 the 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, both including time, were estimated. Results indicate that consumption diversity and caloric intake are positively associated with households which produce a greater diversity of crops, have higher food expenditures, larger farms, and consume more from their own production. 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

**JEL Code:**

1. **Introduction**

Given the FAO's definition[[1]](#footnote-1) of food security, specifying a single indicator or a reasonable set of indicators which can be used to establish whether an individual enjoys food security or not is a complex task. Suggested measures fall into four general categories: caloric deprivation indicators; monetary poverty indicators; dietary diversity indicators, and; subjective indicators (Headey and Ecker 2013). Carletto, Zezza, and Banerjee (2013) compiled the following list of the most common indicators of food security: measures of undernourishment, surveys of household food consumption, food consumption scores, household food security access scales, coping strategy indices, food adequacy factors and non-food factors. In the current paper, we link 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. In addition, we examine the effects of the diversity of farm production on a household’s caloric intake.

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, Shrinivas, and Bezner-Kerr (2014) argues that there is a positive relationship between farm production and the health of household members. We aim to complement their work in two ways. First, concerning technical matters, we use a panel set of data instead of cross-sectional data and apply more appropriate econometric techniques. Using the World Bank LSMS-ISA panel data set for Uganda, we are better able to test the reported relationships between the Dietary Diversity Score (DDS) and consumption diversity as reported in Jones et al. (2014). Panel data allows us to utilize econometric techniques which statistically control for potential problems related to omitted, static, variables which can bias results when only one year of data is used. In addition, we test and, when appropriate, incorporate a more complete set of household variables into the model to better account for household characteristics influencing dietary diversity. The last technical addition concerns the use of a count model in place of the continuous models. Our second contribution is that we test whether there is a relationship between farm production diversity and household caloric intake. Therefore, in addition to the relationship between farm production diversity and adequacy of nutrient consumption via diverse consumption, we examine the influence of production diversity on caloric intake. Our contention is that an index which combines both nutrient diversity and caloric content will provide a better indication of the overall health of the household than one or the other 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 link we draw between production diversity and nutritional adequacy rests on the link between consumption diversity and nutritional adequacy. There is evidence in the literature that dietary diversity is an important component of health, with several papers arguing that there is a significant relationship between diet diversity and micro-nutrient intake. Nutrient adequacy is commonly calculated using the Nutrient Adequacy Ratio (NAR), a measure that compares an individual’s intake of nutrients to the recommended intake levels of those nutrients. The sum of the NAR by nutrient, divided by the number of nutrients, gives an overall indicator known as the Mean Adequacy Ratio (MAR). Two studies in Mali found a positive relationship between the Food Varity Score (FVS), which corresponds to the number of different food items consumed over a defined period, and the MAR. In addition, it has been shown that a significant level of correlation exists between the DDS which, like the FVS, focuses on nutritional food groups, and the MAR (Hatluy, Torheim, and Oshaug 1998; Torheim et al. 2004). In the Philippines, a significant relationship was found between nutrient adequacy intake and the DDS for children which were not breast feed (Kennedy et al. 2007). The FVS was also shown to be a good indicator of dietary adequacy of children (Arimond and Ruel 2004; Steyn et al. 2006). These studies ran their analyses at the individual level except Torheim et al. (2004), who considered both individual and household levels. In contrast, our study examines household dietary diversity as in Thorne-Lyman et al. (2010) and Jones et al. (2014). We assume that within a household food allocation is distributed equitably to optimize the diet of each member according to the total food available. Ideally, the individual consumption data would be available, unfortunately it’s not in the LSMS-ISA databases. However, as argued in Pitt, Rosenzweig, and Hassan (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.

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

1. **Data and Methods**

*Presentation of LSMS-ISA*

The Uganda economy is heavily dependent on agriculture. That sector employed 66% of the population in 2009 (Boysen, Jensen, and Matthews 2014). According to surveys in 2011-2012, half of the surveyed households considered farming to be their main activity and their principal source of income (The Uganda Bureau of Statistics 2015).

Three waves of the LSMS-ISA Uganda National Panel Survey (UNPS), 2009-2010, 2010-2011 and 2011-2012, implemented by the Ugandan Bureau of Statistics, are included in the current analysis. Each of the three surveys consists of data from two household visits separated by six months in order to record the activities of the two Ugandan cropping seasons – dry and rainy. The survey is composed of four different questionnaires. We use two of them, namely, the household and the agriculture surveys, the first of which contains household socio-economics information and weekly food consumption data and the second which contains descriptions of farm characteristics. Specific variables used in analyses are described below. The households of the UNPS were selected such that each region is equally represented and with stratification between rural and urban regions. All three waves of data were used in the analyses allowing us to construct a balanced panel consisting of 1722 household observations per wave. In addition to data from the LSMS-ISA surveys, we estimate a measure of health based on a household’s total caloric intake. We constructed this measure by calculating calories per kilogram of food item consumed by Ugandans using calorific coefficient data from the World Food Programme and the USDA's National Nutrient Database for Standard (References World Food Programme ; USDA, 2013). In most cases, 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 the caloric intake, moreover, this caloric estimation was made at the household level. Although in some cases the matching was imperfect given the exotic nature of the food item consumed or the non-standard quantity used to measure the item.

*Measurement of dietary diversity*

Our study aims to link production diversity and the diversity of household consumption. In keeping with the literature on this topic and to provide a rough crosscheck of outcomes, we use several established measures of dietary diversity. We test two commonly accepted measures of dietary diversity which have been linked to a healthy nutrient diet, namely, the FVS and DDS previously mentioned (Hatluy, Torheim, and Oshaug, 1998; Arimond and Ruel, 2004; Torheim et al., 2004; Steyn et al., 2006; Kennedy et al., 2007). 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). While both the FVS and FCS measure the *number* of different food items consumed over a defined period, the FCS gives a weight to each food item according to its nutritional contribution to the diet (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. The DDS consists of the following 12 nutritional food groups: cereals, roots and tubers, pulses and nuts, vegetables, fruit, meat, eggs, fish and seafood, milk and dairy products, oil and fats, condiments, and sugar. DDS uses the same food items consumed over the same time span as the FCS (Swindale and Bilinsky 2006).

*Measurement of farm production diversity*

In addition to the three measures of dietary diversity, three indicators were used to estimate farm production diversity; farm production diversity is an exogenous variable in our model. All three measures are postulated to be positively linked to our measures of dietary diversity and two of them have been used previously (Jones, Shrinivas, and Bezner-Kerr, 2014). The first measure of farm production diversity simply sums the number of different products produced by the household farm. That sum takes into account only crops which have been harvested at the time the household was interviewed. Our argument for not counting additional potentially harvestable products is that we cannot be certain that those crops will eventually be consumed or sold for reasons including the ability of the farmer to harvest the crops due to health concerns and the threats of insects, rodents, floods, other pests and thefts.

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

With,

Where is the part of crop *j* in the total area cultivated by the household *i*. Then is the area of the crop *j* used by household *i*, is the total cropped area cultivated by the household *i*. The Simpson’s index was estimated for a household for each of the three waves of the panel. The index is bounded by 0 and 1 and allows us to measure the farm production diversity. Values approaching zero indicate that a household 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 according to data available in the LSMS-ISA surveys. 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 fact that there are two seasons, dry and rainy, was accounted for when calculating Simpson’s index and the other variables used in the analyses. The seasons are associated with different crop varieties and amounts of production, combining them reduces eventual seasonal biais.

The third production indicator has not previously been used in the literature. It is designed to reflect farm production effects on food consumption based 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. The same nutritional matching and groups are considered as in the DDS measure and, consequently, a score is calculated between 0 to 12 inclusive. This new indicator is easy to calculate and could provide policy makers with an additional indicator of health. This variable is especially relevant for households consuming their own production and we expect that a production of various nutritional food group should improve the diet quality.

*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 exogenous variables. In practice, our task was to choose a subset of variables that best explains dietary diversity. The selection criteria we used was first to consult the literature to get an overview of the set of variables commonly used to which we added variables which are commonly used in the micro-economics. The economic variables, such as income and expenditures, were added to capture the economic constraints facing households. Finally, a third condition for deciding whether a variable was chosen for inclusion in the model was the condition of parsimony. In short, parsimony in modelling terms means that the decision whether to include a variable has to be balanced by the additional value that variable makes to the model in terms of its effect on RSS, AICc or BIC measures. The following paragraphs discuss potential variables considered for inclusion into out model and our hypotheses concerning its potential effect on dietary diversity. For expository purposes, 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 a household’s 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, Bjørnstad, and Smale (2009) found a positive correlation with a male household head in Ethiopia because of household dependence on hard-labour for some activities 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 et al. (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 is presumed to be positively related to the dietary diversity of the household and their caloric intake because it enables better decisions. The positive influence of this variable was found by Benin et al. (2004) and Jones et al. (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 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 et al. (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, Jensen, and Matthews 2014), agricultural characteristics are an essential component of Ugandan households. The number of household members who have worked in a sector other than agriculture is hypothesized to be positively related to dietary diversity because of its positive influence on income. Such jobs 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 a greater access to a diversity of food items because they are able to choose for themselves which products to produce and are not required to buy them in the marketplace. 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, a household’s total crop area could have an influence on the income of the family and on their own farm production consumption. More land certainly increases the potential for greater crop diversity. Accordingly, this variable is presumed to be positively correlated with food diversity and caloric intakes of the household.

*Location*

Finally, the regions, 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 consumers.

*Data characteristics*

The following paragraphs describe the data. The data was analysed per wave in order to determine whether there are obvious differences between waves. Secondly, the data partitioned according to geographic location in order to discover whether there are large difference across regions which might need to be addressed in the regressions.

Table 1 presents the characteristics of households previously described disaggregated by the wave in which the survey was taken. The most important differences were observed for changes in the size of the household which increased from 2009 to 2012, and the cultivated area which decreased on the same period. Given that we are using a balanced panel set of data, the increase could be caused by the general tendency of surveyed households to increase over time as was the case for Uganda as a whole. Table 2 presents the data partitioned by region. Both dietary diversity measures were greater in the central region while the northern region and western region for the DDS and FCS diversity measures respectively. Households from western region spent less for food and consumed more products from their own farm. That said, and counter to our hypothesis, their farm were the smallest in the country. The central region, which includes the Ugandan capital Kampala and surrounding region, had higher income by household. The standard deviations of the income measures are large and stress the existence of great gaps in income between the poorest and richest households. Although we experimented with removing a few households which were recorded to have an unreasonably large amount of lands or high income, the standard deviations for income and expenditures remained still significantly elevated.

*Table 1: Variable characteristics by year*

*Table 2: Variables characteristics by region*

Some variables were left out for the analysis for statistical reasons. For instance, the number of farm plots could presumably be linked to the diversity of production by encouraging the planting of a greater range of crops to fit the given characteristics of a plot. However, we didn’t include this variable because of its collinearity with several other variables, especially with the production diversity and the cultivated surface both of which were included in the regressions.

*Analytical methodology*

As mention, our initial aim is to complement the work of Jones et al. (2014) two ways, the first of which takes advantage of the three waves of panel data to which we have access to better test reported relationships between the FCS and DDS measures and our exogenous variables. 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 used. And, in addition to standard Ordinary Least Square (OLS) on a continuous measure as used by Jones et al. (2014), we propose to use a Poisson model to account for the count nature of some of our endogenous variables. In short, we compute a Poisson Generalized Panel Linear Model with fixed effects. The fixed effects or within form of the panel model is made under the statistically verified assumption that individual household characteristics are important determinates of differences in the endogenous variables. A time-fixed effect model is used to allow us to control for correlations through time.

In addition, we incorporate a more complete set of household variables into the model to better account for household characteristics influencing dietary diversity. Specifically, we include variables which allow us to analyse both the number of food items in a diet as well as the number of nutritional food groups available. In addition, income is subdivided according to its source because we believe that sources external to the household may indicate better access to diversity. Two quadratic variables were tested, namely, income and age of the household. This was done to see whether there is an indication that these variables have a decreasing affect on diversity the more they increase. Income was partitioned into five categories to identify what the main income source for a diet of quality: agricultural income, non-agricultural income, property income, investments and transfers.

Finally, we test whether there is a relationship between farm production diversity and household caloric intake. Therefore, in addition to the relationship between farm production diversity and adequacy of nutrient consumption via diverse consumption, we examine the relationship between farm production diversity and caloric consumption.

*Measurement of children anthropometric development*

Data in the LSMS-ISA survey allowed us to conduct this approach, we computed independents variables of children development considered as good estimated of children health. Many studies focused on this subject brings to the light the link between children dietary diversity height for age Z-score (HAZ) (Arimond and Ruel, 2004; Steyn et al., 2006; Rah et al., 2010). These variables were linked to the dietary diversity of them. On the limit of our data we need to make the hypothesis that dietary diversity is considered equal for all members of a household. Even if some differences of alimentation could exist between children and adult, we can suppose both are linked. World Health Organisation anthropometric children data were used as references (World Health Organization, 2006). 2932 children anthropometric parameters from the Uganda LSMS-ISA surveys were used in this HAZ estimation. Weight for age Z-score (WAZ) and weight for height Z-score (WHZ) were estimated by the same way from respectively 2929 and 2964 children.

1. **Results and discussion**

*Table 3: Comparison of different regression methods*

*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 dependent variable panel Ordinary Least Squares (OLS) and within transformed regressions were calculated. In addition, for the DDS model an ordered Probit model was run 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 FVS 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.

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 a choice, 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 magnitude 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*

The three production count variables mentioned above – Number of different crops produced; Number of different *nutritional groups* produced; Simpson’s index – were tested using the fixed-time effect method (Table 4). These main variables were significant and positives for our three dependent variables except Number of production by nutritional group and Simpson’s index which were not significant to explain Caloric intakes. The whole variable set gave results in line with previous interpretations across the different production count variables.

The first crop count model, Number of different crops produced variable, is equal to our first model. Upcoming model concern number of different *nutritional groups* produced and is conform to previous one excepted for the Caloric model where the concerning count production variable is insignificant meaning the improving production of crops corresponding to specific nutritional groups have no effect on caloric intakes.

Simpson’s index model present some specificities. Yet, insignificant of the main count production variable was stressed for Caloric. Negative influence was found from male as household head on FCS and DDS when our first models didn’t show, males could focus on food quantity instead of quality but without significant results for Caloric we can’t conclude on this point. Education had positive effect on FCS when it was non-significant for the two other production estimations.

Using time-fixed effect regression we compared the influence of three production variables. Caloric intakes have more significant variables, as calories are linked to the quantity of food consumption we supposed it is maybe more easy to influence this variable. In other word more explicative variable can have an greater influence on food quantities rather than on food quality.

Region of the household was not take into account for our time fixed-effect regressions. By capturing effects for the three nutritional variables, simple count production variable seem the best indicator to evaluate the household diversity production in Uganda.

*Subdivided income and non-linear variables*

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

The income subdivision (Table 5) showed strong relations between our dependent variables and the crops diversity variable.

Food expenditures are always strongly linked to the diet which point could appear relatively obvious and have been related previously.

Concerning the different incomes, negative influence on FCS and Calories intakes of Investment let understand this income category as the one to not prioritize as income source. Positive effect of non-agricultural income on DDS indicate the importance of works which not depend on agriculture to improve the nutritional quality of the diet. It stresses also the current lack for farms to provide a balanced and healthy diet to their own family. When we considered total income this variable appeared positively linked to the household diet. Improving household income could appear as a lever to improve food consumption, in quantity and quality terms, and then the health of Ugandans but non-significances of Transfers categorize let understand that current transfers could have no effects on the household diet. Investigation have to be made in order to identify eventual transfers system lacks. Finally, others income categories did not show significant influence on the diet and time effects was not significant for the Caloric intakes dependent variable.

Effects of squaring the following variables were tested: age of the household head, income, food and non-food expenditures. Results didn’t show any change comparing equivalent models already describe before (results do not show).

*Children development*

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 ; +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.

1. **Conclusion and policies reflexions**

Our preliminary results aim at reproducing and extending the model found in Jones, et al. (2014) using more data and improved techniques. We are testing other versions of that original model using a more concise set of exogenous variables focusing the analysis on the cropping systems diversity and income sources diversity.

Our preliminary hypotheses were twofold: asked whether the influence of farm production diversity by household on household’s consumption diversity remains significant using more appropriate techniques and panel data; test whether farm production diversity leads to higher household caloric intake. We were able to confirm both hypotheses. The caloric intake estimation is based on a matching between the answer of household on their consumption and the USDA nutritional data base. This step can be discuss because it is done according to food production name in both bases, and some of them are approximation but we hope have result not so far from the reality.

On a technical point of view, our results suggest to prefer time-fixed effect but it could appear logical thanks to panel data. We can’t blame other studies to do not use this approach in that certainly they did not have appropriate data. But we recommend to use these panel data when they are available.

Because farm production diversity is likely to increase consumption diversity and therefore nutrient intake and caloric intake, then policies aimed at increasing farm production diversity are likely to improve the health of farm households. This possibly change start with providing information to the population explaining what is a healthy diet in quantity and diversity of foods. Increasing the market access to sell their products but also to buy seeds and agricultural incomes can represent a lever to improve the quantity and quality food consumption.

At last, an efficient transfer system to help vulnerable population could represent another solution especially when we saw the negative influence of this parameter on the diet.

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1. “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). [↑](#footnote-ref-1)