Education's effect on Food and Monetary Security in Burkina Faso: A Joint Semi-parametric and Spatial Analysis

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Abstract

This paper tests human capital theory predictions with respect to formal education, using Burkina Faso's 2014 National Survey on Households Living Conditions, along with geospatial meta-data and semi-parametric modeling techniques. In its design the study relies on households "willingness and ability" to spend annually a per-capita amount above the poverty thresholds to characterize " household food security" and "monetary security". We find that relaxing the linearity and independence assumptions provides a more robust representation of the systemic and inter-dependent relationship that exists between education, food and monetary security. In fact, education is found to increase the joint likelihood of food and monetary security in the country. Specifically, compared to households headed by individuals with no education, those headed by primary, secondary or higher educated individuals are respectively 19.8%, 49.7% and 1.189 times more likely to experience food security, and respectively 40.1%, 77% and 1.723 times more likely to come out of poverty. Furthermore, the high positive correlation (0.927) between the incidence of food and monetary security suggests that coordinated efforts in the food and education sectors will have much greater impact on the country's sustainable development, than isolated initiatives.

Keywords: Burkina Faso, Discrete Choice Modeling, Education, Food security, Poverty, Sustainable Development
JEL: C50, I20, I32, O50

1. Introduction

Food and nutritional (in)security is a global challenge affecting households in both developed and developing countries, and remains a defining feature of life for millions of people worldwide (Teklewold et al., 2019). Despite recent decreases in percentage terms, global food insecurity has been increasing in absolute terms Acevedo et al. (2018) with $\approx$ 800 million undernourished people in the world ($\approx$ 11% of the population) (Lentz et al., 2019). Although Sub-Saharan Africa is leading the way with nearly one-half of its population living in extreme poverty, and depending heavily on agriculture and natural resources either directly or indirectly for their incomes and food security (Bremner, 2012), lack of food security still persists in many regions of the world(Ligmann-Zielinska and Rivers, 2018).

In Australia, food insecurity is shown to originate from poor food literacy behaviors. Indeed, relying on online survey data from 2334 Australian respondents collected between November 2016 and February 2015, Butcher et al. (2019) reports household income and education as among the most significant predictors of food security. Similarly, among 1433 adults enrolled in a food literacy program between May 2016 and April 2018 Begley et al. (2019) shows that education and employment status are among the statistically and independently associated factors with food security in Australia. Using data on Toronto District School Board students, along with college and University application information Robson et al. (2019) reports a positive association between food security and grade 12 grades as well as post-secondary application confirmation. Furthermore, among 120909 Canadian households, Tarasuk et al. (2019) finds that the probability of household food insecurity and the severity of the experience depend among other factors on households province or territory of residence, education and main source of income, highlighting therefore a disproportionate burden of food insecurity among the indigenous population in Canada.

A similar effect on the indigenous population is reported in the United States (Rose et al., 2019). Indeed a 2016 study of the US department of Agriculture (USDA) nutrition assistance program for tribal communities (Pindus and Hafford, 2019) found that Native American living on tribal lands experience significantly higher food insecurity than national averages, with 34% experiencing low food insecurity, and about 22% experiencing very low food security. Due to limited financial resources, and rising cost of tuition, housing and food in the U.S., college students have also been reported as a vulnerable group to food insecurity El Zein et al. (2019).

In Europe, Grammatikopoulou et al. (2019) also reports food insecurity to be associated with lack of higher education, reduced monthly income and low adherence to the Mediterranean diet among a cross-section of 207 older Adult participants from Thessaloniki and Kavala, Greece. In North Africa, Jomaa et al. (2019) reports low maternal and paternal education, and employment as significant correlates of households food insecurity among Lebanese households with 4-18 years old-children. In Asia, among rural households in northern Pakistan Zhou et al. (2017) reports among several other factors, education and employment as determinant factors of households'

food insecurity, and therefore recommend the promotion of education to remedy the issue in the region.

In East Africa, among households in southern Zambia Nkomoki et al. (2019) reports higher education levels of households head, and increasing livestock income to positively influence the probability of household food and nutrition security and therefore recommend policies supporting livestock development programs as potential enhancers of household food and nutrition security in the region. Using a longitudinal mixed-methods approach Roelen and Leon-Himmelstine (2019) investigates children well-being during and after participation in a graduation model program in Burundi, and reports significant improvement in well-being particularly in relation to food security and education. Finally, relying on income and expenditure data from the South African Province of Limpopo, Wanka and Rena (2019) investigate the relationship between a head of household's level of education and the poverty status of the household in South Africa, and report a strong tendency for lower educational attainment to be associated with higher prevalence of household poverty.

Overall, chronic undernourishment is widespread throughout Africa, with the greatest incidence occurring in conflict countries(Messer and Cohen, 2007). The region as a whole remains susceptible to frequent food crises and famines which are easily triggered by even the lightest of droughts (Wiebe et al., 2017), floods, pests (Olabisi et al., 2018) or economic downturns Coates et al. (2006); Denny et al. (2018).

The region's food supply is mainly made of cereals, roots and tubers (Woldetsadik et al., 2018), however their production has generally lagged behind the rate of population growth (Wiebe et al., 2017). As a result, countries in the region have had to rely increasingly on imports to satisfy the demand for food, especially those with already negative trade balances and high debt, for which these imports are not sustainable(Kidane et al., 2006; Altman et al., 2009). Access to food by households in the region is therefore undermined by the inability of the countries to generate the resources required for food import(Kruger et al., 2006). Also contributing to this challenging picture is a high level of poverty resulting from over-dependence on subsistence agriculture, limited access to off-farm employment, sluggish development in urban areas and skewed income distribution (SESRTCIC, 2007).

The world food summit of 1996 defined "National food security" as a state in which "all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preference for an active and healthy life" (Melgar-Quinonez et al., 2006). Dis-aggregating at the household level, we could then extrapolate the definition of "Household food security" which will be the one embraced throughout this analysis, as a state in which *"all household members, in a given time period (for example a year) have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preference for an active and healthy life"*. Although the former definition is broad and universal in nature, the later definition is focused and contemporaneous, allowing us to characterize household level

heterogeneity in food security, as opposed to the initial definition which assumes within-country homogeneity in food insecurity [1] (Pinstrup-Andersen, 2009).

Hunger has long been a concern to world leaders, as evidenced by the 1948 Universal Declaration of Human Rights (Melgar-Quinonez et al., 2006), stating that "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food...". As part of the millennium development goals (MDGs), UN country members through the Rome Declaration on world food security, reaffirmed access to adequate, safe, and nutritious food as a fundamental right for inhabitants throughout the world (FAO, 1996). This commitment was further reiterated in 2015 through goal 02 of the 2030 Agenda for sustainable development(United Nations, 2015).

With support from its development partners, and under the MDGs Burkina Faso has achieved notable progress in many sectors(IFAD, 2012). Nevertheless, serious delays are still apparent in areas such as poverty and hunger reduction (GARRIDO and SÁNCHEZ, 2015). According to a USAID report (USAID, 2015*a*), Burkina Faso's agricultural sector continues to generate roughly a third of the country's GDP and employs 80% of the population. However, this sector is still characterized by low crop and livestock productivity and mainly supports subsistence livelihoods (Zidouemba and Gérard, 2014; FARA, INERA, ZEF, 2015). As a result, 3.5 million people or roughly 20% of the population, are still experiencing food insecurity and approximately 50% of rural households unable to produce sufficient quantities of food to sustain daily caloric intakes (USAID, 2014, 2015*b*). Furthermore, the latest report by the National Institute for Statistics and Demography, INSD (2015) shows a fairly low rate of education and a high rate of poverty in the rural parts of the country.

"*By disregarding the educational needs of the vast numbers of the rural population, countries build an agricultural human resource pyramid which could be considered almost as an inverted pyramid, where the absence of a diffuse general nor specialized knowledge, can limit national efforts to implement sustainable policies for agriculture, rural development, food security and poverty reduction efforts ... Education and training needs to address rural development, sustainable natural resources management and poverty reduction, with a broad, holistic focus by redefining its strategies and responsibilities and expanding its target.* " (Gasperini, 2000)

Since households' members educational choices have the potential to influence households' food and monetary security status, research offering insights into education's impact on households' spending choices in Burkina Faso is of relevance. Furthermore, in their work linking food security to the environment Acevedo et al. (2018) advocate more use of the capabilities of qualitative

[1] The Food and Agricultural Organization (FAO) defines four dimensions of food security: food availability, food access, utilization, and stability (FAO, 2006). In this paper, we focus on food access and utilization and in particular on the role that education plays in facilitating access and utilization of household consumption goods in general, and food consumption in particular.

social sciences in order to address the multiplicity of human factors that may impede improvement in food security. Improving productivity, and thereby food security, requires redoubled efforts in interdisciplinary work to not only design and implement sound agricultural education and management practices, but also efficient use of agricultural production inputs Acevedo et al. (2018).

To address the interconnected aspects of food security a systemic approach based on model building and insights from systems science have recently been embraced by authors. For example using quantitative statistical modeling, Denny et al. (2018) and Woldetsadik et al. (2018) stress the importance of heterogeneity in food security and risk attitudes associated with food production. Relying on qualitative modeling methods Rivers III et al. (2018) and Olabisi et al. (2018) describe the explanatory factors of food insecurity in Africa, focusing on the role of climatic risks factors, and inter-and intra-household behavioral dynamics. Furthermore, using a data-driven approach to real-time food security modeling Lentz et al. (2019) shows that food price, weather and demographic characteristics such as education and income are significant predictors of food security among households in Malawi. Finally, relying on a mixed (qualitative and quantitative) approach through semi-parametric bivariate sample selection modelingNiankara (2019) shows that the unobserved factors affecting heads of households' literacy status in Burkina Faso, significantly affect households' food-wellness as measured by per-capita food consumption spending.

The present study inscribes itself in this recent trend of literature, embracing a systemic approach for a holistic research on reducing the incidence of poverty and food insecurity in Africa. The broad objective here is to shed lights on the nature of the effects that heads of households educational attainment have on households' food and monetary security in the west African State of Burkina Faso. More specifically, the study addresses the following three questions:

Question1: Do households with formally educated heads experience food insecurity to the same extent as do those headed by uneducated heads in Burkina Faso ?

Question2: Do households with formally educated heads experience monetary poverty to the same extent as do those headed by uneducated heads in Burkina Faso ?

Question3: Are the incidences of households' food insecurity and monetary poverty independent in Burkina Faso ?

In relation to the above three questions, we formulate the following hypothesis "Ceteris, Paribus":

H1: there are significant differences between households with formally educated heads and those with uneducated heads in their experience of food insecurity in Burkina Faso;

H2: there are significant differences between households with formally educated heads and those with uneducated heads in their experience of monetary poverty in Burkina Faso;

H3: All things being equal, the incidences of households' food insecurity and monetary poverty are inter-dependent in Burkina Faso.

In our quest to test the above three hypotheses, we organize the remaining of this paper as follows: Section 2 describes our behavioral economic model of spending choices and poverty status; Section 3 describes the data and the analytical strategy used to identify the model; Section 4 presents the

results of the analysis, while section 5 discusses and concludes the analysis.

2. The Behavioral Economic Model

Derived within the context of random utility maximization, our behavioral economic model assumes that each household is faced with two consumption types i (with $i = 1$ for food consumption, and $i = 2$ for non-food items consumption), where they must choose between two spending alternatives, spending either an amount of income below the official poverty thresholds (such that the binary outcome indicators: $y_i = 0$ for all i), or an amount of income above the poverty thresholds (such that the binary outcome indicators: $y_i = 1$ for all i). These two alternatives are indexed respectively with 0 and 1 for each consumption type i, according to which one provides the greatest utility/satisfaction. Relying on the additive representation of the utility function requires the following specifications for the utilities of alternatives 0 and 1 for each consumption type i with $i = 1, 2$:

$$\begin{aligned} U_{i0} &= V_{i0} + \epsilon_{i0}, \\ U_{i1} &= V_{i1} + \epsilon_{i1}, \end{aligned} \tag{1}$$

where V_{i0} and V_{i1} are deterministic components of utility with ϵ_{i0} and ϵ_{i1} being the random components of utility. We observe $y_i = 1$, if $U_{i1} > U_{i0}$, that is if alternative 1 has the highest utility of the two. Because of the presence of the random components of utility this is a random event with

$$\begin{aligned} Pr[y_i = 1] &= Pr[U_{i1} > U_{i0}] \\ &= Pr[V_{i1} + \epsilon_{i1} > V_{i0} + \epsilon_{i0}] \\ &= Pr[\epsilon_{i0} - \epsilon_{i1} < -(V_{i0} - V_{i1})] \\ &= F(V_{i0} - V_{i1}), \end{aligned} \tag{2}$$

where $F(.)$ is the cumulative distribution function of the error differences $(\epsilon_{i0} - \epsilon_{i1})$. giving

$$Pr[y_i = 1] = F(X^{'}\beta_i) \; if \; V_{i0} - V_{i1} = X^{'}\beta_i. \tag{3}$$

The ARUM requires a scale normalization since, if $U_{i1} > U_{i0}$ then $aU_{i1} > aU_{i0}$. This is usually done by specifying the variance of $(\epsilon_{i0} - \epsilon_{i1})$. Different specifications for the distributions of the error terms (ϵ_{i0}) and (ϵ_{i1}) give different $F(.)$ and hence different discrete choice models. The logit model results when $F(X^{'}\beta_i) = \Lambda(X^{'}\beta_i)$, that is the type 1 extreme value cumulative distribution function, with choice probability given by:

$$Pr[-(\epsilon_{i0} - \epsilon_{i1}) < X^{'}\beta_i] = \Lambda(X^{'}\beta_i) \tag{4}$$

On the other hand, the probit model is obtained when $F(X^{'}\beta_i) = \Phi(X^{'}\beta_i)$, that is the standard normal cumulative distribution function, such that the choice probability is given by:

$$Pr[-(\epsilon_{i0} - \epsilon_{i1}) < X^{'}\beta_i] = \Phi(X^{'}\beta_i) \tag{5}$$

Each household is assumed to make spending choices on the basis of observable characteristics such as: household's head education level, age, sex, marital status, region of residence, and other relevant factors as summarized in table (4). These factors make up the vector of observables X in equations 4 and 5.

3. Econometric Specification

Our econometric specification of the above described behavioral economic model corresponds to the bivariate probit of monetary and food security. It specifies a binary food security variable (y_1) defining whether or not a household has spent an amount above the food poverty line, and a binary monetary security variable (y_2) capturing whether or not a household has spent an amount above the overall poverty line. More specifically, if $y_1^{\star}$ is the latent utility characterizing the household's average propensity to spend above the food poverty line, while $y_2^{\star}$ is the latent utility characterizing the household's average propensity to spend above the overall poverty line, and *educ* the nominal variable characterizing the head of household's educational attainment, then the model comprises the food security equation:

$$y_1 = \begin{cases} 1 & \text{if } y_1^{\star} > 0 \\ 0 & \text{if } y_1^{\star} \leq 0 \end{cases} \tag{6}$$

and the monetary security equation:

$$y_2 = \begin{cases} 1 & \text{if } y_2^{\star} > 0 \\ 0 & \text{if } y_2^{\star} \leq 0 \end{cases} \tag{7}$$

The bivariate system of additive random utilities is therefore given as:

$$\begin{cases} y_1^{\star} & = \beta_{01} educ + x_1^{*}\beta_1 + \epsilon_1 \\ y_2^{\star} & = \beta_{02} educ + x_2^{*}\beta_2 + \epsilon_2 \end{cases} \tag{8}$$

Where β_{01} et β_{02} represent the marginal effects of educational attainment on the household propensity to spend above the food poverty line, and the overall poverty line respectively. x_1^{*} represents the vector of covariates in the food security equation; it has two component parts, a vector of nominal component variables $X_{11}^{'}$, and a vector of numerical component variables $X_{21}^{'}$. While x_2^{*} represents the vector of covariates in the monetary security equation; with also two component

parts, a vector of nominal component variables $X_{12}^{'}$, and a vector of numerical component variables $X_{22}^{'}$. Therefore equation(8) can be rewritten more explicitly as:

$$\begin{cases} y_1^{\star} & = \beta_{01} educ + X_{11}^{'}\beta_{11} + X_{21}^{'}\beta_{21} + \epsilon_1 \\ y_2^{\star} & = \beta_{02} educ + X_{12}^{'}\beta_{12} + X_{22}^{'}\beta_{22} + \epsilon_2 \end{cases} \tag{9}$$

In this formulation, β_{11} and β_{12} represent the vectors of marginal effects for the nominal co-variates in the food security equation, and the monetary security equation respectively. While β_{21} and β_{22} represent the vectors of marginal effects for the numerical co-variates in the food security equation, and the monetary security equation respectively. The challenge arises in identifying the coefficients when ϵ_1 and ϵ_2 are correlated. Estimation by maximum likelihood is straightforward if we make the additional assumption that the correlated errors are jointly normally distributed and homosckedastic, with

$$\begin{pmatrix} \epsilon_1 \\ \epsilon_2 \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{pmatrix} \right] \tag{10}$$

Where the normalization $\sigma_1^2 = 1$ is used for identification purposes. The standard in the literature is to use the two step estimator by Heckman (1979) to identify the system (Cameron and Trivedi, 2005, 547-548). In the current analysis, we extend this standard by specifying general copula functions for the parametrically entering numerical variables "hage" and "hhsize", which make up the vectors $X_{21}^{'}$ and $X_{22}^{'}$ thus yielding:

$$\begin{cases} y_1^{\star} & = \beta_{01} educ + X_{11}^{'}\beta_{11} + g_1(X_{21}^{'}\beta_{21}, \epsilon_1) \\ y_2^{\star} & = \beta_{02} educ + X_{12}^{'}\beta_{12} + g_2(X_{22}^{'}\beta_{22}, \epsilon_2) \end{cases} \tag{11}$$

With the general functions $g_1(.)$ and $g_2(.)$ estimated along with the unknown parameters of the model system. This model system representation is called bivariate partially linear, and is identified here using the semi-parametric estimator described in Wojtys et al. (2016).

4. Data and Variables Description

The empirical analysis is based upon data from the 2014 National Survey on Household Living Conditions(EICVM)[2] administered by the National Institute for Statistics and demography (INSD) in Burkina faso. The broad objective of the EICVM survey is to provide information on households'

[2]EICVM: Enquete Intégrale sur les Conditions de Vie des Ménages. or "The National Survey on Household Living Conditions". See http://www.insd.bf/n/nada/index.php/catalog/ECVM. Retrieved 10 October, 2016 from the World bank Micro-data library http://microdata.worldbank.org/index.php/catalog/2538/getmicrodata

living conditions at a given point in time, and more specifically to analyze poverty among those households. The survey uses a two-level stratified random sampling with weights that produce nationally representative estimates for households' per-capita annual spending on food and non-food items, and a wide range of demographic and socioeconomic characteristics for the civilian, non institutionalized population in Burkina Faso. Primary sampling units are selected with probability proportional to their size, and the secondary sampling units or households selected with equal probability within those primary sampling units. The EICVM survey data is collected over a period of twelve months, our analysis includes a total of 10411 households distributed across the 13 administrative regions of Burkina Faso, as mapped below in figure (1).

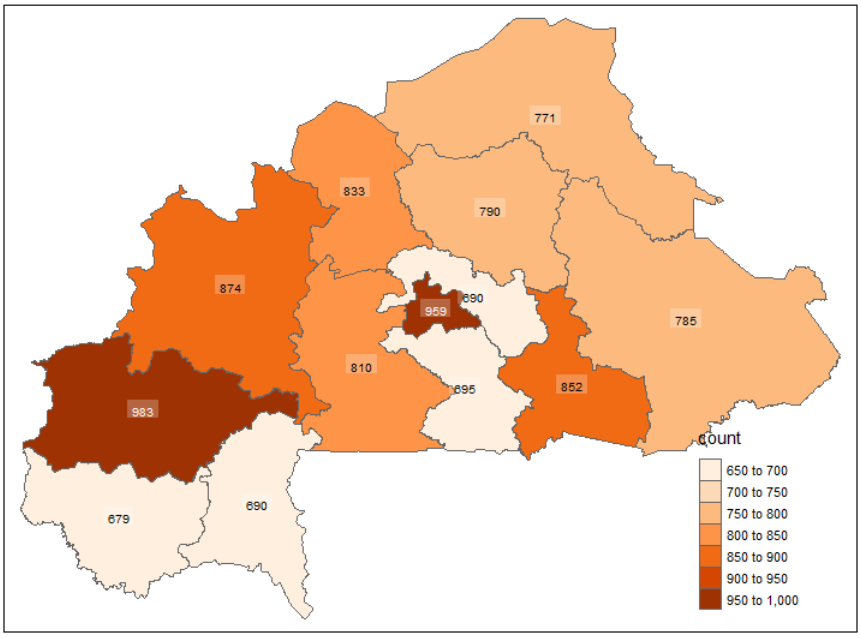

Figure 1: Spatial distribution of sample respondents across the 13 administrative regions

4.1. Dependent Variable Construction

It is assumed that households as rational optimizers are looking to maximize utility from the consumption of goods and services they purchase annually. In this quest to satisfy their needs, households choose to spend yearly on consumption (for food and non-food items), amounts either greater than the poverty lines for both food and overall consumptions (in which cases the household experiences "food security" and "monetary security") or less than the poverty lines (in which cases the household experiences "food insecurity" and "monetary poverty")[3]. These suggest that

[3]This definition of Poverty status, is adopted by INSD in Burkina faso, which is the agency in charge of the EICVM survey. INSD identified the 2014 food poverty line at 102,040 CFA; and the overall poverty line at 153,530

households per-capita annual spending on food, as well as per-capita overall annual spending as spatially summarized in figure (2), are respectively good indicators of households food insecurity status, and monetary poverty status. In this way, being characterized as "food secure", "monetary secure", "food insecure" or "monetary poor" is a reflection of the spending choices households' make in the satisfaction of their needs. Given the 2014 food poverty line, and overall poverty line at 102,040 CFA and 153,530 CFA respectively, and the observed annual per-capita spending y_i, for $i = 1, 2$ (with i=1 if spending on food consumption, and i=2 if overall consumption spending) the binary dependent variables capturing households' food insecurity status, and monetary poverty status are given by :

$$FoodPovStat = \begin{cases} Food\ Security, & or\ 1\ \ \forall\ \ y_1 > 102,040, \\ Food\ Insecurity, & or\ 0\ \ \forall\ \ y_1 \leq 102,040 \end{cases} \tag{12}$$

and

$$MoneyPovStat = \begin{cases} Monetary\ Security, & or\ 1\ \ \forall\ \ y_2 > 153,530, \\ Monetary\ Poverty, & or\ 0\ \ \forall\ \ y_2 \leq 153,530 \end{cases} \tag{13}$$

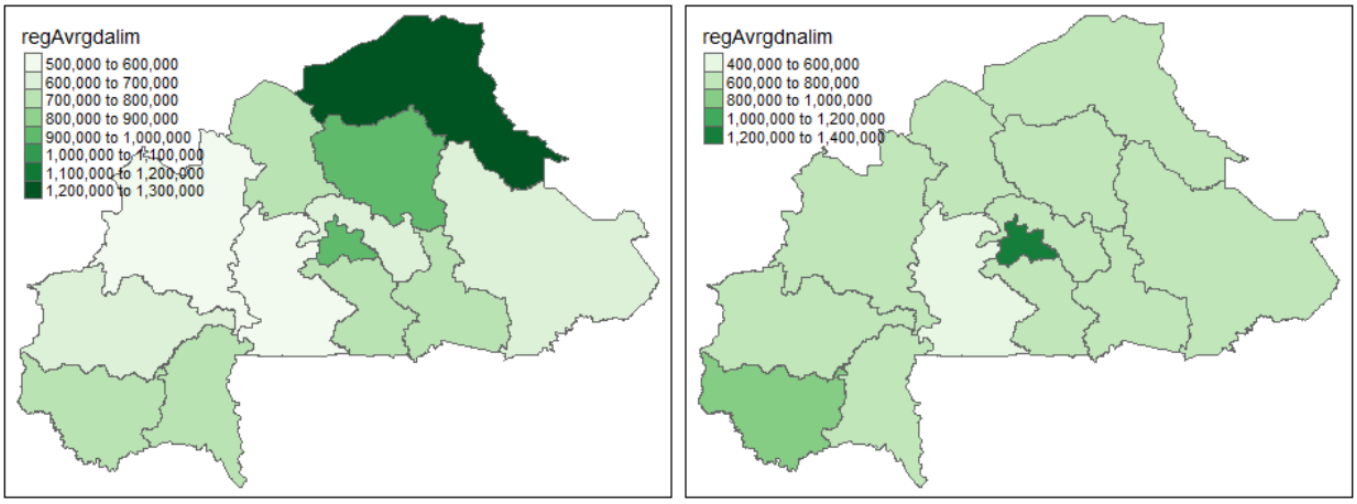

Figure 2: Spatial distribution of household nominal per-capita food (left panel) and non-food (right panel) consumption spending across administrative regions

In addition to the above two discrete welfare indicators of poverty status, which allow us to characterize the extensive margin of poverty, we also rely on a continuous welfare indicator repre-

CFA

sented by household per-capita inflation adjusted (real) consumption expenditure to characterize the intensive margin of poverty. The spatial distribution of the mean and standard deviation of this latter welfare indicator is summarized in figure (3) below.

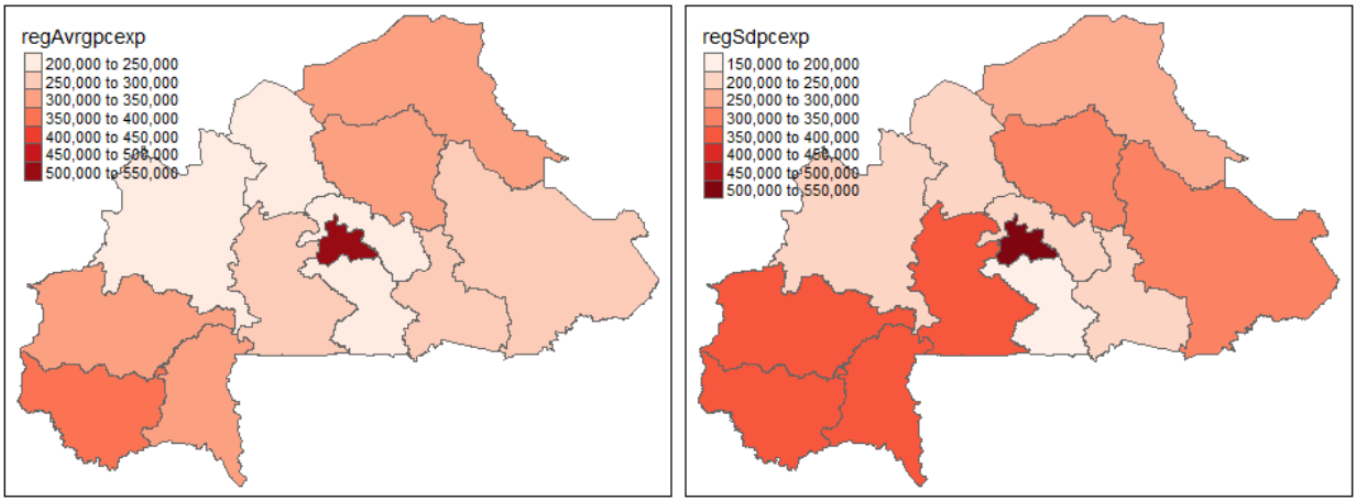

Figure 3: Spatial distribution of the mean (left panel) and standard deviation (right panel) of household real per-capita consumption spending across administrative regions

Assuming households care first about their basic needs in relation to food consumption, before caring about the other relatively less essential needs, then we can define a selection equation characterizing food security, along with an outcome equation characterizing monetary security subject to food security. Together, this gives a bivariate model of food and monetary security and monetary poverty. We later on test whether this assumption is adequate, using the correlation coefficient between the processes describing food security and monetary security in Burkina Faso.

4.2. Independent Variables

Like any scientific study using evidence from observational data, our interests here centers on a postulated causal influence from the attributes and environment of households' to their responses, or per-capita annual spending choices. It's assumed that these spending choices reflect households' food and monetary security statuses. As such, in choosing the variables to be included in the model, the question that needs to be addressed in conjunction with our behavioral model is: In addition to the head of household's education, what other factors affect households spending choices ?

Keeping in mind that the primary goal of this analysis is not to find the determinants of households' food insecurity and monetary poverty in Burkina Faso, but to evidence the role that education plays in reducing household food insecurity and monetary poverty, then our independent

variable of primary interest is the level of education of the head of household. In order to achieve the study goal hoverer we need to account for the effects of the other covariates affecting this relationship (see equations (8, 9, 11))such as socio-demographic covariates (marital status, sex, and age of heads of households). Table (4) provides definitions and summary statistics for all the independent variables in the analysis.

5. Results

The results are presented in two parts, the first part focuses on the descriptive features of the data and welfare measures, while the second part presents the outcome of the econometric estimation.

5.1. Descriptive results and interpretation

5.1.1. The quantitative welfare indicator

The quantitative welfare indicator is captured by household inflation adjusted (real) per-capita consumption expenditure, which unconditional distribution is shown in figure (4). The upper panel of figure (4) shows that in level, the histogram distribution of real per-capita consumption expenditure is right skewed, which suggests a higher concentration Burkina Faso's households at low level of welfare, with fewer households at the higher level. The log transformation of the welfare indicator as shown in the lower panel of figure (4) appears reasonably bell-shaped and symmetrical, hence close to being normally distributed.

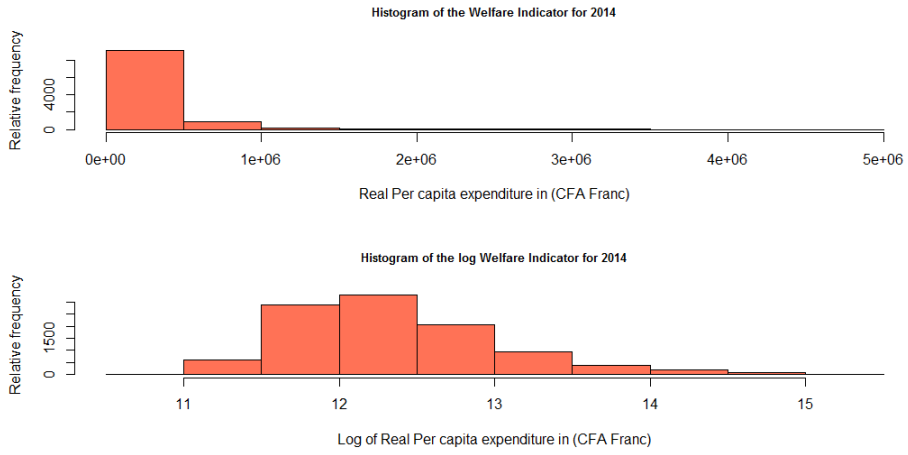

Figure 4: Histogram distribution of real and log real per-capita consumption expenditures

Given our interest on the impact of education on households' welfare, we now turn to the conditional distribution of of real per-capita consumption expenditure. The box-plot representation across levels of education as shown in figure (5), suggests that increased levels of education of households' head is associated with higher level of real per-capita consumption expenditure in Burkina Faso. A result further validated by the quantitative welfare characterizations in table (1).

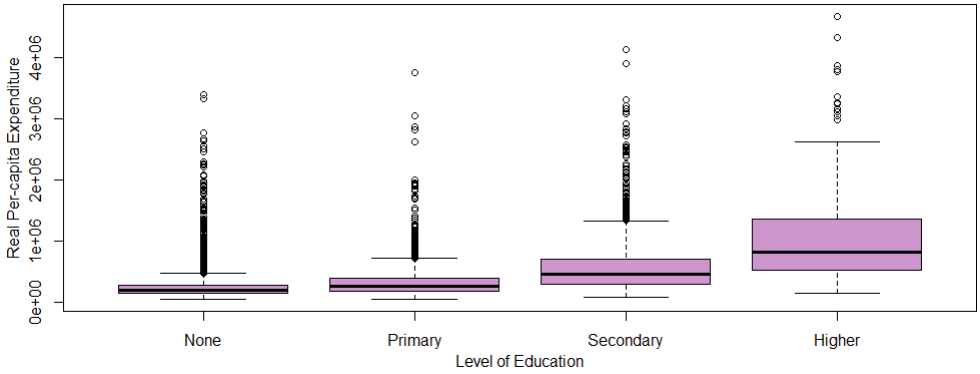

Figure 5: Distribution of welfare by level of education

Table 1: Distribution of the 2014 welfare measure across Education level, and overall

	Education Level				**Overall**
	None	Primary	Secondary	Higher	
N	7782	1273	1087	269	10411
Min	38538.91	50446.18	68540.41	149474.2	38538.91
Q1	133923.07	176019.58	286959.22	515352.3	143664.56
Q2	183513.12	261996.78	456286.16	813986.7	207346.69
Mean	230639.4	344794.2	603314.1	1056351	304842.9
Q3	266378.11	393982.31	708672.91	1363185.5	328577.42
Max	3390547.00	3751827.25	4134306.50	4686805.5	4686805.50

Two important advantages of working with the quantitative welfare indicator, is its ability to characterize the distribution of inequality and poverty in the country. We rely graphically on the Lorenz curves representations, and quantitatively on the Atkinson and Gini coefficients to characterize the level on welfare inequality in the country. The Lorenz curves as shown in figure (6) are computed using the "LC" function in the R library Zeileis (2014), and suggest that the level of inequality in household real-per capita consumption is the smallest among households

with uneducated heads (black curve), followed by the households headed by a higher educated individuals (red curve), then by households headed by a primary educated individual (blue curve), and finally by the households headed by secondary educated individuals that show the highest level of inequality in the country.

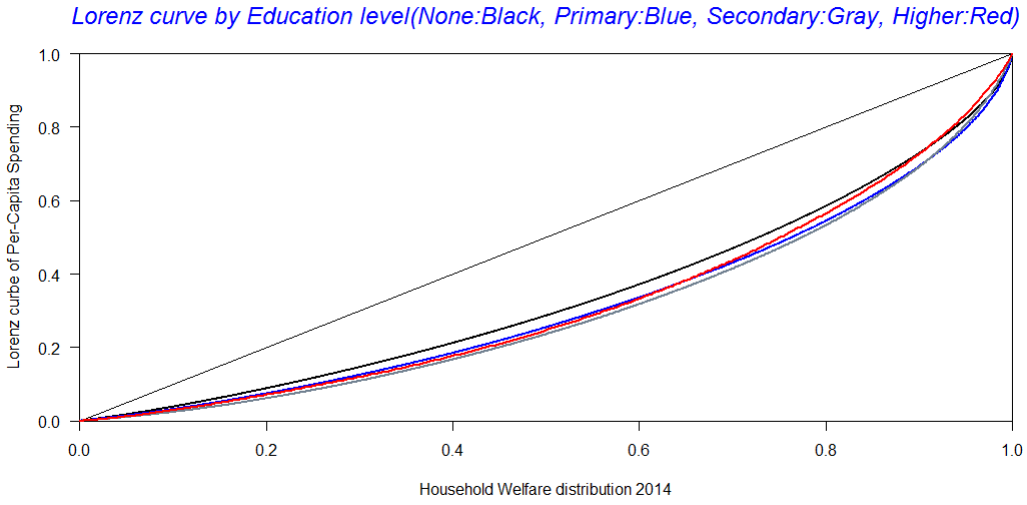

Figure 6: Inequality characterization across education level

The above described graphical results by the Lorenz curves are further supported by the summarized quantitative inequality measures in table (2). In fact, although not as straight forward with the Atkinson coefficient, the Gini coefficient clearly shows its lowest value (32.33%) among the households headed by someone with no formal education, followed by the households headed by a higher educated individuals (36.49%), then by households headed by a primary educated individual (37.47%), and finally by the households headed by secondary educated individuals (39.74%).

Table 2: Inequality measures across education level, and overall

	Education Level				**Overall**
	None	Primary	Secondary	Higher	
Atkinson	8.88 %	11.60 %	12.64 %	12.43 %	14.31 %
Gini	32.33 %	37.47 %	39.74 %	36.49 %	41.41 %

In addition to the above characterization of inequality, we also rely on the "pov" function in the R library "ineq" (Zeileis, 2014) to characterize poverty using the three poverty indices of

Watts, Sen, and Foster (α =1). In doing so, we are able to replicate and extend the empirical methodology in Wanka and Rena (2019), which relies only on the latter of our three measures to describe households' poverty in the South African province of Limpopo. As summarized in table (3), for all three measures, a clear consensus is reached, with the highest values of poverty incidence appearing among households headed by uneducated heads, and decreasing with increasing level of household head educational attainment, down to zero among households with higher educated head.

Table 3: Poverty measures across education level, and overall

	Education Level				**Overall**
	None	Primary	Secondary	Higher	
Watts	5.33 %	2.01 %	0.6 %	0%	8.23 %
Sen	6.20 %	2.39 %	0.7 %	0%	9.20 %
Foster ($\alpha = 1$)	22.91 %	9.74 %	2.67 %	0%	29.56 %

5.1.2. The qualitative welfare indicators

Constructed using the nominal household per-capita consumption expenditures on food and overall consumption, the binary qualitative welfare indicators are assessed in terms of their relationship with the explanatory variables in the econometric model. We first test their association with the nominal explanatory variables using cross-tabulation and chi-square tests.

With our primary interest on the effect of education in reducing household food insecurity and monetary poverty, the null hypothesis of the chi-square test is that both household food insecurity and monetary poverty are independent of the head of household's education level, versus the alternative that they are dependent. The same test is also repeated with the other nominal variables in the model, with results shown in table(5). The p-values for all the tested variables are less than the 5% significance level, suggesting their dependence with the two binary welfare indicators at a 95% confidence level. In addition to the chi-squared test results, table(5) also presents descriptive summary of the study sample.

Focusing on the second column of the table, the descriptive results show that 84.6% of the households experiencing food insecurity in Burkina Faso do not have any formal education, 10.4 % have a primary education, 4.7% a secondary education, and only 0.3% have completed higher education. Similarly, female headed households represent 88.3% of those experiencing food insecurity, against 11.7% for male headed households. In relation to marital status, the greatest share of households experiencing food insecurity in the country is found among households with married heads at 90.1%, followed by those headed by widows at 7.7%, and then by those headed by singles

at 2.1%. Finally in relation to residency status, households in rural areas experience relatively more food insecurity at 72.2%, against 27.8% for those in urban areas.

Focusing now on the third column of table (5), we see that 89.8% of all the households experiencing monetary poverty in Burkina Faso do not have any formal education, 7.8% have primary education, 2.3% a secondary education, and less than 0.1% have higher education. Similarly, female headed households represents 88.5% of those experiencing monetary poverty, against 11.5% for male headed households. In relation to marital status, the greatest share of households experiencing monetary poverty in the country is found among households with married heads at 90.6%, followed by those headed by widows at 7.5%, and then those headed by singles at 1.9%. Finally in relation to residency status, households in rural areas experience more monetary poverty at 79.9%, against 20.1% for those in urban areas. Overall the relative frequency results point out the importance of heads of households educational attainment for both households' food and monetary security in Burkina Faso.

In our quest to test the three hypothesis initially formulated in the introduction, we've specified and estimated three models: (i) a single equation multivariate probit specification with results shown in the second column of table(6), (ii) a single equation multivariate logit specification with results shown in the third column of table(6), and (iii) two bivariate probit (one fully parametric and one semi-parametric) models with results shown in table (8). In the first two specifications (probit and logit) the implicit assumption is that household food and monetary security are described by two independent processes. This assumption is relaxed in the two bivariate specifications so as to test our third formulated hypothesis regarding the independence between these two processes.

5.2. Econometric results and interpretation

5.2.1. The Uni-variate effect of Educational attainment on Food Security

The single equations probit and logit results of the effects of educational attainment on food security are presented in table(6) for the direct effects, and table(7) for the marginal effects and odds ratios. These results allow us to test the first hypothesis (H1), stating " a significant difference between households with formally educated heads and those with uneducated heads in their experience of food insecurity in Burkina Faso". In light of both probit and logit results we fail to reject this null hypothesis, and conclude that the evidence is enough to suggest the existence of a significant difference between households with formally educated heads and those with uneducated heads in their experience of food insecurity in Burkina Faso.

In fact, the results show positive and significant relative effects of primary, secondary, and higher education, compared to no education, in households likelihood of food security in Burkina Faso. These suggest therefore that compared to households headed by someone with no education, those headed by someone with a primary, secondary and higher education are more likely to achieve food security. This higher relative likelihood of achieving food security increases with increasing levels of educational attainment. This observation is validated by both probit and logit representations,

showing its robustness to model specification. The resulting marginal effects, and odds ratio in table(7) further confirm the outcome of the first test of hypothesis.

The marginal effects in the second column under food security show indeed that for households for which the head already has a primary education, a one level increase in the head of household education leads to an 8.3% increase in the household likelihood of achieving food security. This increased probability of achieving food security is 20.2% and 43.1% respectively for households with secondary and higher educated heads. Hence suggesting that education does have positive and increasing marginal effects on the probability of achieving food security in Burkina Faso. The odds ratios in the third column under food security suggest that compared to households where the head has no education, those headed by someone with a primary, secondary, and higher education have respectively 1.40 times, 2.27 times, and 8.17 times more chances of achieving food security in Burkina Faso.

5.2.2. The Uni-variate effect of Educational attainment on Monetary Security

The single equation probit and logit results of the effects of educational attainment on monetary security are presented in table(6) for the direct effects, and table(7) for the marginal effects and odds ratios. These results allow us to test the second hypothesis (H2), stating " a significant difference exists between households with formally educated heads and those with uneducated heads in their experience of monetary poverty in Burkina Faso". In light of both probit and logit results we fail to reject this null hypothesis, and conclude that the evidence is enough to suggest the existence of a significant difference between households with formally educated heads and those with uneducated heads in their experience of monetary security in Burkina Faso.

In fact, the results show positive and significant relative effects of primary, secondary, and higher education, compared to no education, in households likelihood of monetary security in burkina faso. These suggest therefore that compared to households headed by someone with no education, those headed by someone with a primary, secondary or higher education are more likely to achieve monetary security. This higher relative likelihood of achieving monetary security increases with increasing levels of educational attainment. This observation is validated by both probit and logit representations, showing its robustness to model specification. The resulting marginal effects, and odds ratio in table(7) also confirm the outcome of the second test of hypothesis.

The marginal effects in the second column under "monetary security" show indeed that for households for which the head already has a primary education, a one level increase in the head of household education leads to a 12.6% increase in the household likelihood of achieving monetary security. This increased probability of achieving monetary security is 23.3% and 33.7% respectively for households with secondary and higher educated heads. Hence suggesting that education does also have positive and increasing marginal effects on the probability of achieving monetary security in Burkina Faso. The odds ratios in the third column under "monetary security" suggest that compared to households for which the head has no education, those headed by someone with a

primary, secondary, and higher education have respectively 1.87 times, 3.78 times, and 33.73 times more chances of achieving monetary security in Burkina Faso.

5.2.3. The fully-parametric and semi-parametric bi-variate probit results

The bivariate probit (fully parametric in equations (8) and (9) and semi-parametric in equation (11)) specifications relax the implicit assumption by single equation probit and logit models, that household food and monetary security are described by two independent processes. They are therefore intended to test the third formulated hypothesis (H3), stating " the inter-dependence between households' food and monetary security in Burkina Faso".

The results from the bivariate specifications are presented in table(8). They show that the unobserved factors affecting households' average propensity to spend above the food poverty line (or achieving food security), are positively correlated with the unobserved factors affecting the household average propensity to spend above the overall poverty line (or achieving monetary security). This is true for both, the fully parametric specification with $\hat{\theta} = 0.931$, and the semi-parametric bivariate specification with $\hat{\theta} = 0.927$. These $\hat{\theta}$ correlation coefficients are both statistically significant as shown by their respective 95% confidence intervals (0.921, 0.94) and (0.918, 0.937) in table (8). Therefore we fail to reject the null hypothesis (H3), and conclude that the evidence strongly suggest a positive inter-dependence between households' food and monetary security in Burkina Faso.

The outcome of this third hypothesis test, further suggests that the initial implicit independence assumption by the single equation multivariate probit and logit specifications is not valid, as such the bivariate (parametric and semi-parametric) specifications of these two processes can better capture the true effects of heads of households' education on the households' food and monetary security in Burkina Faso. Focusing on the AIC and BIC criterion for the bivariate probit specifications presented in table (8), the semi-parametric model with relatively smaller values of (AIC =18722.06, and BIC = 19024.09) is preferred to the fully parametric specification with (AIC = 19162.41, and BIC = 19314.68). This suggests that relaxing the linearity assumption for the head of household age, and household size variables, in addition to relaxing the independence assumption between food and monetary security, provides for the best model specification among all the presented specifications. Furthermore, for this preferred model, the convergence diagnostic checks for the trust region iteration algorithm (see (Wojtys et al., 2016)) used to identify the parameters of the model, shows satisfactory convergence as the largest absolute gradient value (1.856591e-08) is close to zero, and the observed information matrix is positive definite.

5.2.4. The effects of educational attainment on food and monetary security

Focusing on the semi-parametric bivariate results in the third column of table (8), it can be noted that a head of household educational attainment has positive effects on both household food and monetary security as previously observed with the single equation multivariate probit and logit

specifications. More specifically, compared to households headed by someone with no education, those headed by someone with a primary, secondary or higher education are respectively 19.8% , 49.7% and 1.189 times more likely to achieve food security, and respectively 40.1%, 77.0% and 1.723 times more likely to achieve monetary security. From this, the previous conclusions reached for hypotheses H1 and H2 are once more confirmed. Therefore we can safely conclude that in agreement with human capital theory predictions, the evidence strongly suggests a significant difference between households with formally educated heads and those with uneducated heads in their experience of food insecurity and monetary poverty.

5.2.5. The effects of the other factors on food and monetary security

Although our main aim is to understand the role played by heads of households' education on households' food and monetary security, it's important to note that other factors do significantly affect households' food and monetary security in the country. Focusing on the food security equation in the semi-parametric model, the results presented in the third column of table (8) show that the variables (female and rural) which enter the model parametrically, are statistically significant at the 5% level. In fact, we see that compared to households headed by males, those headed by females have respectively 16.1% and 24.7% less chances of achieving food security and overall monetary security. Similarly, compared to households living in urban areas, those living in rural areas have respectively 38.9% and 63% less chances of achieving food security and overall monetary security.

Now turning to the smoothed terms for the head of household's "age" and household size "hhsize" variables in the food security and monetary security equations of the semi-parametric bivariate probit model, the p-values (< 0.05) and estimated degrees of freedoms (edf) in the third column of table (8) indicate that the age of a head of household, and the household size do have significant impacts on household food and monetary security. As shown by the respective smooth functions estimates and 95% confidence bands in figure(7) for food security and figure(8) for overall monetary security, these effects are fairly convex for age, and concave for household size. These results further suggest that at lower head of household age values(≤ 35), aging contributes to increasing the chances of household food security, however, at higher age values (> 35), aging reduces the chances of household food security. On the other hand, in the reasonable range of household size (≤ 20), an increase in household size by one more member reduces the likelihood of both food and monetary security, as both smooth functions decrease in this size range.

6. Discussions and Conclusion

This paper has concerned itself with analyzing the effects of heads of households educational attainment on households' food and monetary security in Burkina Faso. In its design, the study embraced a more focused and contemporaneous definition of food security which allowed for the

characterization of household level heterogeneity in food and monetary security. Using Random Utility Theory, we explained how education can affect households level per-capita spending choices and thus food and monetary security status.

The results showed that along with factors such as residency status, gender, marital status, and age, a head of household educational attainment is an important determinant of household food and monetary security. Our results are in line with the recent report by Wanka and Rena (2019) in the case of South Africa. The findings also corroborate with the global commitments through the "Education 2030" agenda(Declaration, 2015), while also consistent with human capital theory predictions. This imply that we could possibly decompose the observed effects of education on food security into two types: *(i) A supply side productivity effect*: through which, highly educated family heads by being more productive can achieve greater quantity of food production, and thereby reduce the insecurity linked to food shortage[4]; and *(ii) A demand side purchasing power effect*: trough which families with highly educated heads can benefit from greater purchasing power in terms of real income to acquire food, even under overall food shortage/insecurity.[5]

In addition, the results of the place of residency, and gender although not of direct focus in this study, do signal significant rural-urban divide, and gender-related inequalities in food and monetary security in Burkina Faso. In fact compared to their urban counterparts, rural households are significantly less likely to achieve both food and monetary security. A finding that corroborates with Tarasuk et al. (2019) in Canada; (Pindus and Hafford, 2019) in the United States; Jomaa et al. (2019) in Lebanon; Zhou et al. (2017) in Pakistan; Nkomoki et al. (2019) in Zambia; Roelen and Leon-Himmelstine (2019) in Burundi; Lentz et al. (2019) in Malawi; and Wanka and Rena (2019) South Africa. Similarly for female headed households which compared to their male counterparts, are significantly less likely to achieve both food and monetary security. These later results are indicative of the challenge attached to lower access and educational uptake among young girls, women, and rural households members in the country. The high rate of illiteracy among these groups put them at a higher risk of food insecurity and poverty, as they rely directly or indirectly on agriculture (subsistence farming) for their livelihoods.

The "Agriculture-only model for rural development" seems therefore inadequate for sustainable natural resources management and long-term poverty reduction. Education has to address the

[4]Studies indeed advocate leveraging on this effect to sustainably resolve the global food insecurity crises, since societies may not expand cropland without significant environmental risks (Acevedo, 2011; Acevedo et al., 2018)

[5]These effects are indeed confirmed by the results of a survey of 18 studies for the world bank, and measuring the relationship in low-income countries between farmers' education and their agricultural efficiency (as measured by crop production), which reported an average 8.7% increased productivity for farmers with four years of elementary education compared to those with no education. The effect is even greater (13%) when complementary inputs are available. Furthermore, farmers with more education showed much higher gains in income from the use of new technologies and adjusted more rapidly to technological changes (Gasperini, 2000)

needs of the vast majority of the rural population, who represent a great percentage of the poor, illiterates, and undernourished in the country. Also, there is a need to further strengthen the institutional capacity to support education for rural development and food security. The ministries of education, agriculture, health, and finance will require more awareness and coordinated efforts in targeting the needs of the women and rural populations. This will further require a systemic and inclusive approach involving all stakeholders in the formal and non formal education, at all levels of the educational system in Burkina Faso. An approach also referred to as "Education and Food for All" (Gasperini, 2000) which embraces Education for Rural Development and Food Security (EFRDFS), and places a great emphasis on vocational and technical training and higher education for agriculture and rural development while focusing primarily on the satisfaction of basic learning needs of rural populations.

Additionally the following recommendations could further contribute to reducing the incidence of food insecurity and monetary poverty among households in the country: (i) Making education compulsory and accessible up to the higher education level, while encouraging schooling of children from disadvantaged background through scholarships; (ii) Promoting the adoption of climate smart agricultural practices, which are shown to improve crop and livestock production and farmers' income while reducing greenhouse gas emissions (Teklewold et al., 2019); (iii) Cultivating environmental and food system sustainability in setting national dietary guidance(Rose et al., 2019). Taking into account these recommendations while coordinating efforts between the "Food-for-all" and "Education-for-all" initiatives of the 2015 Sustainable Development Goals should prove effective at moving the country closer to meeting its 2030 sustainable development targets.

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Declaration of interest

None

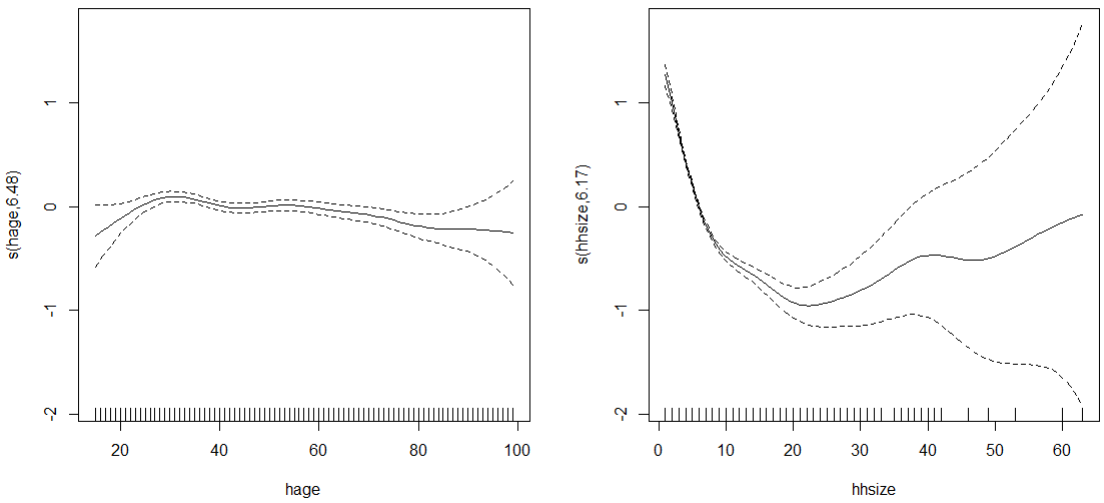

Figure 7: Smooth function estimates and 95% confidence bands for the numerical variables in the food security equation

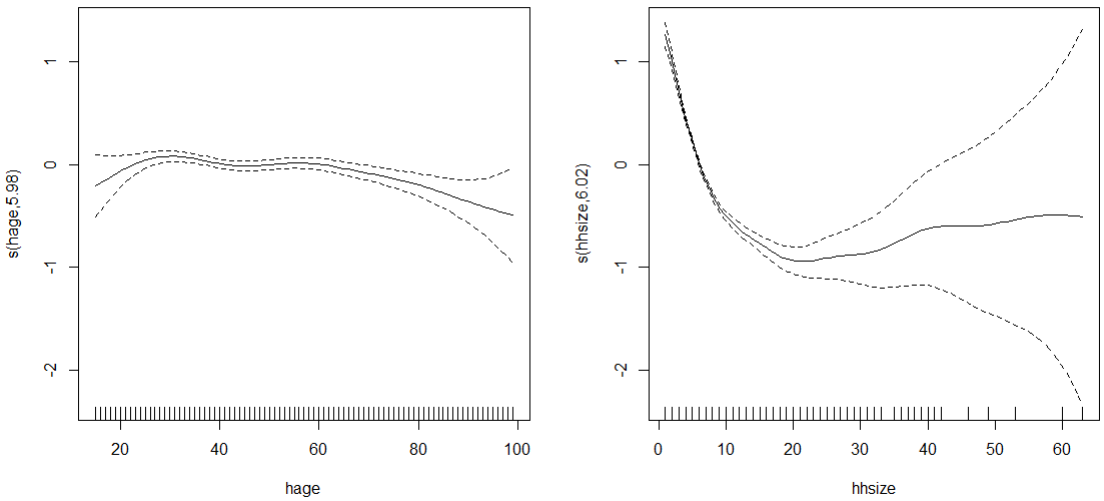

Figure 8: Smooth function estimates and 95% confidence bands for the numerical variables in the monetary security equation

Table 4: Summary Description of the Variables used in the Econometric Modeling

Sample Size	n_{2014}	10,411	
Overall Poverty line	in CFA francs	153,530	
Food Poverty line	in CFA francs	102,040	
		Mean	**sd**
RCapSpendg	Real Per-capita spending in FCA Franc	304842.9	332918.4
CapSpendg	Per-capita overall spending in FCA Franc	273000	309366.8
CapSpendgF	Per-capita spending on food in FCA Franc	137900	164633.5
Hage	age in years of the head of household	46.57	15.52
Hhsize	number of people in the household	7.48	4.97
		Abs. Freq.	**%. Freq.**
Food Poverty Status			
Food Security	= 1 if household experiences food security	4628	44.45
Food Insecurity	= 1 if household experiences food Insecurity	5783	55.55
Monetary Poverty Status			
Monetary Security	= 1 if household experiences monetary security	6330	60.80
Monetary Poverty	= 1 if household experiences monetary poverty	4081	39.20
Education Level			
None	= 1 if head has no education	7782	74.75
Primary	= 1 if head has only a primary education	1273	12.23
Secondary	= 1 if head has only a secondary education	1087	10.44
Higher	= 1 if head has some higher education	269	2.58
Sex			
Female	= 1 if head of household is Female	1389	13.34
Male	= 1 if head of household is Male	9022	86.66
Marital Status			
Single	= 1 if head of household is single	586	5.63
Married	= 1 if head of household is married	9011	86.55
Widow	= 1 if head of household is a widow	814	7.82
Residency Status			
Rural	= 1 if Household lives in Rural area	6408	61.55
Urban	= 1 if Household lives in Urban area	4003	38.45

Source: The National Survey on Household Living Conditions(EICVM, 2014)

Table 5: Chi-Squared test of Independence between the dependent variables and the nominal independent variables

	Food	Poverty	Status (1)	Monetary	Poverty	Status (2)
	Chi^2 stat., df ; p-value	**Food Security**	**Food Insecurity**	Chi^2 stat., df ; p-value	**Monetary Security**	**Monetary Poverty**
Education Level	865.32			901.84		
	3 ; <2.2e-16			3 ; <2.2e-16		
None		62.5	84.6		65.0	89.8
Primary		14.5	10.4		15.1	7.8
Secondary		17.6	4.7		15.7	2.3
Higher		5.4	0.3		4.2	0.0
Sex	28.51			19.594		
	1 ; 9.335e-08			1 ; 9.579e-06		
Female		84.7	88.3		85.5	88.5
Male		15.3	11.7		14.5	11.5
Marital Status	299.71			182.99		
	2 ; <2.2e-16			2 ; 2.2e-16		
Single		10.0	2.1		8.1	1.9
Married		82.1	90.1		83.9	90.6
Widow		7.9	7.7		8.0	7.5
Residency Status	617.75			951.87		
	1 ; <2.2e-16			1 ; <2.2e-16		
Rural		48.3	72.2		49.7	79.9
Urban		51.7	27.8		50.3	20.1

Table 6: Estimates of the Probit and Logit models for Food Security and Monetary Poverty in 2014

	Probit (1)		**Logit (2)**	
	Food Security	Monetary Security	Food Security	Monetary Security
(Intercept)	1.130***	1.521***	1.965***	2.619***
	(0.079)†	(0.089)	(0.135)	(0.158)
primary	0.205***	0.380***	0.333***	0.619***
	(0.041)	(0.044)	(0.067)	(0.075)
secondary	0.538***	0.795***	0.867***	1.390***
	(0.049)	(0.062)	(0.082)	(0.118)
higher	1.256***	1.756***	2.172***	3.630***
	(0.125)	(0.281)	(0.247)	(0.713)
female	-0.041	-0.094	-0.104	-0.189*
	(0.050)	(0.053)	(0.083)	(0.089)
married	-0.286***	- 0.120	-0.413***	-0.205
	(0.068)	(0.079)	(0.117)	(0.142)
widow	-0.347***	- 0.120	-0.545***	-0.224
	(0.088)	(0.099)	(0.149)	(0.171)
rural	-0.367***	-0.600***	-0.603***	-0.999***
	(0.029)	(0.030)	(0.048)	(0.052)
hage	-0.004***	-0.004***	0.006***	-0.007***
	(0.001)	(0.001)	(0.002)	(0.002)
hhsize	-0.096***	-0.085***	-0.186***	-0.155***
	(0.004)	(0.003)	(0.007)	(0.006)
AIC	12099.9	11463.7	12014.6	11432.2
BIC	12172.5	11536.2	12087.1	11504.7
Log Likelihood	-6039.9	-5721.87	-5997.3	-5706.1
Num. obs.	10411	10411	10411	10411

† standard deviation of the parameters in parentheses.

*** Is the 0.01% significance level, ** Is the 1% significance level, *Is the 5% significance level.

Table 7: Marginal Effects and Odds Ratios for the Logit models of Food Security and Monetary Poverty in 2014

	Marginal Effects		**Odds Ratios**	
	Food Security	Monetary Security	Food Security	Monetary Security
primary	0.083***	0.129***	1.395***	1.858***
	(0.017)	(0.014)	(0.094)	(0.140)
secondary	0.213***	0.249***	2.379***	4.013***
	(0.020)	(0.015)	(0.196)	(0.473)
higher	0.448***	0.355***	8.772***	37.714***
	(0.030)	(0.012)	(2.169)	(26.90)
female	-0.025	-0.044*	0.901	0.828*
	(0.020)	(0.021)	(0.075)	(0.074)
married	-0.102***	-0.045	0.662***	0.815
	(0.029)	(0.031)	(0.078)	(0.115)
widow	-0.127***	-0.052	0.580***	0.780
	(0.032)	(0.041)	(0.086)	(0.137)
rural	-0.148***	-0.216***	0.547***	0.368***
	(0.012)	(0.011)	(0.026)	(0.019)
hage	-0.001***	-0.002***	0.994***	0.993***
	(0.001)	(0.001)	(0.002)	(0.002)
hhsize	-0.045***	-0.035***	0.831***	0.857***
	(0.002)	(0.001)	(0.006)	(0.005)

*** Is the 0.01% significance level, ** Is the 1% significance level, *Is the 5% significance level.

† standard deviation of the parameters in parentheses.

Table 8: (Semi)parametric bivariate probit models of Food Security and Monetary Poverty in 2014

	Fully-Parametric Food Security	**Bivariate Model** Monetary Security	**Semi-Parametric** Food Security	**Bivariate Model** Monetary Security
(Intercept)	1.113***	1.598***	0.111***	0.631***
	(0.079)†	(0.089)	(0.077)	(0.119)
primary	0.202***	0.399***	0.198***	0.401***
	(0.041)	(0.044)	(0.042)	(0.045)
secondary	0.544***	1.794***	0.497***	0.770***
	(0.049)	(0.061)	(0.050)	(0.063)
higher	1.256***	1.142***	1.189***	1.723***
	(0.125)	(0.282)	(0.129)	(0.285)
female	-0.050	-0.112*	-0.161**	-0.247***
	(00.051)	(0.053)	(0.052)	(0.055)
married	-0.290***	-0.147	-0.081	0.041
	(0.069)	(0.079)	(0.076)	(0.086)
widow	-0.338***	-0.144	-0.223*	-0.038
	(0.088)	(0.097)	(0.094)	(0.103)
rural	-0.378***	-0.610***	-0.389***	-0.630***
	(0.029)	(0.030)	(0.030)	(0.031)
hage	-0.004***	-0.004***	p-val= 494e-6***	p-val =261e-6***
	(0.001)	(0.001)	(edf = 6.482)	(edf = 5.983)
hhsize	-0.092***	-0.091***	p-val <2e-16***	p-val <2e-16***
	(0.004)	(0.003)	(edf = 6.173)	(edf = 6.018)
$\hat{\tau}$		0.762		0.756
		(0.745,0.777)††		(0.74,0.772)
$\hat{\theta}$		0.931		0.927
		(0.921,0.94)		(0.918,0.937)
AIC		19162.41		18722.06
BIC		19314.68		19024.09

*** Is the 0.01% significance level, ** Is the 1% significance level, *Is the 5% significance level.

† standard deviation of the parameters in parentheses.

†† The 95% confidence intervals on tau and theta

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