

# The Effects of Access to Credit on Household Nutritional Outcomes in Ghana

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# Abstract

This study measures the effects of credit on anthropometric measures of children and women in Ghana's Savannah Accelerated Development Authority (SADA) zone. The study argues that children's anthropometric measures share some relationship and thus need to be modelled as a system. Therefore, we employ the three-stage system of simultaneous equations (reg3) to deal with the structural system and endogeneity of credit in the children's model, and an extended probit with binary endogenous covariate (eprobit) in the women's model. In addition, we test the pathways of credit to nutrition using data from the USAID Ghana Feed the Future (FTF) baseline survey. The results show that credit has a simultaneously strong positive effect on nutritional outcomes of children and reduces the probability of a woman being underweight. Further, crop yield, market participation, income from crop sales, and non-farm business ownership are the key channels through which credit influences nutrition. Through relevant the institutions, the government should establish a full-blown farm credit policy to provide credit to farm households.

**Key Words:** *Credit, Nutrition, Anthropometric measures, Non-separable outcomes, Ghana*

# 1. Introduction

Africa is home to the most nutritionally challenged households in the world. For example, in 2020, two out of five of all stunted children under 5, more than one quarter of all overweight children under 5 and more than one quarter of all wasted children under 5, lived in Africa (UNICEF, WHO and World Bank, 2021). In specific terms, the percentage of stunted children under 5 (30.7%) in Africa is one of the highest in the world. It is the only region where the number of stunted children under 5 has increased – a rise of about 12.9% from 54.4 million children under 5 in 2000 to 61.4 million children under 5 in 2020. Further, there were 12.1 million wasted children under 5 (representing 6.0% of children) in 2020, with 3.0 million severely wasted. Though the prevalence of overweight children under 5 declined from 6.2 per cent in 2000 to 5.3 per cent in 2020, the number of children affected increased from 8.2 million to 10.6 million, respectively.

Africa's nutritional challenges present a paradoxical situation as the continent's economy is driven by agriculture. The question that immediately comes to the fore borders on why nutrition is a challenge given that agriculture is the provider of food resources, which drive nutrition. Perhaps this paradox is the driving force behind the recent calls for a more diagnostic look at the thematic area of the agriculture-nutrition nexus. For example, the Food and Agricultural Organization of the United Nations (FAO, 2013) noted the need for more attention on nutrition-sensitive agricultural policies and interventions as a means of boosting nutritional outcomes.

The fundamental issue that arises from the foregoing is that Africa is an ideal experimental setting for assessing the agriculture-nutrition nexus. As a result, numerous studies have examined specific issues on this thematic area in Africa (see, for e.g., Garrett and Ruel, 1999; Kabubo-Mariara et al., 2008; Habte and Krawinkel, 2016; Amugsi et al., 2017; Ngwira et al., 2017). However, one key area that is fundamentally underexplored in the literature is measuring the impact of agricultural and food policies on nutritional outcomes. The implications of this assessment for rethinking the role of agricultural policies and programmes in boosting nutritional outcomes cannot be overemphasised.

Ghana is noted for its numerous agricultural policies emanating from the Structural Adjustment Programme (SAP) and the Economic Recovery Programme (ERP) that were initiated in the 1980s and 1990s. Notable among these policies is the Food and Agriculture Sector Development Policy (FASDEP) launched in 2002 and later upgraded

to the FASDEP II in 2009. This policy is notable because it is the most nutrition-centred among agricultural policies in Ghana. The policy had a specific objective of achieving food security and emergency preparedness. The basic strategy for achieving this objective was increasing the productivity of basic staples by facilitating access to productive resources such as credit, irrigation and mechanization. Thus, this policy recognized the role of credit in achieving this objective. This measure perfectly complemented the adjacent financial-sector policies that were aimed at liberalizing the sector to enhance accessibility to and usage of financial products and services.

The vision of the policy was that enhancing access to finance would ease liquidity constraints of farm households and afford them the capacity to demand agro-inputs to boost productivity, production and incomes, and thus improve food security and nutritional outcomes. After its implementation, a formal empirical evaluation of the FASDEP's credit pathway to improving nutritional outcomes has not been conducted. The motivation of this paper thus stems from the objective of delivering scientific evidence to contribute to policy formulation on the one hand and the existing literature on the other. Specifically, this paper aims to:

1. Estimate the effect of access to credit by households on nutritional outcomes of children and women.
2. Identify and test the channels through which credit affects nutritional outcomes.

The justification for focussing on women and children is based on the fact that they are the common victims of nutritional challenges (Malapit and Quisumbing, 2015). We use conventional and well-established anthropometric measures of stunting, wasting and underweight as proxies of nutritional outcomes of children and body mass index (BMI) as a proxy of women's nutritional outcome. The underlying hypothesis is that access to credit by households boosts nutritional outcomes of children (i.e., reduces stunting, wasting and underweight) and women (i.e., appropriate mass index).

The paper makes three key contributions to the literature. First, it extends previous studies by arguing that nutritional outcomes of stunting, wasting and underweight are non-separable and that estimating them in standalone models would lead to biased and inconsistent estimates. To the best of our knowledge, this is the first attempt at modelling nutritional outcomes through a structural system of equations. The gains of this methodological approach are non-trivial: unbiased, efficient and consistent estimates. Second, the paper uses unique nutritional data. The advantage of this data over data such as the Ghana Demographic and Health Surveys (DHS) and the Ghana Living Standards Surveys (GLSS) is its two-pronged specificity: thematically specific to nutrition and geographically specific to the hotspots of nutritional challenges in Ghana. A further benefit of its specificity is the availability of appropriate nutrition characteristics that prevent constructing "doubtful" proxies. Therefore, exploiting this data in line with the objective of this study is not only novel, but also empirically advantageous.

Third, this paper represents one of few country-level attempts at exploring the effect of credit on nutritional outcomes. To the best of our knowledge, only Malapit and Quisumbing (2015) explored the relationship between empowering women in agriculture and nutritional outcomes. The main weakness of this study is the application of the ordinary least squares method, which at best could estimate an association between credit and nutritional outcomes but not a causal effect. This paper builds on Malapit and Quisumbing (2015) by using more advanced econometric techniques. Other studies on nutrition in Ghana have explored the generic drivers of nutrition and not credit policy in particular. Notable studies in this regard include Darteh et al. (2014), Aheto et al. (2015), Aheto et al. (2017), Ali et al. (2017) and Atsu et al. (2017).

The observation of a high degree of diversity and heterogeneity of African economies (Beck et al., 2015) warrants country experimental case studies. In light of this, Ghana represents a unique setting for experimentation of the agriculture-nutrition nexus. The second and most important rationale for the Ghana case study is the availability of a rich and unique agricultural and nutritional outcomes dataset collected in the most nutritionally challenged part of Ghana, the Savannah Accelerated Development Authority (SADA) region. This dataset is the product of the Feed the Future (FTF) initiative launched in 2010 by the United States of America. Ghana is one of the initiative's 12 focus countries in Africa, and given that the FTF is mandated to tackle the "root causes of hunger and poverty through the transformation of agricultural production and improvement in health and nutrition", Ghana's inclusion lends credence to the argument of it being an ideal setting for experiments on the effect of agricultural policies on nutrition outcomes. Crucially, an exercise to assess whether incorporating access to credit into agricultural policies is yielding the required benefits at the microlevel in terms of boosting household nutritional outcomes is a vital policy ingredient.

The rest of the paper is organised as follows. The next section presents a description of the country context. Section 3 gives a brief literature survey on the credit-nutrition linkage and the effect pathways. Section 4 describes the data and conceptual framework, as well as the econometric model. In section 5 we present and discuss the results of the effect of credit policy on the nutritional status of women and children and the associated channels of effect. Section 6 presents the conclusion and policy implications.

## 2. Country context

Ghana has made great progress with poverty reduction as evidenced by the fact that 9 years before the 2015 deadline for meeting the Millennium Development Goal (MDG) of halving extreme poverty, Ghana had already achieved this target, reducing poverty from 36.5 per cent in 1991 to 18.2 per cent in 2006. The same success is not seen in terms of nutrition and health-related issues. The Ministry of Health (MoH, 2013) notes that despite an improvement in the health sector, poor nutrition persists. Minimal progress has been made in achieving health-related MDGs (Zereyesus et al., 2014). For example, child and maternal health challenges have not been minimised in appreciable proportions; critical food security and nutrition challenges persist (Zereyesus et al., 2014). Nutritional challenges such as undernutrition in children under 5, micronutrient deficiencies among women and children, suboptimal infant and young child feeding (IYCF), and increasing rates of obesity and nutrition-related non-communicable diseases (NCDs) are pervasive (MoH, 2013). Data from the Ghana Statistical Service [GSS] (2018) indicate that undernutrition, manifesting itself in the form of stunting, affects 17.5 per cent of children under 5 while 4.8 per cent are severely stunted. Further, 12.6 per cent of children under 5 are underweight while 2.4 per cent are severely underweight. In terms of wasting, 6.8 per cent of children under 5 are wasted while 1.1 per cent are severely wasted. Overweight children under 5 are 1.4 per cent, with 0.3 per cent severely affected. Micronutrient deficiencies among women and children is a major public health challenge (MoH, 2013).

The SADA zone has become an important area for this study because of the significant disparity in nutrition indicators between it and the entire country. Table 1 shows that the SADA zone is worse off than the country average in terms of nutritional indicators for children (stunting, wasting and underweight) and women (underweight). For example, while the percentage of stunted children in Ghana is 17.5 per cent, in the SADA zone, it is a staggering 36.1 per cent. Also, while only 9.0 per cent of women in Ghana are underweight, 12 per cent of women in the SADA enclave are underweight. These bleak nutritional statistics point to the need to focus on the SADA zone in terms of research and policy.

**Table 1: Nutritional indicators: Ghana versus SADA zone**

Indicator	Ghana	SADA
Per cent of stunted children	17.5	36.1
Per cent of wasted children	6.8	11.0
Per cent of underweight children	12.6	18.4
Per cent of underweight women	9.0	12.0

Sources: GSS (2018); Zereyesus et al. (2014).

Another worrisome situation is the disproportionate nature of nutritional problems, with the northern part of Ghana, comprising the Northern, Upper East and Upper West regions, the hardest hit (see World Food Programme, WFP, 2009; GSS, 2018; Zereyesus et al., 2014). As an example, stunting is highest in the Upper East and Northern regions, while anaemia is highest in the Upper West and Upper East regions relative to the other regions in Ghana (Zereyesus et al., 2014). According to Zereyesus et al. (2014), stunting, wasting and micronutrient deficiencies are so severe in the SADA region that they have become public health threats. The FAO (2009) associates the causes of undernutrition to issues of food insecurity, inadequate feeding practices, lack of dietary diversity, and minimal access to health services. For example, the SADA region is the poorest and the most deprived in Ghana, with poverty almost twice that of the south (Zereyesus et al., 2014; GSS, 2019). In addition, the SADA regions have the lowest annual household expenditures and per capita expenditures, as well as the highest proportions of households in the lowest expenditure quintile (GSS, 2019).

Apart from nutrition-centred agricultural policies, development and health policies have sought to address nutritional constraints. For example, the Ghana Shared Growth and Development Agenda (GSGDA) and Ghana Vision 2020 recognized food security and nutrition as pillars for boosting human development. Ghana signed up for the Scaling Up Nutrition (SUN) initiative in 2011 to gain the benefits associated with its mandate of improving nutrition. Under this initiative, Ghana pledged to increase nutrition funding, prioritise nutrition and improve the measurement of nutrition indicators. Further, the school feeding programme established in 2005 was another development-oriented policy with a focus on nutrition. The programme was meant to improve children's nutritional and health status by providing one nutritious meal per day for all school children aged 4–12 years.

Healthwise, Ghana boasts a legion of policies and interventions on nutrition. Policies such as the Health Sector Medium Term Development Plan 2010, the National Health Policy 2007 and Child Health Policy 2007 have mandates to improve nutritional outcomes. Notable interventions include iron and folic acid supplementation, Essential Nutrition Actions (ENA), integrated maternal and childcare, Community-Based Management of Acute Malnutrition (CMAM), a Supplementary Feeding and Nutrition Education Programme (SF&NEP), regenerative health and nutrition, nutrition behaviour change communication and National Child Health Days Campaign.

Several donor-funded interventions have also contributed to nutrition. For example, USAID established interventions such as Health Systems Strengthening (HSS), Resiliency in Northern Ghana (RING) and Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING). Perhaps the most notable action towards nutrition enhancement is the National Nutrition Policy (NNP) that was launched in 2013 with the goals to provide a framework for delivering nutrition-specific and nutrition-sensitive services to achieve optimal nutrition and health for people; bolster capacity for sustainable economic growth and development; and to ensure the integration and mainstreaming of nutrition into all national development efforts (MoH, 2013). This policy was developed due to the deficiencies in earlier policies and their implementation.

### 3. Brief review of related studies

Doocy et al. (2005) examined the impact of a credit programme on nutritional outcomes in Ethiopia using a sample of 819 households. The study compared the nutritional status of established clients and their families to those of incoming clients and community controls. The results from analysis of variance (ANOVA) models showed that women clients and their children had superior nutrition status (in respect of malnutrition, acute malnutrition and food insecurity) to the comparison groups. Furthermore, the households of female clients had better food security than the households of male clients. This study points towards the likelihood that well-designed credit policies could help alleviate malnutrition and food insecurity. However, because the ANOVA analysis only shows correlation and not causation, the findings of this study have limited value for policymaking. Based on the Bangladesh Household Income and Expenditure Survey of 2010 and a supplementary primary survey of 1,200 households, Bidisha et al. (2017) investigated the impact of different credit sources on food security and dietary diversity in Bangladesh. After controlling for sample selection and endogeneity, the results showed that households with access to credit from formal sources, informal sources and microfinance companies had better food security and dietary diversity scores than their counterparts without access to credit. In the authors' view, credit improves nutritional outcomes through the income pathway. The main limitation of this study is that the consumption of a diverse diet does not necessarily guarantee good nutrition.

In another study in Bangladesh, Islam et al. (2016) examined the effects of microcredit on a wide range of food security indicators covering food poverty, calorie intake, dietary diversity and anthropometric measures for women and children. Three main findings emerged from this panel study. First, participation in credit programmes and loan amount improve calorie intake and reduce food poverty, but participation does not improve dietary diversity. Second, the impact of credit on anthropometric indicators is inconclusive. While microcredit programme participation reduces stunting in children under 5 years, the impact of participation on wasting and underweight for children under 5 is weak and mixed. Again, while participation reduces the incidence of being underweight among women, it has no impact on women's body mass index (BMI). Third, the impact of credit participation on food security is non-linear. That is, microcredit participation may not significantly impact food poverty and calorie consumption in the short run, but in the long run, the impact is significant.

Further, Islam et al. (2016) postulated three main channels through which access to microcredit could impact nutrition: investment, insurance and financial literacy, and nutrition education. Their first argument is that credit promotes investment by poor households, leading to increases in income, consumption, and wealth. Second, microcredit provides insurance for households by increasing their capacity to cope with the risk and uncertainty associated with agriculture and life. Third, microfinance programmes often have educational components which sensitize clients to financial prudence, food security and nutrition. However, Islam et al. (2016) did not test the efficacy of the channels outlined above. Again, the fixed-effect model adopted by Islam et al. (2016) does not adequately address the endogenous nature of credit and other variables. We build on this study by identifying and testing the channels through which credit policies affect nutrition.

In a study covering the northern part of Ghana (the same catchment as the present study), Malapit and Quisumbing (2015) found that women empowerment strongly influences infant and young child feeding quality, but only weakly affects child nutrition. Another interesting finding is that women empowerment in credit decisions positively affects their dietary diversity, but not their BMI. These findings suggest that women empowerment does not have a wholesale impact on dietary diversity and nutritional outcomes but that it drives specific indicators. In an earlier study of Nepal by Malapit et al. (2013), it was revealed that women empowerment had a significant influence on nutritional outcomes of mothers and their children except for women's BMI. It is often believed that an improvement in women's nutrition will result in better nutritional outcomes for their children. The empirical evidence on this is mixed. For example, Headey et al. (2012) found that while mothers' BMI affects stunting among children, mothers' BMI had no significant impact on the incidence of underweight among children.

In a literature review study covering South Asia, Pandey et al. (2016) sought to examine the channels through which agricultural interventions impacted nutrition on the continent. They found that growing targeted nutrition-rich crops, backyard gardens, and agricultural diversification towards aquaculture, fruits and vegetables improve the nutritional outcomes of farm households. Women empowerment and nutrition education were found to boost nutrition.

A study conducted by Parasuraman and Rajaretnam (2011) based on Indian data revealed the impact of income on nutrition. The study showed that increases in expenditure on food reduced the incidence of under-nutrition among children, adolescents and married women. Wadud (2013) found that credit improved the efficiency, output and income of farmers in Bangladesh. Other researchers identified productivity (Weinberger, 2005; Kiresur et al., 2010) and consumption (Weinberger, 2005; Kiresur et al., 2010; Murshed-E-Jahan and Pemsal, 2011; Yu, 2012) as important pathways through which agriculture impacts nutrition.

Our study builds on the above contributions by investigating the potential impact of credit policy on the nutritional outcome of women and children using robust econometric techniques that address the non-separable nature of nutritional outcomes as well as the endogenous nature of credit, among other variables. Building on these initial results, our study tests the channels through which credit impacts nutrition.

## 4. Methodology and data

### Conceptual and theoretical considerations

Based on the main objective of estimating the effect of credit on nutritional outcomes, the two variables, access to credit and nutritional outcome, need to be appropriately conceptualized. Access to credit (credit policy) is the treatment variable. We used farmers' access to credit from the formal credit market as a proxy for credit flowing from the FASDEP II credit initiative. An advantage of this approach is that evidence of a positive effect of credit on nutritional outcomes would be a key message for policymakers to prioritize a strategy of developing an agricultural credit policy. Government extends credit to farmers mainly through banks and other formal financial institutions. Access to credit is conceptualised as households who applied and secured credit from formal credit sources. This implies that access to credit is a discrete outcome comprising two indicators, 0 and 1, representing households that did not receive credit and households that received credit, respectively.

The outcome variable is nutritional outcome, which is conceptualised for children as three distinct anthropometric measures: stunting, underweight and wasting. The literature conceptualizes stunting as height-for-age (H/A) and measures it by its z-score (see, for e.g., Kabubo-Mariara et al., 2008; Zereyesus et al., 2014); underweight as weight-for-age (W/A) with its z-score as a measure (see, for e.g., Zereyesus et al., 2014; Darteh et al., 2014); and wasting as weight-for-height (W/H) with its z-score as a measure (see, for e.g., Zereyesus et al., 2014; Darteh et al., 2014). The three anthropometric measures are continuous variables.

The z-score,  $Z_{ij}$ , for the  $i^{th}$  indicator for the  $j^{th}$  child is computed as:

$$Z_{ij} = \frac{V_{ij} - V_{Mi}}{\sigma_{Mi}} \quad (1)$$

where  $V_{ij}$  represents the observed value of the  $i^{th}$  indicator for the  $j^{th}$  child, and  $V_{Mi}$  and  $\sigma_{Mi}$ , respectively, represent the median and standard deviation of the  $i^{th}$  indicator in the reference population. WHO Anthro software (WHO, 2011) was used to compute the z-scores for the stunting (HAZ), underweight (WAZ) and wasting (WHZ) indicators. These estimates are used to indicate prevalence rates. A child with HAZ, WAZ and WHZ less than -2 z-scores but greater than or equal to -3 z-scores is

considered moderately stunted, underweight and wasted, respectively. Severe cases are when the z-scores are less than -3 z-scores. For women, the nutritional outcome is conceptualised as BMI. The BMI is computed as:

$$BMI = \frac{W}{H^2} \quad (2)$$

where  $W$  is weight measured in kilograms and  $H$  is height measured in meters. On the basis of this estimate, women are classified as underweight:  $BMI < 18.5 \text{ kg/m}^2$ ; normal:  $18.5 \text{ kg/m}^2 \leq BMI \leq 24.99 \text{ kg/m}^2$ ; overweight:  $25.00 \text{ kg/m}^2 \leq BMI \leq 30.00 \text{ kg/m}^2$ ; and obese:  $BMI > 30.00 \text{ kg/m}^2$ .

The underlying pathways through which credit influences nutrition is summarised in Figure 1. Figure 1 indicates that access to credit eases farmers' liquidity constraints (see, for e.g., Feder et al., 1990). This offers them the opportunity to invest in either farm or non-farm enterprises<sup>1</sup>.

Investments in farm enterprises involve adopting technology which potentially leads to increases in production and productivity (see Duong and Izumida, 2002; Lawal et al., 2009). Productivity and output growth offer households the opportunity to consume their own produce and still raise enough marketable surplus to participate in the market to raise income. Income from crop sales can be used to meet household consumption expenditures such as purchasing quality and nutritious foods to supplement their own consumption. This assertion corresponds to the Ricardian trade theory, which postulates that farmers sell their produce to gain some utility by concentrating on the production of comparatively advantageous crops in exchange for products that have no comparative advantage (see Ricardo, 1817). The combined effect of own consumption and purchased nutritious products improves the nutrition of households, specifically by reducing stunting, wasting and underweight in children, and BMI in women.

Investing credit in non-farm enterprises (e.g., agro-processing, retail shops and services) generates income, which aids in the purchase of nutritious products from the open market and improves nutrition. Further, liquidity from credit could be invested in expenditure on nutritious foods and, subsequently, improve nutrition.

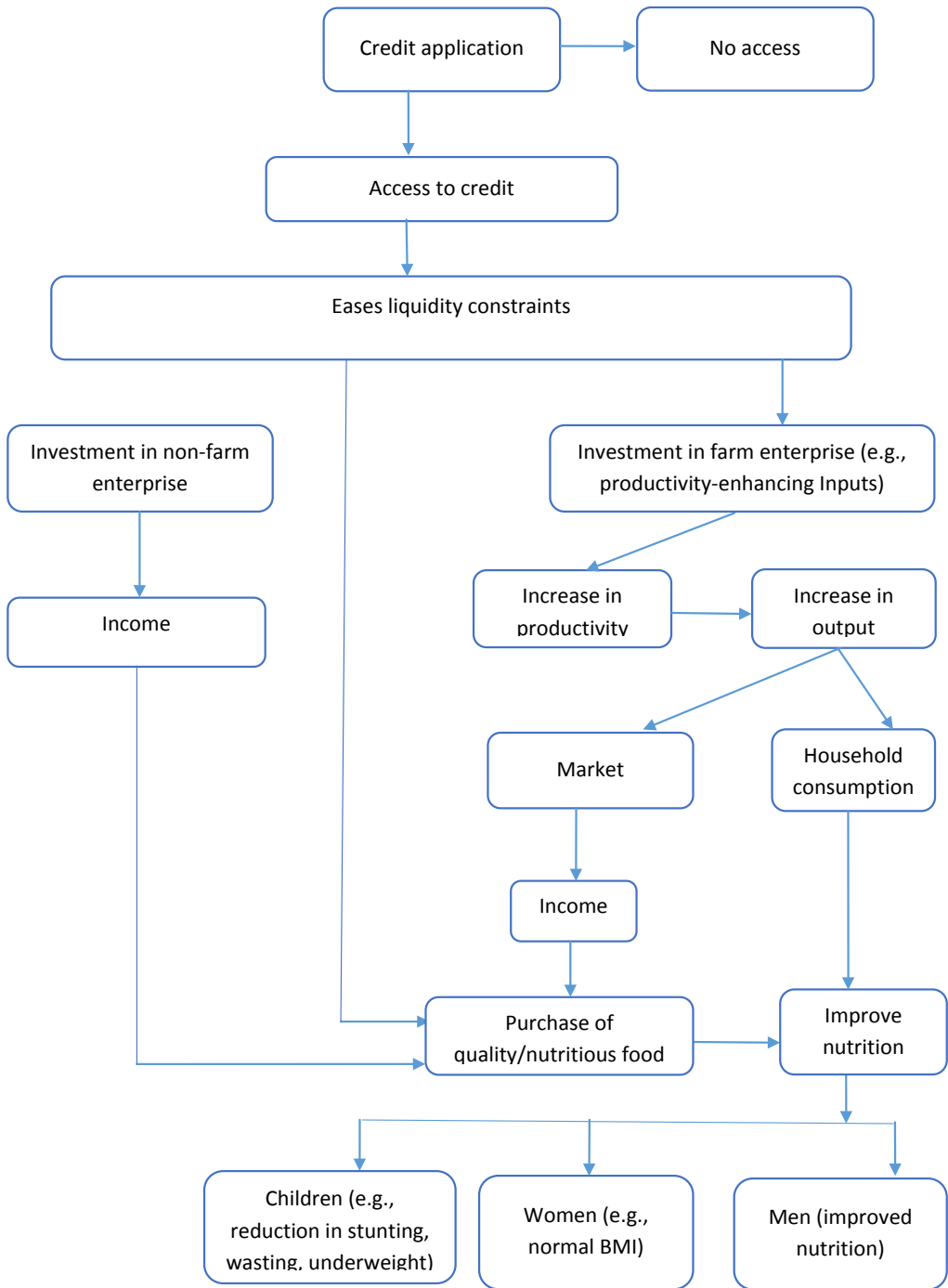
On the basis of the anthropometric outcomes, this study seeks to test the following hypotheses:

*H1: Access to credit by farm households reduces stunting, wasting and underweight in children.*

*H2: Access to credit by farm households improves BMI in women.*

*H3: Credit influences nutritional outcomes through productivity, market participation, income from crop sales and ownership of non-farm business equipment.*

**Figure 1: Pathways of credit to nutrition**



Theoretically, nutritional outcomes (in this case, stunting, wasting, underweight and BMI) are treated under production theory where these outcomes are taken as outputs flowing from a production function (see Behrman and Deolalikar, 1988; Strauss and Thomas, 1995; Garrett and Ruel, 1999) and imply that a specific technology maps some inputs to these outcomes. Thus, we can mathematically represent the output (nutritional outcomes) of a household,  $NO_{ij}$ , and a set of household inputs,  $X_i$ , in a typical nutrition production function as:

$$NO_{ij} = f(X_i) \quad (3)$$

where this typical nutrition production function is derived from a maximization of a household utility function from first principles,  $i$  represents a household, and  $j$  represents the specific outcome (i.e.,  $j = 1, 2, 3$  for children and  $j = 1$  for women). Generally, various proxies of social, economic, locational and biological characteristics (see Garrett and Ruel, 1999) can be used to represent the arguments in Equation 3.

This implies that the nutrition function for children and women on the basis of Equation 3 can be presented as:

$$NO_{ij}^c = f(CC_i, WC_i, HC_i) \quad (4)$$

$$NO_i^w = f(WC_i, HC_i) \quad (5)$$

where  $CC_i$ ,  $WC_i$  and  $HC_i$  define vectors of child, woman and household characteristics, respectively. However, taking the hypothesis underlying this study into consideration, we need to include among the arguments in Equations 4 and 5 a household credit indicator (policy) variable,  $CRED_i$ . Therefore, Equations 4 and 5 are written as:

$$NO_{ij}^c = f(CC_i, WC_i, HC_i, CRED_i) \quad (6)$$

$$NO_i^w = f(WC_i, HC_i, CRED_i) \quad (7)$$

Equations 6 and 7 represent the basic theoretical functions this paper seeks to model.

## Econometric specifications and estimation

A notable implication of Equations 6 and 7 is that appropriate proxies of  $CC_i$ ,  $WC_i$  and  $HC_i$  serve as control factors for an unbiased and consistent effect of  $CRED_i$  to be estimated. The choice of explanatory variables for this study is influenced by the literature and available data. UNICEF (1991) identifies three key input factors: meal frequency, the quantity of food per meal, and energy and nutrient density of food. As we do not have these specific variables, we proxy them using some household

characteristic variables that measure caloric intake such as annual per capita food expenditure, number of crops cultivated, ownership of animals and dietary diversity.

Following the theoretical models in Equations 6 and 7, the empirical models to be estimated are:

$$NO_{ij}^c = \delta_0 + \delta_1 CC_{ij} + \delta_2 WC_{ij} + \delta_3 HC_{ij} + \delta_4 CRED_{ij} + \varepsilon_{ij} \quad (8)$$

$$NO_i^w = \eta_0 + \eta_1 WC_i + \eta_2 HC_i + \eta_3 CRED_i + \epsilon_i \quad (9)$$

where  $NO_{ij}^c$  is children nutrition outcomes proxied by anthropometric measures of HAZ, WAZ and WHZ,  $NO_i^w$  is women's nutritional outcome proxied by BMI, CC, WC, HC, CRED is as defined before,  $\delta_0, \delta_1, \delta_2, \delta_3, \delta_4, \eta_0, \eta_1, \eta_2$  and  $\eta_3$  are the parameters to be estimated, and  $\varepsilon_{ij}$  and  $\epsilon_i$  are the stochastic error terms. The parameters of interest are  $\delta_4$  and  $\eta_3$  as they capture the effect of credit policy on nutritional outcomes.

However, two notable issues can constrain the unbiased estimate of the effect of  $CRED_i$  even if the relevant control factors are included. First,  $CRED_i$  is potentially endogenous to  $NO_{ij}^c$  and  $NO_i^w$ . Unobserved factors that determine access to credit may also determine children and women's nutritional outcomes. Ignoring this potential endogeneity would bias the effect. Second, the three outcomes of children (stunting, wasting and underweight) do have a relationship. Although the literature is inconclusive on the relationship among these indicators (Richard et al., 2012a), we find ample evidence on the type and nature of association that these outcomes share (see, for e.g., Doherty et al., 2001; Dewey et al., 2005; Richard et al., 2012b; Prentice et al., 2013; Ngwira et al., 2017). Guided by the evidence of this association, modelling the children nutritional outcomes as separate standalone models may lead to a biased effect. These two issues imply that an appropriate econometric model must make provision to resolve endogeneity for children and women models, and deal with non-separability for the children model. The well-known impact evaluation estimation techniques, such as propensity score matching and difference-in-differences, are not applicable in this case.

For the children model (Equation 8), we propose constructing a three-stage estimation for systems of simultaneous equations (*reg3*) model. This model estimates a system of structural equations that permits the inclusion of endogenous explanatory variable(s), with estimation through a three-stage least squares (3SLS) model. The structural equation system component of the model deals with the second econometric issue (non-separability of outcomes), and the endogenous explanatory variable(s) component deals with the first econometric issue (endogeneity of credit access). Essentially, *reg3* follows an instrumental variable (IV) approach, and this introduces another confounding challenge as the success of an IV estimation relies on the reliability and validity of instruments. The dataset has a variable on membership of a household in credit and microfinance group that can potentially serve as an instrument. However, this variable is likely to be correlated with other variables in the model. We rely on an approach used by Strauss (1986) and Mwabu (2009) to construct

a cluster-level variable from the membership variable to be used as an instrument. This cluster-level instrument is the proportion of households in a cluster who are credit group members. The argument for the exogeneity of this instrument is that a typical household does not have any influence on the number of households in a cluster who belong to credit groups. Therefore, by implication, this instrument affects access to credit directly but is orthogonal to nutritional outcomes.

The first stage of the reg3 model is to obtain estimates of the regression:

$$CRED_i = \phi_0 + \phi_1 WC_i + \phi_2 HC_i + \phi_3 CRDGR_i + \psi_i \quad (10)$$

Where  $CRDGR_i$  is the instrument (cluster-level proportion of households in a credit group). From the regression in Equation 10, predicted values,  $\widehat{CRED}_i$  are obtained. The second stage is the internal estimation of the covariance matrix of the equation disturbances from the residuals of 2SLS estimates of each of the four equations in the system. This stage differentiates 3SLS from 2SLS where the purpose of this estimation is to improve the efficiency of the three-stage estimator. The third stage is the application of a generalized least squares (GLS) estimator (see Aitken, 1935)<sup>2</sup> using the covariance matrix and the instrumented values to derive the estimates of the parameters of the system:

$$NO_{ij}^c = \delta_0 + \delta_1 CC_{ij} + \delta_2 WC_{ij} + \delta_3 HC_{ij} + \delta_4 \widehat{CRED}_i + \varepsilon_{ij} \quad (11)$$

In Equation 11,  $\delta_4$  is the unbiased and consistent estimate of the effect of credit on child nutritional outcomes.

For the women empirical model in Equation 9, a model that considers the quantitative nature of BMI would not be appropriate given the categorization of BMI into discrete classes. For example, if a quantitative model predicts a positive effect of credit on BMI, it would imply credit increases BMI, but this increase could move a woman from underweight to normal (an expected outcome); from normal to overweight (an unexpected outcome); or from overweight to obese (an unexpected outcome). Based on this, we developed two binary sub-samples: underweight versus normal, and overweight versus normal, and applied an extended probit<sup>3</sup> (eprobit) that permits the modelling of an endogenous binary covariate (credit). The eprobit is considered over the binary probit because it can account for possible endogeneity of credit and BMI through the simultaneous modelling of BMI and credit equations yielding an unbiased estimate of the effect of credit.

For the second objective, the conceptual model (Figure 1) shows a number of potential channels through which credit affects nutritional outcomes. The available data provide the opportunity to evaluate four of these channels: productivity, market participation, income from crop sale and ownership of non-farm business equipment. The model posits that credit would increase productivity, guarantee market engagement and thus income from crop sales, and boost investment in non-farm enterprise. These four channels would be estimated with credit as an

explanatory variable to test the transmission mechanism of credit empirically. As market participation and ownership of non-farm business equipment are dummy variables (see Table 2 for measurement of these variables), extended probits (eprobits) that permits the modelling of endogenous covariate (credit) models are estimated to account for possible endogeneity of credit and these variables. For productivity and crop sale income, a linear regression that permits the modelling of an endogenous covariate is applied to account for the endogeneity of credit and these variables. In these models, the statistical significance of the credit variable would imply that credit does work through them and would therefore validate the conceptual model.

## Data

This study used the USAID Ghana Feed the Future (FTF) baseline survey data. Broadly, the FTF seeks to aid developing economies in fixing the root causes of hunger and poverty through the transformation of agricultural production and improvement in health and nutrition. In Ghana specifically, the initiative began in mid-2011 with the aim of increasing competitiveness in the production of maize, rice and soya, to improve the resilience of vulnerable households and communities, and to reduce undernutrition and improve the nutritional status of women and children. The data were first collected in 2012 in the SADA region comprising Northern, Upper West, Upper East, Northern Volta and Brong Ahafo by Monitoring Evaluation and Technical Support Services (METSS) with support from Kansas State University, University of Cape Coast, the Institute of Statistical, Social and Economic Research at the University of Ghana and the GSS.

The SADA region covers a land area of 123,141 square kilometres, representing about 52% of the total land area in Ghana (see Figure A1 in the Appendix). It houses 61 administrative districts: all the 26 districts in the Northern region, 9 districts of the 29 districts in the Brong Ahafo region, all the 15 districts in the Upper East region and all the 11 districts in the Upper West region. The total population of the area in 2010 was 4,933,838 million, accounting for about 20 per cent of Ghana's population (GSS, 2012). Agriculture is the region's mainstay, accounting for over 80% of economic activity. The justification for concentrating on the SADA areas for this study was based on the realization that poverty, malnutrition, and stunting among children under five years were high, so that by concentrating efforts in these areas, actions could be taken to tackle the situation. Therefore, the main goal of the survey was to obtain baseline data on key variables of interest such as poverty, expenditures, nutritional outcomes (such as dietary diversity and feeding behaviours), food security status (using the hunger scale), women empowerment, and agricultural production and access to productive resources such as credit.

A total of 4,410 households were interviewed across the zone, including 3,361 children (0–59 months) and 4,513 women (15–49 years). However, after merging the data from the various modules, the final sample was 2,085 households comprising 3,179 children (0–59 months) and women (15–49 years). The specific variables used in the analysis are presented in Table 2.

**Table 2: Description and measurements of variables**

<b>Description</b>	<b>Measurement</b>
<b><i>Outcome and treatment characteristics</i></b>	
Height-for-age z-score (H/A)	H/A z-score
Weight-for-age z-score (W/A)	W/A z-score
Weight-for-height z-score (W/H)	W/H z-score
Body Mass Index (BMI)	Kilograms per meter-squared
Access to formal credit	Dummy: 1 = if received formal credit; 0 = otherwise
<b><i>Household characteristics</i></b>	
Age of head	Number of years
Male head	Dummy: 1 = if yes; 0 = otherwise
Household size	Number of people in household
Head can read and write in English	Dummy: 1 = if yes; 0 = otherwise
Area of residence	Dummy: 1 = if rural; 0 = otherwise
Number of group membership of head	Count of membership in 4 groups <sup>a</sup>
Number of crops grown	Count of 3 crops cultivated <sup>b</sup>
Household has animals	Dummy: 1 = if yes; 0 = otherwise
Household hunger score <sup>4</sup>	Number (from 0 to 6)
Annual per capita food expenditure	Food expenditure per household member (GHS/person)
Number of agricultural land owned	Hectares
Joint crop and livestock decision making	Dummy: 1 = if head and spouse decide; 0 = otherwise
Total output of crops	Kilograms (kg)
Total farm size	Hectares
Yield	Total output per total farm size (kg/ha)
Sold crop	Dummy: 1 = if yes; 0 = otherwise
Crop sale income	Ghana cedi (GHS)
Ownership of non-farm business equipment	Dummy: 1 = if yes; 0 = otherwise
<b><i>Women characteristics</i></b>	
Age of woman	Number of years
Woman can read and write in English	Dummy: 1 = if yes; 0 = otherwise
Height of woman	Centimetres
Number of food groups consumed	Count of nine food groups consumed <sup>c</sup>

*continued next page*

**Table 2 Continued**

<b>Description</b>	<b>Measurement</b>
<b><i>Child characteristics</i></b>	
Age of child	Number of months
Male child	Dummy: 1 = if yes; 0 = otherwise
<b><i>Regional and cluster characteristics</i></b>	
Northern	Dummy: 1 = if in Northern; 0 = otherwise
Brong Ahafo	Dummy: 1 = if in Brong Ahafo; 0 = otherwise
Upper East	Dummy: 1 = if in Upper East; 0 = otherwise
Membership in credit group	Proportion

Notes: <sup>a</sup> Groups are agricultural/livestock, trade and business, civic and mutual help; <sup>b</sup> Crops grown are maize, rice and soya; <sup>c</sup> Food groups are starchy staples, dark green leafy vegetables, other vitamin A-rich fruits and vegetables, other fruits and vegetables, organ meat, meat and fish, eggs, legumes and nuts, and milk and milk products.

## 5. Results and discussion

### Descriptive statistics of outcome and explanatory variables

The descriptive statistics of anthropometric indicators for children and women and credit are presented in Table 3. The mean BMI is 22.146 and implies that, generally, women have a normal BMI. This is confirmed by the fact that 2,413 of women (75.9%) are within the normal BMI bracket. Women who are underweight represent 9.3% of the sample women, while overweight and obese women represent 12% and 2.8%, respectively.

**Table 3: Descriptive statistics of anthropometric indicators and credit**

Variable	Sample	Mean	S.D.	Min.	Max.
<b>Women</b>					
BMI	3,179	22.146	3.934	10.32	68.46
Underweight	295	17.103	1.336	10.32	18.49
Overweight	381	26.611	1.205	25.02	29.91
Obese	90	36.624	8.559	30.06	68.46
Normal	2,413	21.517	1.664	18.50	24.99
<b>Children: Before WHO standard reference</b>					
Height-for-age z-score (HAZ)	3,179	-1.232	3.021	-11.88	25.15
Weight-for-age z-score (WAZ)	3,164	-0.554	2.756	-9.55	63.48
Weight-for-height z-score (WHZ)	3,141	0.349	3.969	-14.23	85.51
<b>Children: After WHO standard reference</b>					
Height-for-age z-score (HAZ)	2,781	-1.280	1.961	-5.99	6.00
Boys	1,412	-1.361	1.975	-5.99	5.72
Girls	1,369	-1.197	1.945	-5.91	6.00
Weight-for-age z-score (WAZ)	2,781	-0.903	1.328	-5.23	4.29
Boys	1,412	-0.925	1.352	-5.19	4.29
Girls	1,369	-0.881	1.303	-5.23	4.04
Weight-for-height z-score (WHZ)	2,781	-0.227	1.633	-4.97	4.98
Boys	1,412	-0.206	1.670	-4.97	4.97
Girls	1,369	-0.249	1.595	-4.97	4.98

*continued next page*

**Table 3 Continued**

Variable	Sample	Mean	S.D.	Min.	Max.
<b>Prevalence rates</b>					
Stunting (HAZ < -2SD)	2,781	0.347	0.476	0.00	1.00
Boys	1,412	0.368	0.483	0.00	1.00
Girls	1,369	0.324	0.468	0.00	1.00
Underweight (WAZ < -2SD)	2,781	0.183	0.387	0.00	1.00
Boys	1,412	0.184	0.388	0.00	1.00
Girls	1,369	0.182	0.386	0.00	1.00
Wasting (WHZ < -2SD)	2,781	0.111	0.314	0.00	1.00
Boys	1,412	0.111	0.314	0.00	1.00
Girls	1,369	0.111	0.314	0.00	1.00
<b>Credit access</b>					
Before WHO reference	2,085	0.258	0.438	0.00	1.00
After WHO reference	1,820	0.170	0.376	0.00	1.00

Before applying the WHO anthropometric standards, only HAZ had valid estimates for all 3,179 children with a mean of -1.23, ranging from -11.88 to 25.15. WAZ and WHZ, respectively, had valid estimates for 3,164 and 3,141 children, with means of -0.55 and 0.35 and ranges of -9.55 to 63.48 and -14.23 and 85.51, respectively. Therefore, 15 and 38 WAZ and WHZ estimates were missing due to weights or heights that were not in a range that the “Anthro” software accepts.

To ensure that extreme z-scores do not distort the analysis, the WHO has provided guidelines on z-scores that qualify as outliers and should be eliminated. The observations for HAZ when the z-score for a child is greater than 6 or smaller than -6; for WAZ when the z-score is greater than 5 or smaller than -6; for WHZ when the z-score is greater than 5 or smaller than -5, should be flagged and removed from the analysis. After applying these standards, 398 observations (12.5% of the sample of 3,179) were dropped, leaving the final sample for analysis at 2,781. Therefore, after applying the WHO standards, the mean HAZ is -1.28 with a minimum of -5.99 and a maximum of 6.0; the mean WAZ is -0.90 with a minimum of -5.23 and a maximum of 4.29; and the mean WHZ is -0.23 with a minimum of -4.97 and a maximum of 4.98. The sex distribution of these anthropometric indicators shows that except for the WHZ indicator, girls have better z-scores than boys for all indicators.<sup>5</sup> Focussing on the prevalence of stunting, underweight and wasting, the results in Table 3 show that 34.7% of children (964 children 0–59 months old) are stunted, 18.3 per cent (509 children 0–59 months old) are underweight, and 11.1 per cent (309 children 0–59 months old) are wasted. The sex distribution of prevalence indicates that boys (520) are more stunted than girls (444), boys (260) are more underweight than girls (249) and boys (157) are more wasted than girls (152).

The results for the treatment variable (credit) in Table 3 show that from the initial 2,085 households, 25.8% have access to formal credit. After dropping observations

with flagged anthropometric scores, 17.0% of the remaining observations (1,820) have access to credit. This observation implies that there is low access to credit and agrees with previous findings on access to financial services in Ghana (see Abu and Issahaku, 2017; Sekyi et al., 2017) and data from the Global Findex.

The descriptive statistics of all other variables used for econometric estimations are presented in Table 4. The mean age of household heads is 40 years, with most males (86.1%) as household heads. Only 16.9 per cent of heads can read and write in English, and a majority of households (81.1%) reside in rural settings.

The mean family size is 7 people, while the mean number of crops cultivated is 1. The majority of households (70.8%) own animals, while the mean hunger score is about 1.5. This indicates that a majority of households experience little to no hunger. The mean annual per capita food expenditure is GHS710. On average, women are moderately diverse in their diets as they consume 4 out of 9 food groups. The mean age of children is about 29 months, and the majority of children are boys (50.8%).

**Table 4: Descriptive statistics of the sample**

Variable	Credit (n = 309)		No credit (n = 1,511)		Overall (n = 1,820)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Access to formal credit					0.168	0.374
<b>Anthropometric indicators (n = 2,781)</b>						
Height-for-age z-score (HAZ)	-0.656	2.890	-1.405	1.689	-1.280	1.961
Weight-for-age z-score (WAZ)	-0.228	1.617	-1.039	1.218	-0.903	1.328
Weight-for-height z-score (WHZ)	0.294	2.359	-0.332	1.422	-0.227	1.633
<b>Household characteristics (n = 1,820)</b>						
Age of head	41.17	12.51	39.88	13.23	40.10	13.12
Male head	0.841	0.366	0.865	0.342	0.861	0.346
Household size	7.006	3.358	6.910	3.430	6.926	3.417
Head can read and write in English	0.324	0.469	0.137	0.344	0.169	0.375
Area of residence	0.715	0.452	0.831	0.375	0.811	0.392
Number of group membership of head	0.573	0.715	0.320	0.575	0.363	0.608
Number of crops grown	1.272	0.907	1.180	0.843	1.196	0.855
Household has animals	0.712	0.454	0.707	0.455	0.708	0.455
Household hunger score	1.777	2.116	1.469	1.829	1.521	1.884
Annual per capita food expenditure	752.7	671.4	701.3	795.2	710.0	775.6
Number of agricultural land owned	4.759	6.920	3.205	3.968	3.469	4.639
Joint crop & livestock decision making	0.165	0.372	0.087	0.281	0.100	0.300
Total output of crops	966.8	2,168	738.1	1,313	776.9	1,495
Total farm size	1.605	2.225	1.700	2.508	1.684	2.462

*continued next page*

**Table 4 Continued**

Variable	Credit (n = 309)		No credit (n = 1,511)		Overall (n = 1,820)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
<b>Household characteristics (n = 1,820)</b>						
Yield	615.1	549.3	442.9	393.3	470.7	426.9
Sold crop	0.489	0.501	0.512	0.500	0.508	0.500
Crop sale income	236.0	622.2	105.9	349.4	128.0	411.4
Ownership of non-farm business eq.	0.278	0.449	0.228	0.419	0.236	0.425
<b>Women characteristics (n = 2,781)</b>						
Age of woman	30.21	7.325	29.93	7.573	29.98	7.532
Woman can read & write in English	0.135	0.343	0.088	0.283	0.096	0.294
Height of woman	159.3	8.384	159.2	7.969	159.2	8.038
Number of food groups consumed	4.574	2.459	4.123	1.722	4.198	1.873
<b>Child characteristics (n = 2,781)</b>						
Age of child	27.98	17.34	29.18	16.28	28.98	16.47
Male child	0.523	0.500	0.505	0.500	0.508	0.500
<b>Regional and cluster characteristics (n = 1,820)</b>						
Northern	0.540	0.499	0.677	0.468	0.654	0.476
Brong Ahafo	0.126	0.333	0.110	0.313	0.113	0.316
Upper East	0.181	0.386	0.132	0.338	0.140	0.347
Proportion in credit group	0.407	0.232	0.280	0.202	0.302	0.213

Notes: For anthropometric indicators, women and child characteristics (with observations of 2,781), the distribution of credit and no credit observations are 465 and 2,316, respectively; Total observations are 1,820 because of flagged anthropometric indicators.

Before undertaking the econometric estimations, we estimated the Pearson correlation between all explanatory variables in Table 2. The results are reported in Table A1 in the Appendix. Generally, there is low correlation among the variables, an indication that too many extremely high correlations that have the potential to dampen econometric estimations are absent. However, the correlation between formal credit and agricultural land endowment (0.52), and between number of food groups consumed and hunger score (-0.65) are very high. To protect the integrity of estimations, land endowment and hunger score are dropped in all nutrition equations. The rationale for this is that dietary diversity is a better control variable in a nutrition model than hunger score, while credit is the main variable of interest in this study.

## Effect of formal credit on nutritional outcomes

This section presents the effect of credit policy on nutritional outcomes. Two effects are examined: the effect of credit on children's nutritional outcomes and the effect of credit on women's nutritional outcomes.

## Effect of credit policy on nutritional outcomes of children

Before estimating the baseline 3SLS model, we first estimated the structural system of HAZ, WAZ and WHZ separately using OLS. The results of both the OLS and 3SLS are presented in Table 5, where columns 2, 3 and 4 are the OLS standalone estimates and columns 5, 6 and 7 are the structural estimates of the 3SLS. We checked the relevance of the instrument used in the 3SLS estimates by examining whether it is strongly or weakly correlated with credit using the rule of thumb suggested by Staiger and Stock (1997). According to this approach, the instrument is weakly identified if the F-statistic in the estimates of Equation 10, the first-stage regression of the 3SLS, is less than 10. The results of the estimates are presented in Table A2 (in the Appendix), and the F-statistic is 17.63, which clearly shows that the instrument is strongly identified. In addition, the statistically significant effect of the instrument on credit access in Table A2 strengthens its relevance.

Turning to the results in Table 5, we found that after controlling for relevant factors, the effect of formal credit on anthropometric indicators is positive and statistically significant in all three indicators for both the OLS and the 3SLS estimates. This implies that access to formal credit increases HAZ, WAZ and WHZ and this effect is robust for the two models.

**Table 5: Determinants of child anthropometric indicators**

Variable	OLS			3SLS		
	HAZ	WAZ	WHZ	HAZ	WAZ	WHZ
<b>Access to formal credit</b>	<b>0.454***</b>	<b>0.665***</b>	<b>0.676***</b>	<b>1.336***</b>	<b>1.700***</b>	<b>1.558***</b>
<i>Household characteristics</i>						
Age of head	0.005	0.003*	0.001	0.004	0.002	0.001
Male head	-0.156	-0.057	0.051	-0.122	-0.017	0.084
Household size	0.020**	0.007	-0.010	0.017*	0.003	-0.013
Head can read & write in English	0.368***	0.115	-0.138	0.217*	-0.063	-0.289**
Area of residence	-0.069	0.001	0.076	-0.012	0.068	0.134
No. of group mem. Of head	-0.114**	-0.168***	-0.171***	-0.175***	-0.239***	-0.231***
Number of crops grown	0.123***	0.093***	0.023	0.095**	0.060*	-0.005
Household has animals	0.439***	0.364***	0.185**	0.461***	0.390***	0.207***
Annual per capita food exp.	0.000**	0.000***	0.000***	0.000	0.000***	0.000***
Joint crop/livestock decision	0.570***	0.435***	0.155	0.490***	0.341***	0.074

*continued next page*

**Table 5 Continued**

Variable	OLS			3SLS		
	HAZ	WAZ	WHZ	HAZ	WAZ	WHZ
<b>Woman characteristics</b>						
Age of woman	-0.000	0.000	-0.000	-0.000	0.000	-0.000
Woman can read & write in English	-0.110	0.026	0.098	-0.100	0.038	0.108
Height in centimetres	0.014***	0.010***	0.003	0.015***	0.011***	0.003
No. of food groups consumed	0.250***	0.136***	-0.015	0.245***	0.130***	-0.020
<b>Child characteristics</b>						
Age of child	-0.031***	-0.008***	0.014***	-0.030***	-0.008***	0.014***
Male child	-0.137**	-0.039	0.028	-0.146**	-0.049	0.019
<b>Regional characteristics</b>						
Northern	-0.234*	-0.178**	-0.007	-0.182	-0.116	0.045
Brong Ahafo	0.066	0.150	0.228	0.102	0.192	0.264*
Upper East	-0.154	-0.308***	-0.276**	-0.148	-0.301***	-0.270*
Constant	-4.261***	-3.456***	-1.452**	-4.462***	-3.691***	-1.652**
Observations	2,781	2,781	2,781	2,781	2,781	2,781
F-statistic	38.41***	31.16***	9.33***	36.41***	24.76***	6.51***
R-squared	0.22	0.18	0.06	0.19	0.11	0.03
Log likelihood					-10,106.58	

Note: \* p<0.1; \*\* p<0.05; \*\*\* p<0.01; HAZ is height-for-age z-score; WAZ is weight-for-age z-score; WHZ is weight-for-height z-score; Endogenous variables – HAZ, WAZ, WHZ and credit; Exogenous variables are all the above explanatory variables including the instrument (proportion of households in credit group in a cluster). See definitions of variables in Table 2.

However, the OLS estimates are consistently lower in magnitude. This may suggest that the OLS is downwardly biased in its estimates arising from two likely sources: endogeneity of credit and non-separability of child nutritional outcomes, which underlines the need to correct for these. Therefore, we concentrate our discussion on the estimates of 3SLS. Specifically, the 3SLS estimates indicate that access to credit increases HAZ, WAZ and WHZ by 1.336, 1.700 and 1.558, respectively. These findings indicate that credit positively affects the nutritional outcomes of children. The positive effect of credit on nutritional outcomes can be attributed principally to easing farmers' liquidity constraints by offering capital to invest in adopting technology. This could lead to increases in productivity and stimulate own consumption and income from crop sales to finance the purchase of quality and nutritious foods in the open market. This capital can also be invested in non-farm businesses to generate income to purchase quality and nutritious foods. Therefore, the finding confirms the conceptual model in Figure 1.

This finding conforms to some of the literature. For example, Kiresur et al. (2010) observed that providing productive assets such as credit to poor farm households would stimulate nutritional outcomes by boosting productivity. Webb and Block

(2012) indicated that providing support to agriculture facilitates a reduction in stunting and wasting. In part, the finding also corroborates the findings of Malapit and Quisumbing (2015) regarding the effect of women's empowerment in credit decisions on child nutritional outcomes. They found that the active participation of women in credit decisions positively influences WHZ as well as increasing the number of food groups consumed and the probability of female children consuming minimum acceptable diets. Further, Malapit and Quisumbing (2015) observed that women empowerment in agriculture, though weakly, is positively correlated with child nutritional outcomes.

The results of significant control factors are in three classes: control factors that simultaneously correlate with all three indicators (ownership of animals, number of group membership and age of child), control factors that simultaneously correlate with only two anthropometric indicators (number of crops cultivated, joint crop and livestock decision making, height of woman and number of food groups consumed by woman which positively correlate with HAZ and WAZ; head able to read and write in English which, respectively, positively and negatively correlate with HAZ and WHZ; annual per capita food consumption expenditure, which positively correlates with WAZ and WHZ; and an Upper East dummy which negatively correlates with WAZ and WHZ) and control factors that are non-simultaneous correlates – those that influence only one anthropometric indicator (household size and male child dummy influencing HAZ, and Brong Ahafo dummy influencing WHZ). The results of the control factors are generally as expected.

Based on the fact that there are different nutritional paths for children greater than or below 24 months of age, we decided to divide the sample into two sub-groups, 6–23 months and 24–59 months, to examine the effect of credit. The results of the sub-group estimates are presented in Table A3 in the Appendix. The results generally show that the effect of credit on the nutritional outcomes of the 24–59 sub-group is robust. However, credit only affects HAZ in the 6–23 sub-group. Also, the results with respect to locality (not shown due to space considerations, but available upon request) shows that the effect of credit on nutritional outcomes is robust irrespective of locality.

### ***Effect of credit policy on nutritional outcomes of women***

The results of the effect of credit policy on women's BMI estimated through the eprobit model are presented in Table 6. The underweight column presents estimates of the probability of underweight, and the overweight column presents the estimates of the probability of overweight. In all estimates, the comparison group is women with a normal BMI. Controlling for relevant factors, we found that credit significantly affects the probability of underweight. The coefficient is negative and implies that access to credit reduces the likelihood of a woman being underweight. Therefore, credit increases the probability of a woman having a normal BMI. This finding is non-trivial because women's BMI falling in the underweight bracket is observed to be a more

serious health issue for women, especially considering their duties in managing the health and economic wellbeing of children (Zereyesus et al., 2014). However, credit does not significantly affect the probability of being overweight. This may be because compared to being underweight, being overweight is often more of a lifestyle problem than a “financial” problem. This means that attitudinal change interventions may be more effective in addressing overweight issues than credit.

**Table 6: Extended probit estimates of determinants of womens’ nutritional outcome**

Variable	Underweight		Overweight	
	BMI < 18.5	Credit	BMI ≥ 25	Credit
<b>Access to formal credit</b>	<b>-1.303***</b>		<b>0.123</b>	
<b>Household characteristics</b>				
Age of head	-0.001	-0.000	0.005*	-0.000
Male head	-0.169	-0.048**	-0.065	-0.064***
Household size	0.013	0.000	-0.012	0.001
Head can read & write in English	-0.105	0.172***	0.079	0.176***
Area of residence	0.067	-0.074***	-0.418***	-0.067***
Number of group membership	-0.097	0.038***	-0.012	0.042***
Number of crops grown	0.046	-0.009	-0.039	-0.005
Household has animals	0.046	-0.041**	-0.131*	-0.022
Annual per capita food expenditure	-0.000	0.000**	0.000	0.000*
Number of agricultural land owned		0.025***		0.026***
Joint crop and livestock decision making	-0.055		0.102	
Yield	0.000	0.000***	-0.000*	0.000***
<b>Woman characteristics</b>				
Age of woman	0.002	0.001	0.009**	0.001
Woman can read & write in English	0.345***	-0.016	-0.049	0.010
Number of food groups consumed	-0.032	-0.009***	0.029*	-0.011***
<b>Regional and cluster characteristics</b>				
Northern	-0.349***	-0.012	-0.378***	-0.039
Brong Ahafo	-0.464**	0.028	0.154	0.001
Upper East	0.428***	0.090***	-0.341***	0.073**
The proportion of membership in credit group		0.397***		0.363***
Constant	-0.759***	0.030	-0.721***	0.083
Observations	2,708		2,926	
F-statistic	10.18***		8.78***	
Var(credit & underweight)	0.117***		0.125***	
Var(credit & overweight)	0.328***		-0.006	

Notes: \* p<0.1; \*\* p<0.05; \*\*\* p<0.01; survey weights used in estimations.

In terms of the control factors in the underweight model, women who can read and write are more likely to be underweight, and women in the Northern and Brong Ahafo regions are less likely to be underweight, while those in Upper East are more likely to be. For the overweight model, age of household head, area of residence, the household has animals, age of woman, number of food groups consumed, yield and regional dummies are significant determinants. Women in rural areas are less likely to be overweight. This is expected as rural women engage in more physical economic activities that require expending calories than urban women. Women in households with animals and those in the Northern and Upper East regions have a lower likelihood of being overweight. Older women are more likely to be overweight.

## Credit policy channels to nutritional outcomes

From the conceptual model, we identified four channels that are supported by the data through which credit can work to affect children and women's nutritional outcomes. An extended probit model is used for market participation and ownership of non-farm business equipment channels, while extended linear regression (eregress) is used for productivity and income from crop sale channels. Tables 7 and 8 present the results of the eregress and eprobit models, respectively.

**Table 7: Estimates of determinants of productivity and income from crop sales**

Variable	Productivity		Income from crop sales	
	Yield	Credit	Sales	Credit
<b>Access to formal credit</b>	<b>134.051***</b>		<b>304.001***</b>	
Age of head	-1.717***	-0.000	-2.052*	0.000
Male head	124.795***	-0.039*	-50.709	-0.049**
Household size	-0.729	-0.000	17.432*	-0.000
Head can read & write in English	-11.910	0.178***	-19.913	0.178***
Area of residence	3.860	-0.066***	-48.279	-0.066***
Number of group membership of head	20.172	0.045***	-1.452	0.043***
Number of crops grown	141.828***	0.005	39.325***	-0.008
Household has animals	51.249***	-0.028	-23.002	-0.032*
Annual per capita food expenditure	0.009	0.000*	0.009	0.000*
Joint crop and livestock decision making	-48.427*		-20.365	
Yield			0.359***	0.000***
Number of agricultural land owned		0.026***		0.026***
Age of woman	0.570	0.000	0.460	0.000

Woman can read & write in English	-32.864	-0.004	-54.619**	-0.002
DDS	5.788	-0.010***	-0.552	-0.010***
NR	34.995	-0.025	89.846***	-0.029
BA	14.968	0.015	114.720***	0.012
UE	-54.671*	0.062*	18.503	0.065**
Proportion in credit group		0.372***		0.363***
Constant	60.505	0.067	-136.106*	0.063
Observations	3,179		3,179	
F-statistic	32.66***		11.60***	
Corr(credit & yield)	-0.010			
Corr(credit & sales)			-0.087*	

Note: \* p<0.1; \*\* p<0.05; \*\*\* p<0.01; sampling weights used in estimations.

**Table 8: Estimates of determinants of market participation and non-farm business**

Variable	Market participation		Non-farm business	
	Sold crop	Credit	Equipment	Credit
Access to formal credit	0.270**		0.181*	
Age of head	-0.005**	-0.000	-0.005**	0.000
Male head	0.066	-0.020	-0.261***	-0.049**
Household size	-0.012*	0.001	0.007	-0.000
Head can read & write in English	0.015	0.167***	-0.033	0.178***
Area of residence	0.065	-0.024	-0.224***	-0.065***
Number of group membership of head		0.047***		0.044***
Number of crops grown	0.316***	-0.024**	-0.020	-0.008
Household has animals	-0.159**	-0.030	-0.014	-0.032*
Annual per capita food expenditure	0.000***	0.000*	0.000**	0.000*
Number of agricultural land owned		0.025***		0.026***
Joint crop and livestock decision making	-0.287***		-0.271***	
Yield	0.001***	0.000***	0.000***	0.000***
Age of woman	0.001	0.001	0.007*	0.000
Woman can read & write in English	-0.254**	-0.021	-0.005	-0.002
Number of food groups consumed	0.070***	-0.009***	0.072***	-0.010***
Northern	0.504***	-0.033	-0.075	-0.028
Brong Ahafo	0.875***	-0.021	-0.021	0.013

*continued next page*

**Table 8 Continued**

Variable	Market participation		Non-farm business	
	Sold crop	Credit	Equipment	Credit
Upper East	0.164	0.093***	-0.385***	0.066**
Proportion in credit group		0.384***		0.367***
Constant	-0.932***	-0.021	-0.681***	0.062
Observations	2,669		3,179	
F-statistic	12.49***		6.95***	
Corr(credit & participation)		-0.079		
Corr(credit & non-farm business)				-0.019

Note: \* p<0.1; \*\* p<0.05; \*\*\* p<0.01; sampling weights used in estimation.

The results in Tables 7 and 8 show that the coefficients of the credit variable in productivity, sales income, market participation and ownership of non-farm business equipment models are positive (134.05, 304.00, 0.27 and 0.18, respectively) and statistically significant. This implies that households with access to credit are 134.05kg/ha more productive, earn GHS304 more in crop sales, and are more likely to sell crops they produce and own non-farm business equipment than those who do not have access to credit. Credit fuels productivity gains through the provision of capital to invest in adopting productivity-enhancing technology. Gains in productivity then offer households the opportunity to produce more for consumption as well as raise marketable surpluses for sale and, subsequently, increase incomes from crop sales to enable them to purchase diverse foods that they do not grow on their farms. Therefore, incomes from crop sales can be used to meet household consumption expenditures such as the purchase of quality and nutritious foods to supplement their own consumption. Credit also provides capital for investment in non-farm enterprises that generate income to purchase nutritious products from the open market and improve nutrition.

The general conclusion from these findings is that access to credit does promote nutrition by easing liquidity constraints for farmers, which allows them to increase productivity, market participation, non-farm engagements and income. This is consistent with our conceptual model.

## 6. Conclusion and policy implications

This study used credit from formal sources to assess the effect of credit policy on nutritional outcomes of children and women in the Savannah Accelerated Development Authority zone of Ghana. We used anthropometric indicators of height-for-age, weight-for-age and weight-for-height z-scores to proxy for child nutritional outcomes of stunting, underweight and wasting, and the BMI of women to proxy their nutritional outcomes. In addition, we validated a transmission mechanism of credit policy by estimating the pathways through which credit affects nutritional outcomes. In terms of econometric approaches, we argued that stunting, underweight and wasting of children have an intrinsic relationship and so should be modelled as a system, and that credit is endogenous to these outcomes. Consequently, we applied a three-stage estimation for systems of simultaneous equations (reg3) model to deal with the structural system and endogeneity of credit access in the children outcome model. For women, we applied eprobit to deal with the endogeneity of credit, and BMI classes of underweight and overweight. In addition, we employed eregress and eprobit models to test the pathways of credit to nutrition.

The entire results can be summarised in three key findings. First, while there may be numerous sources of improving nutritional outcomes of children, this study demonstrates that providing farm households with credit is one of the ways to make child-centred nutritional improvements in a household. Credit access by adult members in a household trickles down to improve nutritional outcomes of children through investments in both farm and non-farm enterprises. Second, credit affects the nutritional outcomes of women, albeit not across all outcomes. While credit reduces a woman's likelihood of being underweight, it shows no effect on the probability of being overweight or obese. Finally, credit works through yield, market participation, income from crop sales and non-farm business enterprise to affect nutritional outcomes. Based on these findings, this study concludes that a credit policy which is targeted at farm households will significantly affect nutritional outcomes in Ghana positively and that this effect will affect children the most.

The policy implication of the conclusion of this study is that, to retool agriculture to respond to burgeoning calls for nutrition-sensitive agriculture, the Government of Ghana, specifically through collaboration with the Bank of Ghana (BoG), the Ministry of Food and Agriculture (MoFA) and financial institutions, should prioritize and develop an agricultural credit policy to offer credit to farm households. As Ghana already has

the Agricultural Development Bank, a bank established mainly to provide low-cost credit to agriculture, the collaboration should use this bank to develop a well-targeted credit policy that would ensure that barriers to credit such as collateral requirements, high-interest rates, bureaucratic procedures and tedious paperwork among others are removed to make formal credit accessible to farm households. For a successful credit policy, the liquidity of the bank should be augmented, and the Government should provide the political will for the bank to stay within its mandate.

For the poor and the hungry, a targeted nutrition-sensitive credit policy is required to address their specific problems. This will involve the government and other development agencies deliberately targeting these people in terms of easing access to credit and nutritional packages. Because of their disadvantaged situation, these poor individuals do not have the social connections and economic muscle to compete with those with the wherewithal for credit in the open and competitive financial marketplace. They will therefore require a “big push” from policymakers to fully participate in the formal financial system and leverage the resources to improve their livelihood and nutrition.

## Notes

1. The available data do not specify the use of credit exclusively on agricultural investments. This necessitates the direct consumption and investment in non-farm aspects of the framework.
2. See Greene (2018) and Davidson and MacKinnon (1993) for an extensive treatment.
3. Due to space considerations, the theoretical framework of the model is not presented.
4. For complete information, see Ballard et al. (2011).
5. Although only the estimates of HAZ shows a statistically significant difference.

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## Appendix

Figure A1: Feed the Future zone of influence in Ghana



Source: Malapit and Quisumbing (2015). The Feed the Future zone of influence includes the Brong Ahafo, Northern, Upper East, and Upper West regions of Ghana.

**Table A1: Correlation matrix of explanatory variables**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
cred (1)	1.00																		
ageyrs (2)	-0.01	1.00																	
hsex (3)	-0.04	0.13*	1.00																
hsize (4)	0.01	0.43*	0.14*	1.00															
rw (5)	0.27*	-0.07	0.00	-0.1*	1.00														
hhloc (6)	-0.10*	-0.01	0.06	0.08	-0.2*	1.00													
Gmemno (7)	0.09*	0.02	0.05	0.03	-0.02	0.03	1.00												
cnum (8)	-0.02	0.01	0.14*	0.11*	-0.1*	0.16*	0.11*	1.00											
Anima (9)	0.11*	0.05	0.13*	0.12*	0.05	0.16*	0.11*	0.26*	1.00										
hsscore (10)	0.20*	0.01	0.00	0.04	-0.3*	0.06	0.03	-0.04	-0.28*	1.00									
pchhexp (11)	0.11*	-0.14*	-0.03	-0.3*	0.07*	-0.1*	-0.01	-0.1*	-0.05	0.03	1.00								
alandno (12)	0.52*	0.04	0.02	0.10*	0.23*	0.00	-0.00	0.02	0.32*	0.12*	0.06	1.00							
jtdeamk (13)	0.22*	0.02	-0.05	-0.0*	0.31*	0.01	0.04	0.03	0.2*	-0.2*	0.02	0.29*	1.00						
wageyrs (14)	0.01	0.30*	-0.6	0.14*	-0.03	-0.01	0.05	0.02	-0.01	0.01	-0.11*	-0.01	0.03	1.00					
wrw (15)	0.03	0.01	-0.09*	-0.08	0.24*	-0.2*	-0.03	-0.1*	-0.07*	-0.06	0.01	-0.04	0.04	-0.19*	1.00				
Hgtwov (16)	-0.02	0.02	-0.02	-0.01	0.00	-0.05	-0.02	0.03	0.01	-0.00	-0.04	-0.03	0.04	0.03	0.08*	1.00			
DDS (17)	0.09*	0.03	-0.01	0.00	0.45*	-0.1*	0.02	0.03	0.25*	-0.6*	0.03	0.17*	0.32*	0.00	0.07*	0.01	1.00		
Agechd (18)	-0.08*	0.09*	0.01	0.06	-0.54	-0.02	0.02	-0.00	-0.03	-0.01	-0.04	-0.10*	-0.07*	0.11*	-0.12	0.01	-0.02	1.00	
Sexchd (19)	0.00	0.02	0.02	0.02	-0.2	-0.01	-0.00	-0.02	-0.04	0.05	-0.01	-0.01	-0.00	-0.01	0.02	-0.02	-0.04	-0.01	1.00
NR (20)	-0.00	-0.01	0.19*	0.17*	-0.1*	0.05	-0.07*	0.04	0.06	0.03	-0.01	0.16*	-0.09*	-0.05	-0.12*	-0.13*	0.02	0.03	0.00
BA (21)	-0.04	-0.06	-0.18*	-0.2*	0.04	-0.07	-0.03	-0.2*	-0.15*	-0.1*	0.08*	-0.12*	-0.02	0.01	0.04	-0.08*	-0.03	-0.01	0.03
UE (22)	0.03	0.03	-0.10*	-0.1*	0.03	-0.05	0.04	0.12*	0.01	0.05	-0.00	-0.07*	0.07	0.03	0.08*	0.21	-0.02	-0.03	-0.02

Note: \* denotes statistical significance at 0.05.

**Table A2: First-stage regression of credit in 3SLS regression**

Variable	Coefficient	Std. error
Age of head	0.001	0.001
Male head	-0.024	0.022
Household size	0.002	0.002
Head can read & write in English	0.157***	0.021
Area of residence	-0.054***	0.019
No. of group mem. of head	0.046***	0.011
Number of crops grown	0.033***	0.009
Household has animals	-0.021***	0.017
Annual per capita food exp.	0.000**	0.000
Joint crop/live. decision	0.080***	0.024
Age of woman	-0.000	0.001
Woman read & write in English	-0.008	0.025
Height in centimetres	-0.000	0.001
No. of food groups consumed	0.009**	0.004
Age of child	-0.001	0.001
Male child	0.010	0.013
Northern	-0.004	0.025
Brong Ahafo	0.051	0.034
Upper East	0.072**	0.031
<b>Proportion in credit group</b>	<b>0.366***</b>	<b>0.034</b>
Constant	0.007	0.150
Observations	2,781	
F-statistic	17.68***	
R2	0.114	

Note: \*\* p<0.05; \*\*\* p<0.01.

**Table A3: Determinants of child anthropometric indicators by age group**

Variable	6–23 sample			24–59 sample		
	HAZ	WAZ	WHZ	HAZ	WAZ	WHZ
<b>Access to formal credit</b>	<b>1.818**</b>	<b>0.486</b>	<b>-0.489</b>	<b>1.096*</b>	<b>2.051***</b>	<b>2.162***</b>
Age of head	0.002	-0.002	-0.004	0.005	0.005*	0.004
Male head	-0.233	0.118	0.313*	-0.080	-0.021	0.060
Household size	0.001	-0.013	-0.017	0.019	-0.001	-0.019
Head can read & write in English	0.306	-0.030	-0.223	0.045	-0.049	-0.117
Area of residence	0.215	0.004	-0.127	-0.100	0.127	0.283**
No. of group membership	-0.252**	-0.163**	-0.067	-0.161**	-0.264***	-0.259***
Number of crops grown	0.022	0.039	0.025	0.102*	0.072*	0.008
Household has animals	0.637***	0.286***	-0.080	0.430***	0.474***	0.323***
Annual per capita food expenditure	0.000	0.000	0.000*	0.000	0.000***	0.000***
Joint crop and live. decision	0.346	0.461**	0.388	0.464***	0.333***	0.103
Age of woman	-0.012	-0.003	0.004	0.004	-0.000	-0.004
Woman read & write in English	-0.446*	-0.164	0.060	0.198	0.105	-0.035
Height in centimetres	0.014*	0.003	-0.005	0.015***	0.014***	0.008*
No. of food groups consumed	0.238***	0.079***	-0.074**	0.231***	0.151***	0.020
Age of child	-0.107***	-0.033***	0.012	-0.013***	-0.008**	0.007*
Male child	-0.401***	-0.145	0.062	-0.070	-0.010	-0.003
Northern	-0.104	-0.477***	-0.536**	-0.194	0.128	0.383**
Brong Ahafo	0.191	-0.083	-0.231	0.109	0.458***	0.613***
Upper East	-0.059	-0.230	-0.264	-0.174	-0.228	-0.151
Constant	-3.001**	-1.191	0.669	-5.236***	-4.773***	-2.835***
Observations	796	1,723				
F-statistic	12.96***	5.34***	1.57*	12.94***	15.84***	4.88***
R-square	0.25	0.15	0.01	0.09	0.01	0.01
Log likelihood	-2,560.69	-4,808.93				

Note: \* p<0.1; \*\* p<0.05; \*\*\* p<0.01



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To strengthen local capacity for conducting independent, rigorous inquiry into the problems facing the management of economies in sub-Saharan Africa.

The mission rests on two basic premises: that development is more likely to occur where there is sustained sound management of the economy, and that such management is more likely to happen where there is an active, well-informed group of locally based professional economists to conduct policy-relevant research.

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