Crop Commercialization and Nutrient Intake Among Farming Households in Uganda

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Bringing Rigour and Evidence to Economic Policy Making in Africa

Crop Commercialization and Nutrient Intake Among Farming Households in Uganda

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Abstract

Agricultural commercialization is seen as a pathway towards rural economic transformation as it is expected to enhance a wide array of household welfare indicators. This study examines the channels through which household nutrient intake is influenced in the process of crop commercialization. This was investigated using LSMS-ISA survey data for Uganda using the control function econometric approach. The results show that commercialization affects nutrient intake via crop income. Another crucial finding was that while rural-based households registered higher nutritional gains from crop commercialization, they were less commercialized on average. The role of markets as a key factor in the agricultural commercialization process was confirmed; households that had access to produce markets are more commercialized and have better nutrient intake. While male-headed households were found to practice more commercialization, their households have less nutrient intake compared to their female-headed counterparts. This finding is in line with the literature and casts a shadow on the nutritional benefits of agricultural commercialization given that the majority of households in Uganda are male headed. The findings point to two important implications. First, interventions geared towards agricultural commercialization are beneficial to household nutrition via income generation. The findings showed that agricultural commercialization positively affects nutrient intake via income generation. Given this income-nutrition linkage, this calls for proactive steps towards support for nutrition-sensitive commercial agriculture to ensure that nutrient-rich foods are available for purchase from the markets, using the accrued income. Second, while rural-based households are the primary target of the commercialization policy, the study found them less commercially oriented. Such households need support in the form of inputs and equipment to reorientate their production as farm capital was found to be a significant driver of commercialization.

1. Introduction

The transition from subsistence to commercial agriculture has been proposed by development practitioners as key to socioeconomic transformation. The economies of scale associated with agricultural commercialization are expected to enhance efficiency in production, which in turn is expected to improve household income. Big welfare gains from commercialization are expected, especially among rural households whose livelihoods are directly derived from agriculture. Household income, consumption, food security and nutrition are expected to improve as a result. Anticipating such benefits, many developing countries have embarked on agricultural commercialization as a growth strategy. In Uganda, objective three of the country's Agricultural Policy is to "promote specialization in strategic, profitable and viable enterprises and value addition through agro-zoning" (GoU, 2013). This is informed by the understanding that commodity specialization and agro-zoning strengthen agri-business, and enhance profitability and market access, leading to the creation of farm and off-farm employment. The creation of additional employment opportunities necessitates increased agricultural commercialization and the establishment of industries for adding value to agricultural products.

In the analysis of the nexus between agriculture and nutrition, the focus has mainly been on the link between on-farm production diversity and farm household diets (Sibhatu et al., 2015; Jones, 2017). However, such studies use household dietary diversity scores, which are suitable for measuring household food security but not dietary quality (Kennedy et al., 2013). Other literature has analyzed the effects of agricultural commercialization on household welfare in terms of income (Muriithi and Matz, 2015). However, commercialization may impact income but not nutrient intake. For example, the risk associated with micronutrient deficiency cannot be identified if the analysis of the welfare effects is only restricted to income (Ecker and Qaim, 2011; Horton and Ross, 2003). In addition, even if the accrued income is allocated to food purchases, this may possibly change dietary quality by increasing calorie consumption but not necessarily micronutrients (Popkin et al., 2012). Furthermore, commercialization tends to cause changes in gender roles as men take charge of farm production as well as the accrued income (Von Braun and Kennedy, 1994; Ogutu et al., 2017). Evidence shows that agricultural income in male-controlled households is often spent on things other than those that improve household dietary quality (Fischer and Qaim, 2012).

1.1 Problem Statement

While the drive towards commercialization has been accompanied by policy reforms to create competitive agricultural markets with the aim of improving household welfare, there are studies in the literature which emphasize that agricultural commercialization may not yield the desired welfare effects (Carletto et al., 2017; Herens et al., 2018). In Uganda, the debate on the welfare impacts of agricultural commercialization comes at a time when government policies and programmes in the agricultural sector, which have resulted in the expansion of commercial crop production, are being met with mixed reactions. Specifically, the potential for policies and programmes that focus on market-oriented agricultural production in improving income generation and household nutrition is being called into question. A case in point is the scaling up of sugarcane production, which has caused concern for increasing food insecurity and rising poverty as the extensive nature of sugarcane production requires considerable acreage of land for a farmer to break even. The resulting increase in demand for land has inevitably pushed households into allocating their entire landholdings to sugarcane, leaving almost none for food production (Mwavu et al., 2018).

Mwavu et al. (2018) show that households that chose to cultivate sugarcane were food insecure, as they were often short of the physical and economic access to sufficient food to meet their dietary needs (also see Koczberski et al., 2012; Mwavu et al., 2016). They found that home gardens in sugarcane-growing regions has been rapidly losing important and nutritious food crops like cowpeas, soya beans, aerial yams and Bambara groundnuts, with dire implications for household food security and nutrition. Households were reportedly coping with food insecurity by resorting to offering labour in exchange for food, borrowing and rationing food, and at times using unsavoury survival strategies such as stealing from their neighbours (Mwavu et al., 2018).

Critics of commercial crops contend that the resources used to produce such crops would otherwise be used to produce food to improve nutrition and household food security (Koczberski et al., 2012; Mwavu et al., 2016). Conversely, others insist that the production of commercial crops can increase households' income which, in turn, can improve nutrition. In their study of agricultural commercialization and nutrition in the Philippines, Bouis and Haddad (1990) found that smallholder sugarcane landowners made substantially higher profits per hectare than those that had opted for corn, following the establishment of sugar mills in their region. In the case of Uganda, the opposing views are focussed on the proposition that such commercialization has generally been detrimental to household welfare. This study therefore contributes to the literature by investigating the link between commercialization and nutrient intake based on a nationally representative dataset.

From the existing evidence on the commercialization-nutrition linkage, Von Braun et al. (1990), Headey (2012) and Kadiyala et al. (2014) identify six channels through which agricultural interventions can impact nutrition: i) agriculture as a source of food for own consumption, ii) agriculture as a source of income which can be used to purchase food, iii) agricultural policies that can influence prices of food and non-food crops, iv) the effect of women's social status and empowerment on their access to and control over resources, v) the impact of women's participation in agriculture on their time allocation, and vi) the impact of women's participation in agriculture on their own health and nutritional status and that of their household. Based on these channels, we use a framework by Von Braun et al. (1990) to hypothesize that both commercialization policies and programmes that the Government of Uganda has undertaken over the years are important determinants of household nutrition among farm households in Uganda.

This study therefore seeks to establish whether or not the different interventions towards commercialization have had an effect on household nutrient intake based on the following research questions:

a) Does crop commercialization affect crop income?
b) How does nutrient intake vary between urban and rural-based households?
c) How does commercialization affect household nutrient intake?
d) How do socioeconomic factors influence micro- and macro-nutrient intakes?

1.2 Objectives

The overall objective of the study is to examine the effect of crop commercialization on household micro- and macro-nutrient intakes. In this regard, the study sets out to:

i) Analyze the differences in macro- and micro-nutrient intakes between urban and rural households.
ii) Determine the relationship between crop commercialization and crop income.
iii) Analyze the nutrition impact pathways of agricultural commercialization.
iv) Determine the effects of crop commercialization on calorie and micronutrient intake from different food sources.

1.3 Contribution

While previous studies have analyzed the effects of commercialization on productivity and income, the implications of such commercialization on household nutrition have received less attention. Some key outcomes, such as income that most certainly results from commercialization cannot be assumed to automatically translate into improved nutrition.[1] This study adds to the literature on the effects of crop commercialization on nutrient intake by analyzing the intake of calories and micronutrients by farming households (Ogutu et al., 2017). We also examine the transmission mechanisms from commercialization to nutrition by analyzing the role of income, sex of the household head, and possible substitution between the consumption of own-produced and purchased foods. A control function is econometrically used to address issues of endogeneity.

We assess both calorie and micronutrient intake given that a number of studies, especially on nutrition outcomes in sub-Saharan Africa, have concentrated on calorie intake, mainly through staples (AGRA, 2016). However, malnutrition in all its forms – undernutrition, micronutrient deficiencies, and overweight and obesity – has been observed to impose high economic and social costs on countries at all income levels (FAO, 2013). The impact of malnutrition on the global economy is estimated to cost US$3.5 trillion per year or US$500 per individual (Global Panel, 2016). This economic loss often stems from reduced adult productivity in individuals that were malnourished (stunted) as children. These end in premature adult mortality, loss of human capital investment, and increased healthcare costs for malnutrition-related non-communicable diseases. Malnutrition also presents adverse intergenerational consequences. Conversely, when nutrition status improves, it helps break the intergenerational cycle of poverty, generates broad-based economic growth and leads to a host of positive outcomes for individuals, families, communities and countries (AGRA, 2016).

While the contribution of the agricultural sector to GDP in Uganda has declined from 51 per cent in 1992/93 to approximately 23 per cent, it still remains key for the provision of employment, foreign exchange earnings and, most importantly, a source of food and nutrition security (MoFPED, 2016). The sector employs about 77 per cent of the rural population, and 89 per cent of poorer households (World Bank, 2015). Against this background, this study seeks to establish whether government policies and programmes geared towards market-oriented agricultural production are contributing to improved household nutrient indicators.

This investigation is critical, given previous experiences of policies aimed at boosting agricultural production in Africa. For instance, the food shortages experienced in Malawi during the mid-2000s saw the introduction of a farm input subsidy programme to promote maize production (AGRA, 2016). Similar initiatives were undertaken in Zambia with the implementation of the farm input support programme and the Food Reserves Agency to buy maize from farmers at above market prices (Africa Research Institute, 2013). While such policies can greatly improve the production of particular crops, they often create a bias in the diversity of crops produced, thereby introducing an imbalance in what is easily available for consumption. Such imbalances point to the need for policies that ensure that food production reflects the optimal response to the nutrition needs of a population.

The focus of this study is based on evidence that the need to engender food production that addresses the nutritional needs of the population is often met with the challenge that a number of farmers in Africa are left with little or no incentive to produce foods that provide other dietary components such as minerals, vitamins and protein (AGRA, 2016). In some rural communities, it is observed that indigenous foods that are known for their high nutritional value compared to some of the conventional and fashionable foods still exist. However, since they are produced by fewer farmers, their cost is often so high that poor households are not consistently able to afford these foods. This is given the fact that while ensuring that adequate supplies of high-quality food is necessary for countries to achieve their nutrition targets, it is not a sufficient condition. Ironically, households involved in food production have been identified to be among the most vulnerable to malnutrition (AGRA, 2016). The current study therefore investigates some of the key issues in light of the ongoing agricultural commercialization efforts in Uganda.

1.4 Policy Context of Agricultural Commercialization and Nutrition

Sub-Saharan Africa and South Asia are the two regions of the world with the highest concentration of undernutrition (Gillespie et al., 2015). However, it is worth noting that the bulk of this under-nourished population primarily depends on agriculture. Agriculture is a critical sector in any endeavour towards a sustained reduction in under-nutrition, yet there is mixed evidence on the channels through which its potential can be unleashed. Existing evidence reveals limited information on the wider political, institutional and policy-related challenges relating to the agriculture-nutrition nexus (see Gillespie et al., 2015). In Uganda, the agricultural policy direction and interventions are derived from the National Agriculture Policy (NAP) of 2013, which seeks to orient the sector as private-sector-led. All sector investments are guided by the Agriculture Development Strategy and Investment Plan (DSIP). This plan aims to enhance agricultural production and productivity by improving access to and ensuring the sustainability of markets, thereby creating an enabling environment and undertaking institutional reforms and development of the sector. The plan also promotes a commodity approach where value chain development is directed towards ten selected commodities within the different agro-ecological zones of the country.

Based on the foregoing policy environment, there have been a number of initiatives aimed at increasing agricultural production with a bias towards market-oriented production. For example, the Poverty Eradication Action Plan (PEAP) of 1997, whose activities were rooted in agriculture, was developed with the overall aim of enhancing rural incomes. Several revisions were made to the plan which later saw the emergence of the Plan for the Modernization of Agriculture (PMA) in 2000 as a second-tier policy framework to provide direction to agricultural-sector development in the country. The PMA was envisaged to turn agriculture into an engine that would contribute to income generation by raising farm productivity, increase the share of farm production that is marketed, and create off-farm and on-farm employment (Adong et al., 2014; Kasirye, 2013).

The National Agriculture Advisory Services (NAADS), which formed a pillar of the PMA, was a significant contributor towards agricultural commercialization through interventions such as input provision and advisory services to farmers in Uganda. The NAADS implementation strategy involves selecting a market-oriented farmer at parish level and a commercialized farmer at district and/or sub-county level plus nuclear farmers at the national level to ensure the provision of targeted farmer support towards commercialization (Adong et al., 2014; MAAIF, 2010). These selected farmers use their farms as demonstration sites for other farmers to learn the recommended farming practices. The agency also supports farmers to get organized into groups along a common identifiable farming interest. This was done with a view to promoting agricultural production based on a commercialization strategy.

Other interventions in the direction of agricultural commercialization include the Rural Development Strategy (RDS) and the Prosperity for All (PFA) programme. The objective of RDS was to stimulate agricultural production towards value addition and stable markets. Support was directed to farmer groups to ensure value addition and market stability, with the latter being achieved through the establishment of a commodity information system, enhancement of market access for agricultural products and facilitation of the delivery of agricultural inputs through the market. The RDS spanned the period 2005–2007, with its successor being the PFA, whose aim is to ensure that all households earn a minimum of 20 million shilling (US$6,000) annually through the effective selection of profitable farm enterprises.

The foregoing discussion highlights the attention which public policy in Uganda has paid towards agricultural transformation through the development of several strategies and initiatives aimed at making the sector commercially viable. However, while agriculture has the potential to reduce under-nutrition, this potential is yet to be realized (Ruel and Alderman, 2013; Gillespie et al., 2013; Balagamwala and Gazdar, 2013; Kadiyala et al., 2014). Evidence shows that the focus on market-oriented agriculture as reflected in the various initiatives, the limited multi-sectoral coordination and the view that nutrition is more of a health than an agricultural matter have dampened the critical role of agriculture as a contributor to nutrition (Gillespie et al., 2015).

It is vital to note that if strategically harnessed, agriculture can deliver relatively high economic returns to investment with benefits to nutrition (Hoddinott et al., 2012; Ruel and Alderman, 2013). However, as Gillespie et al. (2015) observe, an increase in food production or even consumption does not automatically lead to improvements in final nutrition outcomes. As Herforth and Ahmed (2015) found, it can be the case that food that is easily available, affordable, and convenient is not necessarily aligned with optimal nutrition and health outcomes. Non-food factors such as poor sanitation, women's disempowerment, inadequate quality of health services and agriculture-associated diseases equally stand in the way of the realization of effective nutrition.

Contextualized research into the policy processes and the political economy of agriculture and nutrition is therefore needed to better characterize the "set-up" under which agriculture can benefit nutrition, and how such "set-ups" can be shaped and sustained. For example, in a comparative assessment of priorities and perceptions of malnutrition in Afghanistan, Levitt et al. (2009) found that both agriculture and health sector stakeholders differed consistently in defining the problem of malnutrition. In East Africa, stakeholders identified the pathways from agricultural production to nutrition as income generation (the primary motivation behind the policy initiatives towards agricultural commercialization), household food production, education and women's empowerment. Yet evidence suggests that this link is not too obvious (see Gillespie et al., 2015; Herens et al., 2018). In this study, we aim to contribute to filling the gap between the expected increase in agricultural production following commercialization policies and its potential for translation into improved nutrition. This is done by identifying the primary channel (among several) through which nutrient intake is affected following crop commercialization. We draw on evidence from Uganda and position it within the literature from other regions of the world on the agriculture-nutrition nexus.

2. Literature Review

The early works on the agriculture-nutrition nexus produced results which were inconclusive and at times contradictory (see, e.g., Von Braun and Kennedy, 1986; Herens et al., 2018; Gillespie et al., 2015). In cross-country studies, results for the same crop produced opposite effects both between and within countries. For such studies, the focus was on the comparison of nutrition outcomes between cash-crop adopters and non-adopters. The evidence was often anecdotal and based on country case studies, making it impossible to compare results both across and within countries. In most studies, the definition and measurement of commercialization was subjective (based on the adoption or non-adoption of a given list of cash crops). However, there is no longer a strict dichotomy between cash or non-cash cropping systems. Subsequent studies, especially that by the International Food and Policy Research Institute (IFPRI),[2] developed a framework that articulated the complex set of relationships between the process of agricultural commercialization and the nutrition and health status at the household level (see Von Braun et al., 1989; Von Braun and Kennedy, 1994). Essentially, these cohorts of studies (e.g., Von Braun et al., 1989) examine how agricultural commercialization affects national food production and individual nutrition outcomes (Carletto et al., 2017).

The adoption of a market-oriented production system is expected to influence the degree of food availability at the national, community and household levels. Basically, competition among the limited resources (such as land, labour and capital), the amount of food imports and aid, the degree of diversity of available foods and the presence of seasonal and irregular fluctuations may be influenced by a rise in market orientation even among smallholder farmers. In that way, they may impact national or regional food availability which, by affecting food prices, may have important implications for nutrition (Kadiyala et al., 2014). However, national food sufficiency can be a poor indicator of household nutrient intake, as ‘‘food may be plentiful but the poor may still be unable to access it” (Von Braun and Kennedy, 1986). Thus, at a household level, it is vital to look at the ability of each household and household member to effectively obtain food. This ability varies depending on the effects of the commercialization process on several factors including, household income (Carletto et al., 2017).

Increases in real household income have the potential to enhance food consumption, which would then impact household nutrition positively. However, there are challenges for such an outcome to be realized. Intra-household factors may stand in the way in cases where individual household members possess different income elasticities overall, also within foodstuffs. Furthermore, even when additional income is spent on food, intra-household food consumption could be heterogeneously distributed among family members, with children and women often being relatively penalized compared to adult males (Carletto et al., 2017). In addition, a high marginal propensity to spend on food does not automatically imply a high marginal propensity to consume nutrient-rich diets. Households quite often choose to go for “variety”, thereby buying higher-cost diets rather than simply using the acquired income to increase nutrient intake (Von Braun and Kennedy, 1994).

Some studies on the impact of agricultural commercialization on nutrition among rural households have found it to be mostly positive, though rather small in magnitude (Carletto et al., 2017; Ogutu et al., 2017; Herens et al., 2018). In other cases, no such evidence has been found (Wood et al., 2013). Where a positive relationship was found, it was primarily achieved through linkages between household income, household calorie intake and child calorie intake (Bellin, 1994). Cash crop adoption generally increased real incomes, which were then used to increase food consumption. This increase was observed to have benefited, on average, both the household in general and children in particular. Furthermore, the effects of agricultural commercialization on nutrition were found to depend on a number of conditioning complementary factors both at the macro- and micro level, making the adoption of commercial crops more or less remunerative and sustainable (Kadiyala et al., 2014; Ogutu et al., 2017). However, the positive income effects from the sale of commercial crops can be attenuated if households are unable to smooth their consumption or if there is more risk involved in commercial diversification (Sen, 1981). Furthermore, in the case of seasonal crops, households may not be able to smooth consumption during the growing season of a commercial crop. Besides, increases in lump sum income, as is the case with seasonal crop sales, may not be evenly distributed within the household.[3] In this study, we seek to fill the gap by establishing the channels that influence the different nutrient intakes following commercialization, as the existing evidence points to the heterogeneity of effects depending on the dominating factors in each context. A lot of focus has also been on calories and child nutrition.

From a gender perspective, evidence on agricultural commercialization in developing countries shows different production and consumption outcomes for men and women. This has been partly attributed to the limited prioritization of female farmers in the design and implementation of interventions that can effectively transform agriculture from its subsistence state to a commercial undertaking (Adenegan et al., 2013). The main reason for this lopsided attention relates to the sociocultural constraints in many developing countries that place limitations on the resources for production, markets and services for women (Pandey et al., 2016). Addressing constraints to participation is crucial as this has implications for food security and poverty reduction. For example, commercialization can undermine women’s control over certain agricultural crops. A case in point is a project in The

Gambia which introduced a new irrigation system for rice production, inadvertently transforming rice from a "woman's crop" to a male-controlled crop. This can have implications for household nutrition (Adenegan et al., 2013).

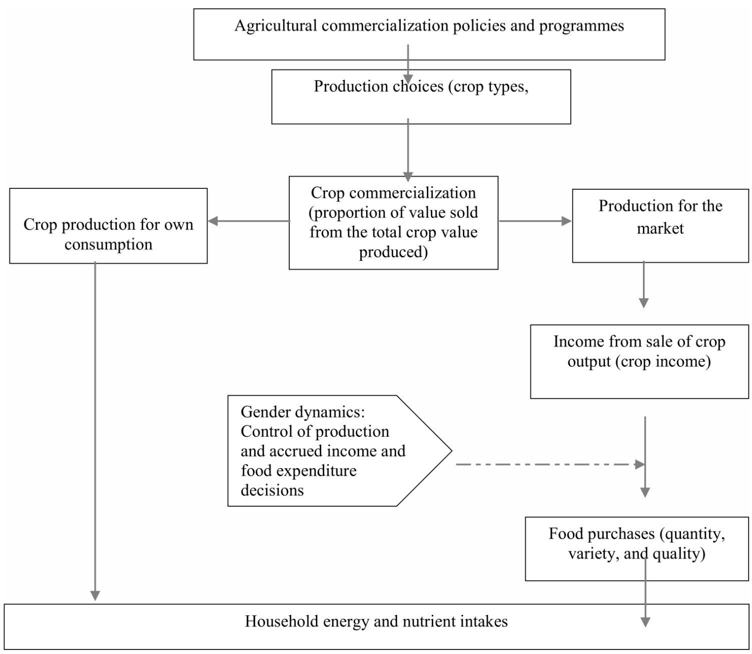
Household and individual health and nutrition effects of commercialization are related to changes in time and income. Decisions about the allocation of household income for food, childcare, health, and education depend on who is in control of the resources. For example, where women have less control over income and expenditure decisions and yet critical decisions regarding food, health and other household essentials are largely under their control, there are adverse implications for the nutritional outcomes of such households. Evidence from an irrigated rice project in Kenya in which the earnings from the crop were given only to men showed that household incomes rose but nutrition levels fell because women were dependent on their husbands for food expenditure (Suda, 1996). In Côte d'Ivoire, Duflo and Udry (2004) found that an increase in crops cultivated by women increased household food expenditures, while an increase in agricultural output grown by men had mostly no impact. Cross-country evidence from Tanzania, Uganda and Malawi indicates that female-headed households participate less in, but tend to sell larger shares of their production, conditional on participation (Carletto et al., 2017). From a policy and programme perspective, evidence shows that female-headed households tend to be different from male or jointly-headed households with respect to expenditure behaviour directly related to nutrition (see Allendorf, 2007; Pandey et al., 2016). This study therefore identifies gender as it relates to commercialization and nutrition in terms of sex of the household head.

Finally, the reviewed evidence shows a complex set of linkages which characterize the commercialization of agriculture and its impact on household nutrition. This underscores the fact that several scenarios can emerge depending on the factors dominating in each context (see Sraboni et al., 2014; Malapit and Quisumbing, 2015; Malapit et al., 2015; Ruel et al., 2017; an den Bold et al., 2013). As such, policies geared towards enhancing beneficial outcomes, while minimizing the adverse effects following such transformation must play a key role. Generally, the literature review of the link between agricultural commercialization and nutrition reveals that the findings can be as inconclusive as they can be mixed. As such, this study sheds light on this issue given the role which agricultural commercialization[4] can play in the socioeconomic transformation of developing economies. The overall focus is to identify mechanisms through which the positive benefits can be amplified while minimizing any adverse outcomes.

3. Conceptual Framework

The conceptual framework summarized in Figure 1 forms the basis for our empirical analysis of the channels through which policies and programmes geared towards increasing crop commercialization can result in improvements in nutrient intake among farming households. The basic premise is that the introduction of such policies and programmes influence farmers to make choices with respect to the type of crops grown and the production technology, subject to resource constraints. Crop production choices influence farm output which, in turn, determines the degree of success of crop commercialization. Commercialization in this case is defined by the proportion that is directed to the market versus the proportion that is retained for own consumption. These two subsets of output are expected to affect nutrient intake directly and indirectly. Basically, the proportion of the retained output directly affects nutrient intake via own consumption, while the sold output indirectly affects nutrient intake via the accrued income from the sold crops being committed to the purchase of food or not.

Figure 1: Crop commercialization and household nutrition



Source: Adapted from Von Braun et al. (1990) and Ogutu et al. (2017).

It is critical to note that the types of crops grown have implications for nutrition as they determine what is available within a household and in the market. Between the two subsets of output (sold or retained for home consumption), a balance is expected to be achieved from the fact that while selling the output can reduce the proportion that is available for own consumption, thereby limiting nutrient intake through the own production pathway, the resulting loss can be attenuated through market purchases from the accrued crop income. However, nutrient intake via the market purchases pathway is affected by gender dynamics which are underpinned, in part, by social-cultural factors. These factors determine the nature of decision-making within the household on how the accrued income is spent. This has implications for the quantity and quality of food purchased which, in turn, manifests in the amount of nutrients available to a household. Studies show that female-controlled income is often beneficial for household nutrition, as women tend to spend more on food, dietary quality, and healthcare than men. Thus, nutrition following crop commercialization is affected through the gender pathway from the accrued income, while the direct effect is from own production. Both channels have a direct effect on nutrient intake, depending on the production choices.

4. Methodology

4.1 Data

The study uses data from the 2013/14 Uganda National Panel Survey (UNPS), which captured data on agricultural production, household food consumption and a range of other socioeconomic and community characteristics. The UNPS is a nationally representative dataset with information on the key variables contained in the household, agriculture and community modules. The study focusses only on farming households (both rural and urban), defined as households that reported involvement in agricultural activities through ownership and/or cultivation of land and have non-zero crop production data.

4.2 A Theoretical Model for Crop Commercialization and Household Nutrient Intake

Household macro- and micro-nutrient intake is modelled in terms of a demand function within the framework of an agricultural household model. In the framework, a household is both a producer and a consumer of food. Following Kirimi et al. (2013), the household utility function is specified as:

$$U = \varphi(X_i, X_m, l; D_h)U = \varphi(X_i, X_m, l; D_h) \quad (1)$$

where U is a well-behaved utility function (assumed to be twice differentiable, increasing in its arguments, and strictly quasi-concave); X_i, and X_m are vectors of home-produced and market-produced goods, respectively, that are consumed by the household; l is leisure, D_h represents a set of a household's socioeconomic and environmental characteristics that influence preferences of household members. The household is assumed to maximize its utility from consumption of goods subject to farm production, income and time constraints.

4.2.1 *Empirical Estimation Strategy*

The analysis starts by estimating the overall effect of commercialization on calorie and micronutrient intake in Equation 2. Formally:

$$N_i = \alpha_0 + \alpha_1 CC_i + \alpha_2 X_i + \epsilon_i N_i = \alpha_0 + \alpha_1 CC_i + \alpha_2 X_i + \epsilon_i \quad (2)$$

where N_i is the nutrition indicator for household i, CC_i is the level of commercialization, X_i is a vector of control variables, and ϵ_i is a random error term. We use different nutrition indicators (N_i), namely: vitamin A, iron, zinc and calcium, which were computed using adult male equivalents (see Appendix A). The choice of nutrients for analysis was informed by evidence that deficiencies in vitamin A, zinc and iron pose serious health challenges in many developing countries. Thus, the consumption level of these three micronutrients is considered to be an important proxy for a healthy diet (Chege et al., 2015; Ogutu et al., 2017). The level of commercialization (CC_i) is a continuous variable ranging between zero (complete subsistence) and 1 (fully commercialized). Building on Strasberg et al. (1999) and Govereth et al. (1999), we construct a household crop commercialization index (CCI) as follows:

$$CCI_i = \frac{Gross\ value\ of\ crop\ sales_{hh_i,}}{Gross\ value\ of\ all\ crop\ production_{hh_i}}$$

Control variables (X_i) include age, sex and education of the household head, as well as other farm, household, community and environmental variables that may affect nutrition. In this model, we are particularly interested in the effect of α_1. Positive and significant estimates of α_1 would imply that commercialization contributes to improved nutrition, and vice versa. It is possible that the sign of α_1 differs between the nutrient indicators. For example, if households substitute energy-dense purchased foods for more nutritious own-produced foods, we would expect a positive coefficient α_1 in the calorie intake model and possibly negative coefficients in the micronutrient consumption models.

4.2.2 Addressing Potential Endogeneity in the Model

If X_i in Equation 2 includes all the factors that influence commercialization and there is no correlation between CCI_i and ϵ_i, then the ordinary least squares (OLS) method would produce an unbiased and consistent estimate of α_1. However, it is possible that there are unobserved factors that jointly influence CCI_i and N_i, which would lead to endogeneity bias. For example, unobserved heterogeneity could occur through differences in farmers' abilities or entrepreneurial skills, which are difficult to measure from the data. The potential for endogeneity of the commercialization variable (CCI_i) was tested through a control function (see Wooldridge, 2015; Smith and Blundell, 1986; Rivers and Vuong, 1988). This approach entails predicting residuals from a first-stage model of the determinants of commercialization, then using the predicted residual term as an additional regressor in the nutrition outcome model in Equation 2. Formally:

$$CC_i = \alpha_0 + \alpha_1 ncycle_i + \alpha_2 X_i + \epsilon_i \quad (3)$$

This control function approach requires at least one valid instrument in the first-stage regression. In this case, we use the variable $ncycle$ (the number of motorcycles per parish). A statistically significant coefficient of the predicted residual term obtained from Equation 3, and used in Equation 2, would imply that commercialization is endogenous and would also correct for the resulting bias. An insignificant residual term would fail to reject the null hypothesis of exogeneity of CCI_i. In that case, OLS would be preferred. Since CCI_i is bounded between 0 and 1, we estimated the first-stage regression (Equation 3) using a generalized linear model (GLM) with a binomial family and a probit link in order to obtain consistent residual predictions for use in Equation 2 (see Wooldridge, 2015; Papke and Wooldridge, 1996). Both stages of the process were based on bootstrapped standard errors of the observed coefficients.

4.2.3 *Choice of Instrument*

As noted earlier, the control function requires at least one instrument for inclusion in the first-stage regression. A valid instrument must be strongly correlated with commercialization (instrument relevance), but uncorrelated with omitted variables that may affect nutrition (instrument exogeneity), except indirectly through commercialization (Imbens and Wooldridge, 2009). The instrument of choice was the average number of motorcycles in a parish. The strength and validity of the chosen instrument for commercialization is based on the view that farmers without motorcycles can easily hire and take their produce to the markets (see, e.g., Ogutu et al., 2017). Similarly, traders who buy at farm gate prices can sell in the marketplace. Hence, the more motorcycles in a parish, the better the market access situation.

4.3 Analyzing the Transmission Channels for the Commercialization-Nutrition Nexus

The critical questions to better understand the transmission channels from commercialization to nutrition are the extent to which purchased foods are substituted for own-produced foods, and how this affects dietary quality. To analyze this, we estimated the different models in Equation 2, which entailed a differentiation between calories and micronutrients from purchased and own-produced foods. If households primarily purchase energy-dense foods in the market, we would expect a positive effect of commercialization on calorie consumption, but not necessarily micronutrient consumption from purchased foods. Conversely, the effects of commercialization on calorie and micronutrient consumption from own-produced foods would depend on possible changes in farm productivity and production diversity. Furthermore, we are also interested in better understanding the role of the income and gender pathways that were discussed earlier.

4.4 Nutrition Data and Measurement

The literature presents various measures of assessing nutrition among households, including clinical measures, anthropometric measures, food-consumption-based measures (De Haen et al., 2011). In this study, the data used include a food consumption recall, capturing the quantities of different food items consumed by all household members over a seven-day period. Survey respondents were also asked to specify the source of each food item consumed, including market purchases, own production, gifts and other sources. Based on the food quantities consumed by the household, edible portions were calculated which were then converted into calorie and micronutrient levels using food composition tables for Uganda (Hotz et al., 2012). We focus on vitamin A, zinc, iron and calcium as their deficiency has been noted to pose serious health challenges in many developing countries (Adepoju and Allen, 2019; Gernand et al., 2016; Tulchinsky, 2010; Lindsay, 2003).

We computed the calorie and micronutrient consumption at household level by adult male equivalents (see e.g., Karageorgou et al., 2018; Chiputwa and Qaim, 2016). Bromage et al. (2018) note that estimating diet from household survey data using direct inference from per capita household consumption is inferior to the disaggregated approach that uses the "adult male equivalent" method, as per capita household consumption overestimates dietary energy in single and multi-person households. We use minimum consumption recommended thresholds to characterize undersupplied households (FAO 2001; IOM, 2006). An individual's intake is considered to be inadequate when they consume less than 2,750 kcal per AME a day and 50g per AE per day for proteins. This would also be the case if their intake of vitamin A is less than 1,000µg of adult male equivalents. For zinc and iron, the thresholds are 14mg and 27mg, respectively, while for calcium it is 1,000mg.

4.5 Summary Statistics

From the summary statistics in Table 1 the average household, both rural and urban, sells approximately 71% of its total farm output. This highlights the fact that changes in market orientation have resulted in the disappearance of a strict dichotomy between "cash-crop" and "food-crop" agriculture as the ability to sell has increased. The policies geared towards production for the market appear to be yielding fruit. In the analysis, we seek to establish whether or not commercialization has translated into improved household welfare from a nutrient intake point of view. Urban-based households own more land with an acreage double that of their rural counterparts. The bigger size of total planted area compared to land ownership is attributed to the fact that a number of rural households seeking to expand their production typically rent land from large landowners who are typically urban based. In fact, the larger landowners who are mostly urban based tend to have their land lie fallow. It is these landowners who usually rent out to those that wish to actively engage in agriculture.

Table 1: Summary statistics of the key variables

Variable	Location	Observation	Mean	Standard Dev	Min	Max
Socioeconomic characteristics						
Education of house head (years)	Urban	1369	9.04	3.71	0.00	17.00
	Rural	2627	5.69	2.73	0.00	17.00
Age of household head (years)	Urban	2399	63.26	17.86	17.86	84.00
	Rural	6601	49.61	15.52	19.00	89.00
Male household head (dummy)	Urban	2399	0. 65	0.48	0.00	1.00
	Rural	6601	0.63	0.48	0.00	1.00
Household size	Urban	8668	4.71	2.85	1.00	23.00
	Rural	25188	5.33	2.85	1.00	24.00
Number of motorcycles (Parish)	Urban	8668	0.77	1.03	0.00	4.00
	Rural	25188	0.81	1.04	0.00	4.00
Value of farm assets (UGX'000)	Urban	266	131	188	5.05	863
	Rural	5137	57.60	70.05	2.00	438
Customary land tenure system	Urban	266	0.32	0.47	0.00	1.00
	Rural	5137	0.36	0.48	0.00	1.00
Presence of produce market	Urban	8668	0.032	0.179	0.00	1.00
	Rural	25,188	0.242	0.154	0.00	1.00
Farm production characteristics						
Crop commercialization index	Urban	266	0.71	0.20	0.27	1.00
	Rural	5137	0.71	0.22	0.13	1.00
Total land ownership (acres)	Urban	266	4.61	9.00	0.16	42.00
	Rural	5137	2.37	2.65	0.04	28.2
Planted area (acres)	Urban	266	3.59	2.16	1.1	10.5
	Rural	5137	4.1	3.23	0.12	22
Crop income (UGX '000)	Urban	266	262	417	103	1,809
	Rural	5137	195	267	10.02	2,703
Number of family workers	Urban	266	6.79	3.18	2.00	17.00
	Rural	5137	5.34	2.87	1.00	16.00

Note: UGX = Uganda Shilling.
Source: Author's computations from LSMS-ISA 2014 data.

Table 2 presents summary statistics for the nutrient intake indicators. All sampled households' intake of calories, calcium and protein is at least 75% of the recommended amount. Essentially, rural and urban alike access foodstuffs that are rich in proteins and calories, which is clearly demonstrated in the data.

Table 2: Summary statistics for total nutrient intake based on adult male equivalents

	National	Urban	Rural			**National**	**Urban**	**Rural**
Variable	Mean			Median	**Recommended**	Mean adequacy (%)		
Total calorie intake (kcal/day/AE)	2974.58	2274.76	3002.782	2420.70	2750.00	8.1*	82.72	9.1*
	(2277.5)	(1050.75)	(2308.95)					
Total calcium intake (mg/day/AE)	396.46	393.75	396.57	342.03	1000.00	39.65	39.38	39.66
	(275.67)	(277.67)	(275.6)					
Total protein intake (g/day/AE)	78.84	56.611	79.76	61.72	50.00	57.68*	13.22*	59.52*
	(71.18)	(39.05)	(72.05)					
Total iron intake (mg/day/AE)	9.63	8.56	9.28	9.06	27.40	35.15	35.15	33.87
	(5.32)	(4.59)	(4.87)					
Total zinc intake (mg/day/AE)	7.35	6.54	7.14	6.95	14.00	52.5	46.71	51
	(4.06)	(4.29)	(3.97)					
Total vitamin A intake (µg RE/day/AE)	833.89	676.69	840.44	603.18	1000.00	83.39	67.67	84.04
	(697.3)	(577.16)	(701.14)					
Observations	5403	266	5137					

Notes: The variables were analytically weighted before the summary statistics were computed. Energy and macro- and micro-nutrients were measured as follows: caloric intake (kcal/day/AE), calcium intake (mg/day/AE), protein intake (g/day/AE), iron intake (mg/day/AE), zinc intake (mg/day/AE), and vitamin A intake (µg RE/day/AE). AE, adult male equivalents; RE, retinol equivalent. Values for mean intake adequacy are computed as the percentage of recommended intake that is met. Asterisks indicate the percentage for which nutrient intake is above the recommendation based on the FAO/WHO recommended daily nutrient intake. The computations are based on food intake from a seven-day recall. Standard deviations are in parentheses.
Source: Authors' computations from LSMS-ISA data based on recommended thresholds.

The nutrition challenge is with respect to micronutrient intake where the levels are lower compared to calories and protein, where intake is above three quarters of the recommended threshold. Micronutrient intake is still low at the national level, save for vitamin A. However, there are challenges in the intake of vitamin A for the urban population. The national average micronutrient intake stands at only 52% for zinc and 35% for iron, while calcium stands at 40%. This finding is strikingly similar to that of Ogutu et al. (2017) in their study of the impact of commercialization on nutrition in Kenya where similar trends in micro-nutrient deficiency were found. What is fundamental to note is the fact that, as expected, rural households perform better on all indicators compared to their urban counterparts. This finding is contrary to the expectations that commercialization results in nutrient-rich food items being available in the market. As such, conditional on income, nutrition knowledge and market access, urban households should purchase the right foodstuffs. In order to make sense of Table 3, it should be noted that the percentage contribution for each nutrient is a function of: (a) the amount of the nutrient in the foods within the group, and (b) the amount of the food group in the consumption patterns. Food groups included in the consumption patterns in larger amounts contribute more than those included in smaller amounts. This is also the case for contributions of individual foods (item clusters) within each group. Item clusters that represent a larger proportion of the food group because they are more commonly consumed, such as grains and root tubers, may contribute more nutrients than those that are a smaller proportion of the group average due to limited consumption.

Table 3: Contribution of nutrient intake by food group (%)

Food group	Calories	Calcium	Protein	Iron	Zinc	Vitamin A
Cereals	32.36	2.18	14.73	55.74	2.73	3.61
Roots and tubers	9.76	3.66	7.20	8.49	5.21	0.03
Sugar and sweets	2.97	41.70	6.60	3.78	24.90	0.66
Pulses	0.85	23.66	52.95	0.15	4.91	24.56
Nuts	7.43	3.52	2.30	8.39	48.81	11.26
Vegetables	3.78	17.96	5.87	4.48	5.43	0.99
Fruits	1.64	1.25	2.35	2.21	2.24	2.82
Meat and poultry	5.24	2.10	4.66	5.79	4.20	0.61
Milk and diary	3.90	3.63	1.19	10.44	1.02	54.56
Fat and oil	23.28	0.11	0.32	0.16	0.27	0.71
Beverages	3.76	0.00	0.04	0.00	0.00	0.00

Source: Authors' computations.

Table 3 shows the contribution of the different food groups to the household calorie and micronutrient intake. It is important to note that most, if not all the nutrients are provided in substantial amounts by multiple food groups. Further note that the contribution of each food group and food pattern component (i.e., oils, solid fats and sugars) to the overall amount of energy and selected nutrients in the patterns is tremendous. Table 3 gives a snapshot of the dietary partners of households in Uganda.

5. Empirical Results and Discussion

5.1 Basic Model Results and Tests for Endogeneity

The discussion of the estimated results starts by looking at the tests for the endogeneity of crop commercialization.

Table 4: Estimates of commercialization effects on calorie and micronutrient intake

	CCI	Calories	Protein	Calcium	Iron	Zinc	Vitamin A
Number of motorcycles	0.042***						
	(0.010)						
Commercialization index		-0.872***	-1.020***	-0.836***	-0.335*	-0.517**	-0442
		(0.289)	(0.283)	(0.272)	(0.180)	(0.203)	(0.381)
Rural households dummy	-0.121**	-0.195	0.141	0.534**	0.602***	0.655***	-0754*
	(0.050)	(0.221)	(0.217)	(0.232)	(0.124)	(0.141)	(0.386)
Crop income	0.096***						
	(0.010)						
Number of family workers	0.067**						
	(0.027)	(0.159)	(0.167)	(0.132)	(0.093)	(0.095)	(0.223)
Proportion of planted area	0.052***	-0.073	-0.138	-0.346****	-0.119**	-0.171***	-0.130
	(0.014)	(0.097)	(0.098)	(0.085)	(0.053)	(0.053)	(0.119)
Total land ownership (acres)	0.023*	0.005	-0.086	-0.081	0.096**	0.036	-0.137
	(0.012)	(0.069)	(0.057)	(0.059)	(0.048)	(0.045)	(0.085)
Farm assets (UGX'000)	0.035***	0.254***	0.090***	0.392***	0.126***	0.098**	0.342***
	(0.012)	(0.075)	(0.079)	(0.070)	(0.044)	(0.048)	(0.096)
Education of house head (yrs)	-0.078***	0.048	0.018	-0.111	0.102	0.003	0.459***
	(0.021)	(0.120)	(0.110)	(0.095)	(0.069)	(0.073)	(0.153)
Household size		-0.013	0.362***	0.358***	0.286***	0.385***	-0.249
		(0.114)	(0.117)	(0.094)	(0.069)	(0.073)	(0.167)

Age of house head (yrs)	0.511	-1.473	1.409	2.583	1.234	1.252*	-7.876***
	(0.474)	(2.467)	(2.209)	(2.321)	(1.527)	(1.687)	(2.801)
Age of house head (yrs sq)	-0.075	0.194	-0.223	-0.384	-0.204	-0.182	1.076***
	(0.065)	(0.341)	(0.306)	(0.320)	(1.208)	(0.230)	(0.391)
Male house head (dummy)	0.054**	0.102	-0.175	-0.807***	-0.442***	-0.411***	0.307**
	(0.023)	(1.131)	(0.126)	(0.108)	(0.083)	(0.086)	(0157)
Freehold land tenure system	-0.061***	-0.856***	-0.665***	-0.426***	-0.323***	-0.330***	-1.073***
	(0.021)	(0.137)	(0.126)	(0.110)	(0.074)	(0.076)	(0.157)
Presence of produce market	0.173**	0.389	0.912***	0.582	0.4567*	0.003	0.699**
	(0.847)	(0.918)	(0.205)	(0.360)	(0.233)	(0.121)	(0.284)
Constant	-0.287***	5.199	-0.029	-4.836	-2.762	-4.271	-12.448***
	(0.842)	(4.193)	(0.126)	(3.959)	(2.765)	(2.999)	(4.548)
Log likelihood	142.817						
Adj-R^2	-	0.387	0.514	0.495	0.459	0.579	0.419
Observations		5403	5403	5403	5403	5403	5403

Notes: Model results are based on observed coefficients and bootstrapped standard errors in parentheses. The crop commercialization model was estimated using GLM, while OLS was applied to the rest. All results are based on observed coefficients and bootstrapped standard errors. *, ** and *** denote significance at 10%, 5% and 1% level, respectively.

Source: Authors' computations.

As noted in section 4, a control function was used with the average number of motorcycles owned by households in the parish as the instrument. The first-stage results with commercialization as the dependent variable are shown in the first column of Table 4. The coefficient estimates for the residual terms included in the second-stage equations are shown in Table 5 for all the relevant nutrient intake models. Both stages of estimation were bootstrapped. In all models, the residual terms from the first-stage GLM estimation are statistically significant, hence rejecting the null hypothesis of exogeneity of commercialization in the structural Equation 2 (see Table 5). In Table 4, the results in column 1 show that rural-based households engage less in production for sale, on average. This could be attributed to the pervasive nature of subsistence agriculture in the country and the fact that rural-based households, on average, are engaged in smallholder agriculture. Male-headed households, on average, are more commercialized than those headed by females. The role of the primary factors of production is brought into the picture with both farm capital, land and family labour, exhibiting a very significant and positive relationship with the likelihood that a household produces for sale. Furthermore, we find that larger households have more nutrient intake, on average, than smaller households. This could possibly be due to the fact that larger households are in a position to farm more, and therefore gain from having both crop income and consumption from own production.

The impact of commercialization on nutrient intake is negative for all nutrient intake indicators. However, rural households have better intake for some of the micronutrients such as calcium, iron and zinc, but perform less well than urban households in Vitamin A intake. This could be attributed to the fact that the bulk of vitamin A nutrients are derived from market purchases. From Table 4, it can be seen that commercialization has a negative and significant effect on nutrient intake. These findings suggest that commercialization on its own may not primarily result in improved household nutrient intake. In Table 6 we establish whether the nutrition effects of commercialization can be observed from one of the key channels (accrued income from crop market sales). More dimensions of the analysis follow based on our conceptual framework (Figure 1).

Table 5: Endogeneity test results for crop commercialization model based on control function

Variable	Coefficient	Std. error.	Z
Total calorie intake (kcal/day/AE)	-2.695	1.120	-2.410
Total calcium intake (mg/day/AE)	-2.004	0.901	-2.220
Total protein intake (g/day/AE)	-2.851	1.111	-2.570
Total iron intake (mg/day/AE)	- 17.998	10.880	-1.650
Total zinc intake (mg/day/AE)	-4.495	2.470	-1.820
Total vitamin A intake (μg RE/day/AE)	-5.426	1.393	-3.900

Note: Coefficients of the residual terms for the relevant models are shown with bootstrapped standard errors.
Source: Authors' computations from LSMS-ISA 2014 data.

Table 6 presents results for the effects of crop commercialization on household crop income and how crop income affects nutrient intake. The findings show positive effects of commercialization on crop income as well as the different factors that positively impact on crop income such as land ownership, land tenure and the age of the household head. From the results it is clear that commercialization affects nutrition via the accrued income from crop sales. This is in line with Bellin (1994), where a positive relationship between commercialization, income and nutrient intake was found. Rural households also have better nutrient intake compared to their urban counterparts. In line with the earlier findings on the negative effects of commercialization on nutrient intake, the proportion of planted area also has a negative effect on micronutrient intake in this case. Total land ownership has a significant effect on crop income, but is only positive for the intake of iron.

Table 6: Estimates of commercialization effects on crop income, calorie and micronutrient intake

Variables	Crop income	Calories	Protein	Calcium	Iron	Zinc	Vitamin A
Commercialization index	2.088***						
	(0.268)						

Crop income		0.087*	0.167***	0.148***	0.066**	0.144***	0.210***
		(0.048)	(0.042)	(0.042)	(0.031)	(0.031)	(0.063)
Rural household dummy	0.380*	0.376**	0.620***	0.837***	0.646***	0.736***	0.217
	(0.225)	(0.165)	(0.171)	(0.212)	(0.109)	(0.127)	(0.342)
Number of family workers	0.041						
	(0.155)	(0.112)	(0.125)	(0.118)	(0.072)	(0.080)	(0.169)
Proportion of planted area	0.091	0.195**	0.089	-0.202***	-0.097***	-0.132***	0.323***
	(0.078)	(0.076)	(0.078)	(0.055)	(0.037)	(0.037)	(0.066)
Total land ownership (acres)	0.402***	0.087	-0.007	-0.030	0.102**	0.049	0.022
	(0.067)	(0.056)	(0.050)	(0.062)	(0.045)	(0.042)	(0.080)
Farm assets (UGX'000)	0.102	0.106	-0.037	0.310***	0.114***	00.076*	0.091
	(0.083)	(0.067)	(0.073)	(0.062)	(0.039)	(0.046)	(0.078)
Education of house head (yrs)	0.065	0.281***	0.220**	0.019	0.120*	0.036	0.856***
	(0.116)	(0.097)	(0.091)	(0.083)	(0.063)	(0.065)	(0.140)
Household size		0.227**	0.566***	0.488***	0.305***	0.421***	0.156
		(0.089)	(0.089)	(0.084)	(0.056)	(0.062)	(0.128)
Age of house head (yrs)	11.288***	0.025**	2.689	3.401	1.369	1.482*	-5.398*
	(2.339)	(2.506)	(2.246)	(2.358)	(1.574)	(1.721)	(2.844)
Age of house head (yrs sq)	-1.542***	-0.039	-0.422	-0.511	-0.225	-0.218	0.689*
	(0.326)	(0.346)	(0.310)	(0.325)	(0.214)	(0.234)	(0.393)
Male house head (dummy)	-0.409***	-0.195	-0.418***	-0.959***	-0.466***	-0.455***	-0.192
	(0.118)	(0.120)	(0.102)	(0.099)	(0.075)	(0.081)	(0.132)
Freehold land tenure system	0.269***	-0.630***	-0.475***	-0.305***	-0.305***	-0.298***	-0.690***
	(0.097)	(0.116)	(0.112)	(0.107)	(0.066)	(0.068)	(0.140)
Presence of produce market	-0.131	0.255	0.346	0.254	-0.189	0.027	1.064*
	(0.524)	(0.697)	(0.555)	(0.549)	(0.260)	(0.299)	(0.596)
Constant	-11.011***	4.903	-3.246	-5.016	-2.812	-4.337	12.048**
	(4.107)	(4.314)	(3.894)	(4.100)	(2.853)	(3.055)	(4.734)
Adj-R^2	0.365	0.345	0.469	0.487	0.506	0.575	0.363
Observations	5403	5403	5403	5403	5403	5403	5403

Notes: Model results are based on observed coefficients and bootstrapped standard errors in parentheses. The crop commercialization model was estimated using GLM, while OLS was applied to the rest. All results are based on observed coefficients and bootstrapped standard errors. *, **, and *** denote significance at 10%, 5% and 1% level, respectively.

Source: Authors' computations.

Farm assets have a positive influence as they are key in boosting agricultural production, while households with the freehold land tenure system appear to utilize their land in ways that do not positively affect nutrient intake. Household size remains a key contributor to nutrient intake, perhaps underscoring the common dependency on family labour among smallholder farmers. It is thus possible that since smallholder farmers practice agriculture to meet their consumption needs, nutritional considerations are borne in mind in making their choice of what is produced. Crop income has a positive effect on calories as well as other measures of micronutrient intake. The results also show that households with younger heads generate higher incomes from agriculture compared to their older counterparts. Intake of micronutrient-rich food is also higher if the household heads are educated and female.

Generally, male-headed households perform poorly on nutrient intake and generation of crop income compared to their female counterparts. This finding is in line with Carletto et al. (2017), in a cross-country study on Eastern Africa where they indicate that while female-headed households participate less in commercialization, they tend to sell larger shares of their production, conditional on participation. Fischer and Qaim (2012) find that less male-controlled income is spent on dietary quality and nutrition than female-controlled income. This result reinforces a common finding in the literature on the effects of commercialization on income and gender, which shows that female-controlled income is often particularly beneficial for household nutrition, as women tend to spend more on food, dietary quality and healthcare than men (Hoddinott and Haddad, 1995; Chege et al., 2015). Thus, commercialization may potentially have different effects on household nutrition depending on the decision maker.

5.1.1 Effects of Commercialization on Nutrient Intake from Purchases and Own Production

In this section, we present results of the effects of commercialization on household nutrient intake from food purchases and own production. Table 7 shows the results of the effects on nutrient intake from purchased foods.

Table 7: Estimates of commercialization effects on purchased calorie and micronutrient intake

	Calories	Protein	Calcium	Iron	Zinc	Vitamin A
Commercialization index	0.578*	0.041	0.633	0.039	-0.003	0.043
	(0.336)	(0.409)	(0.392)	(0.445)	(0.397)	(0.627)
Rural household dummy	-0.089	0.331	0.110	0.375	0.559	-1.164
	(0.256)	(0.496)	(0.429)	(0.536)	(0.511)	(0.437)
Crop income						

Number of family workers						
Proportion of planted area	0.099	-0.192***	-0.083	-0.077***	-0.244***	0.043
	(0.192)	(0.052)	(0.084)	(0.025)	(0.080)	(0.068)
Total land ownership (acres)	-0.243**	-0.371***	-0.214**	-0.428***	-0.342***	-0.131
	(0.097)	(0.100)	(0.100)	(0.110)	(0.098)	(0.143)
Farm assets (UGX'000)	0.321***	0.115	0.228**	0.183*	0.127	0.120
	(0.073)	(0.094)	(0.091)	(0.102)	(0.095)	(0.127)
Education of house head (yrs)	0.026	-0.462**	-0.746***	-0.526**	-0.593***	-0.350
	(0.189)	(0.216)	(0.229)	(0.218)	(0.214)	(0.281)
Household size	0.531*	0.048	0.286	0.270	0.223	-0.028
	(0.277)	(0.340)	(0.359)	(0.371)	(0.369)	(0.437)
Age of house head (yrs)	-3.380	-8.017*	1.230	-10.211**	-10.448**	-2.973
	(3.071)	(4.390)	(4.358)	(4.582)	(4.127)	(4.882)
Age of house head (yrs sq)	0.526	1.215**	-0.089	1.508**	1.568***	0.391
	(0.421)	(0.608)	(0.609)	(0.636)	(0.573)	(0.672)
Male house head (dummy)	0.623***	1.145***	0.573**	1.338***	1.111***	0.896***
	(0.190)	(0.252)	(0.252)	(0.247)	(0.248)	(0.286)
Freehold land tenure system	-1.503***	-1.779***	-1.463***	-1.646***	-1.460***	-2.238***
	(0.151)	(0.186)	(0.211)	(0.207)	(0.193)	(0.249)
Presence of produce market	0.991	0.395	0.397	0.297	0.397	1.498
	(0.935)	(0.801)	(0.891)	(0.792)	(0.786)	(1.456)
Constant	7.764	25.585***	-0.770	25.376***	15.388**	7.230
	(5.083)	(7.579)	(7.196)	(7.742)	(6.909)	(8.787)
Adj-R^2	0.341	0.387	0.264	0.321	0.271	0.382
Observations	5403	5403	5403	5403	5403	5403

Notes: Model results are based on observed coefficients and bootstrapped standard errors in parentheses. The crop commercialization model was estimated using GLM, while OLS was applied to the rest. All results are based on observed coefficients and bootstrapped standard errors. *, ** and *** denote significance at 10%, 5% and 1% level, respectively.

Source: Authors' computations.

The results in Table 7 suggest that commercialization has positive but weakly significant effects only on the consumption of calories. A unit percentage-point increase in the level of commercialization increases calorie consumption from purchased foods by 0.58 units/AE/day. In his study on Kenya, Ogutu et al. (2017) found that the benefits of commercialization resulted in increased consumption of both calories and micronutrients from purchases. In Uganda's case, we see that the effect is only on calorie intake. This finding is in line with our postulation that households that purchase energy-dense foods register positive effects of commercialization on calorie intake.

This might be the case with Uganda given that the bulk of the staple foods are rich in calories. In addition, food consumption data show that the bulk of calories are derived from purchased foodstuffs and that these are primarily from the consumption of cereals and grain products, beverages, and fats and oils. The proportion of planted area has a negative effect on nutrient intake. This implies that more production could result in better nutrition only and only if the resulting income is spent on purchasing nutrient-rich foods. Male-headed households have better nutrient intake from food purchases.

Table 8: Estimates of commercialization effects on own-produced calorie and micronutrient intake

	Calories	Protein	Calcium	Iron	Zinc	Vitamin A
Commercialization index	-0.995***	-0.770**	-1.614***	-0.931***	-0.604*	-0.042
	(0.305)	(0.345)	(0.389)	(0.329)	(0.330)	(0.511)
Rural household dummy	0.441	0.172	0.685*	0.390	0.407	3.768***
	(0.279)	(0.340)	(0.380)	(0.288)	(0.293)	(0.581)
Crop income						
Number of family workers						
Proportion of planted area	0.043	-0.427***	-0.123	-0.474***	-0.404***	0.204
	(0.133)	(0.160)	(0.158)	(0.160)	(0.151)	(0.229)
Total land ownership (acres)	0.237**	0.040	-0.060	0.095	0.052	0.003
	(0.093)	(0.090)	(0.103)	(0.086)	(0.090)	(0.144)
Farm assets (UGX'000)	0.304***	0.366***	0.491***	0.268***	0.360***	0.425**
	(0.066)	(0.080)	(0.110)	(0.082)	(0.077)	(0.176)
Education of house head (yrs)	-0.061	-0.147	-0.232	-0.091	-0.256*	0.642***
	(0.126)	(0.146)	(0.166)	(0.139)	(0.138)	(0.240)
Household size	0.417**	0.272	0.342	0.219	0.350	0.769
	(0.204)	(0.266)	(0.355)	(0.234)	(0.249)	(0.490)
Age of house head (yrs)	-2.461	-1.827	-7.256**	-1.655	-2.629	-21.927***
	(2.751)	(3.158)	(3.237)	(3.251)	(2.974)	(4.961)
Age of house head (yrs sq)	0.313	0.229	0.989**	0.171	0.342	2.888***
	(0.379)	(0.435)	(0.445)	(0.447)	(0.408)	(0.685)
Male house head (dummy)	-1.073***	-1.239***	-1.222***	-1.152***	-1.184***	-1.331***
	(0.171)	(0.191)	(0.191)	(0.181)	(0.183)	(0.255)
Freehold land tenure system	0.270*	0.421**	0.161	0.334**	0.313*	1.203***
	(0.161)	(0.181)	(0.185)	(0.168)	(0.169)	(0.282)

Presence of produce market	0.001	-0.145	0.026	-0.522	-0.178	1.055
	(0.380)	(0.328)	(0.400)	(0.544)	(0.340)	(0.690)
Constant	8.927	2.665	10.679*	2.458	1.367	32.009***
	(8.802)	(5.400)	(5.580)	(5. 460)	(5.076)	(8.295)
Adj-R^2	0.417	0.466	0.489	0.378	0.440	0449
Observations	5403	5403	5403	5403	5403	5403

Notes: Model results are based on observed coefficients and bootstrapped standard errors in parentheses. The crop commercialization model was estimated using GLM, while OLS was applied to the rest. All results are based on observed coefficients and bootstrapped standard errors. *, ** and *** denote significance at 10%, 5% and 1% level, respectively.

Source: Authors' computations.

Table 8 shows that commercialization has negative and significant effects on the consumption of calories and micronutrients from own-produced food. This is an insightful finding and could be attributed to the fact that the increase in market-oriented agriculture results in households selling their farm produce. Hence, commercialization can only be beneficial for nutrition if the resulting income is spent on nutrient-rich foods as the results in Table 5 show. Carletto et al. (2017) note that while income is crucial for improving nutrient intake, as the current findings show, it may not necessarily result in improving household nutrient intake if households are not deliberate about obtaining nutrient-rich food. Farm assets maintain significant and positive effects for nutrient intake, while male-headed households have positive effects on nutrient intake from food purchases; the converse is not true for intake from own production. Households with older heads have a higher intake of Vitamin A nutrients from own production.

6. Conclusion

While studies on agricultural commercialization show that it can improve productivity and income for farmers, evidence of its effects on household nutrition is not obvious. This study adds to the literature by not only analyzing household nutrient intake under commercialization, but also identifies the transmission channels by which the observed effects are realized. In this study, the summary statistics indicate that, on average, rural households have better nutrient intakes compared to their urban counterparts. In a review of Africa's agriculture, Christiaensen (2017) shows that while market participation remains widespread, the extent of agricultural commercialization is limited, without clear benefits for nutritional outcomes. In this paper, it was established that commercialization affected nutrition negatively in all indicators. This finding could be attributed to the fact that decisions regarding food consumption depended on several factors. For example, commercialization can increase real household income with the potential to enhance food consumption, which would then impact household nutrition positively. However, there are challenges for such an outcome to be realized. Intra-household factors may stand in the way in cases where individual household members possess different income elasticities overall, or even within foodstuffs.

Furthermore, even when additional income is spent on food, intra-household food consumption could be heterogeneously distributed among family members, with children and women often being relatively penalized compared to adult males (Carletto et al., 2017). In addition, a high marginal propensity to spend on food does not automatically imply a high marginal propensity to consume nutrient-rich diets. Households often choose to go for "variety" by purchasing "fancy" higher cost diets rather than simply using the acquired income to increase nutrient intake (Von Braun and Kennedy, 1994). Also, in the context of Uganda and Africa generally, the effects of commercialization on nutrition are rooted in the socioeconomic and cultural settings of the population. Sociocultural constraints in many developing countries place limitations on what kinds of food is consumed with little or no regard to its nutritional value.

Two important policy implications emerge from this study. First, given that agricultural commercialization is beneficial to nutrient intake via income generation, nutrition-sensitive commercial agriculture is critical. This points to the need to proactively provide incentives that engender commercial agricultural production that addresses the nutritional needs of the population so that nutrient-rich food is easily available on the market. This is key because AGRA (2016) indicates that such efforts have often been met with the challenge that farmers in Africa are left with little or no incentive to produce nutrient-rich food. It notes that in some rural communities, while indigenous foods with high nutritional value still exist, they are produced by fewer farmers and their cost is often so high that poor households are not always able to afford them. Second, as rural-based households are less commercialized, on average, they need support in order to benefit from market-oriented agricultural production. The current government policy on credit and agricultural input provision through the programme code-named “Operation Wealth Creation” is one such intervention that can help improve rural household market participation.

Notes

1 A lot of literature on this subject exists (see, e.g., Popkin et al., 2012; Fischer and Qaim, 2012).

2 The IFPRI research agenda on agricultural commercialization and nutrition spanned the period of the mid-1980s to the mid-1990s.

3 This is the dilemma which smallholder farmers who have switched to sugar-cane production in Eastern Uganda quite often face.

4 In this study we focus on agricultural crop commercialization.

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Appendix A

Table A1: Comparing per capita and AME-based intra-household distribution of corn meal

Sex	Age (years)	Energy requirements (kcal/d)	AME	Household AME	Individual AME (AME ÷ Household AME)	Individual consumption (g/d), AME	Individual consumption (g/d), PC
Female	48	2,375	0.778688525	3.508196721	0.221962617	366.2	412.5
Male	50	3,000	0.983606557	3.508196721	0.280373832	462.6	412.5
Male	19	3,050	1	3.508196721	0.285046729	470.3	412.5
Female	12	2,275	0.745901639	3.508196721	0.212616822	350.8	412.5

Notes: The AMEs were calculated based on FAO guidelines (Weisell and Dop, 2012). Daily energy requirements were calculated based on tables for energy requirements, assuming moderate physical activity for individuals (FAO, 2004). For children under 1 year of age we used the average energy requirements of the 12 months.

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