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Abstract

Agriculture commercialization is seen as a pathway towards rural economic transformation since it is expected to enhance a wide array of household welfare indicators. This study examines the channels through which household nutrient intake can be influenced in the process of crop commercialization. This was investigated using LSMS-ISA survey data for Uganda under the control function approach. The findings show that while commercialization increases crop income, its impact on overall nutrient intake was negative. Another crucial finding was that while rural based households stood to gain more from the crop commercialization benefits, they were less commercialized on average. The role of markets as a key ingredient in the agricultural commercialization process was confirmed, with households that had access to an agricultural produce market being more commercialized and with better nutrient intake. Male headed households practice more commercialization on average. However, their households have less nutrient intake compared to their female headed counterparts. While this finding is in line with a considerable strand of the literature, it casts a shadow on the nutritional benefits of agricultural commercialization given that majority households in Uganda are male headed. The findings point to two important policy implications. First, policy interventions geared towards agricultural commercialization are proving beneficial for household income generation. However, this is not necessarily translating into improved nutrient intake. Second, the rural households who are the primary target of the commercialisation policy are less commercialized. These need support. Third, there is the need for the improvement of societal knowledge and perception about what constitutes a good diet. Basically, while there is a link between agricultural production, income, education, health and nutrition. This link is so far weak in this study and previous evidence on a number of developing countries.

1. Introduction

The transition from subsistence to commercial agriculture has been proposed as key to socioeconomic transformation. The economies of scale associated with agricultural commercialization are expected to enhance production efficiency which in turn is expected to improve household income and the prospects for economic growth. Big gains are expected among rural households whose livelihood is directly derived from agriculture. Household income, consumption, food security and nutrition are expected to improve as a result. In anticipation of such benefits, many developing countries have embarked on agricultural commercialization as a growth strategy. In Uganda, objective 3 of the country's National Agricultural Policy seeks to "promote specialization in strategic, profitable and viable enterprises and value addition through agro-zoning". This is informed by the understanding that commodity specialization and agro-zoning strengthen agri-business, enhance profitability and market access, leading to the creation of farm and off-farm employment. The creation of additional employment opportunities necessitates increased commercialization of agriculture and the establishment of industries for value addition to agricultural products (GoU, 2013).

The literature on the nexus between agriculture and nutrition mainly focuses 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). Another strand of literature analyses the effects of agricultural commercialization on household welfare, in terms of income (Muriithi, and Matz, 2015). However, the impacts of commercialization may impact income but not nutrient intake . For instance, the risk of micronutrient malnutrition can result into health problems of an inter-generational nature (Ecker and Qaim, 2011; Horton and Ross, 2003). In addition, substitution of own-produced food with purchases may also change dietary quality, possibly increasing the consumption of calories but not necessarily micronutrients (Popkin et al., 2012). Following commercialization, changes in gender roles tend to emerge as men take charge of farm production as well as the accrued income (von Braun and Kennedy, 1994; Ogutu et al., 2017). Yet, evidence shows that agricultural income in male controlled households is often spent on other things than improve household dietary quality (Fischer and Qaim, 2012).

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 literature which emphasize that agricultural commercialization may not yield the desired welfare effects (see Carletto et al., 2017; Herens et al., 2018). This is likely to be the case for the poor households that are positioned at the lowest income strata (Carletto et al., 2017). 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 put 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 to food production (see Mwavu et al., 2018).

Mwavu et al. (2018), in their study of the food security implications of expanded sugarcane cultivation among smallholder farmers in Uganda show that households that chose to cultivate sugarcane are food insecure, as they are 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 the sugarcane growing regions were rapidly losing important and nutritious food crops like cowpeas, soya beans, aerial yams, and Bambara groundnuts, with dire implications for household food security. Households were reportedly coping with food insecurity by resorting to offering labor in exchange for food, borrowing and rationing food, and at times using unsavory survival strategies such as stealing from their neighbours (Mwavu et al., 2018).

Furthermore, critics of commercial crops contend that the resources used to produce such crops would otherwise be used to produce food for the local economy so that nutrition and household food security are improved. Proponents on the other hand insist that production of commercial crops such as sugarcane can increase their income which in turn, can improve nutrition. Bouis and Haddad (1990), in their study of agricultural commercialization and nutrition in the Philippines found that smallholder sugarcane land owners 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 stuck on the proposition that such commercialization has generally been detrimental to household welfare. This study therefore contributes to the nutrition and food security debate by investigating the link between commercialization and nutrient intake using a series of econometric procedures on a nationally-representative household survey dataset for Uganda.

From the existing evidence on the commercialisation-nutrition linkage, Von Brown et al. (1990); Headey et al. (2012); 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 a household. Based these channels, we use a framework by Von Brown et al. (1990) to hypothesise that both commercialisation policies and programmes which the government of Uganda has undertaken over the years are important determinants of household nutrition among farm households in Uganda.

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

a) Does crop commercialization affect agricultural income?
b) Does nutrient intake vary between urban and rural based households?
c) Does commercialization result in improved household micronutrient and caloric intake?
d) How does commercialization influence micronutrient and caloric intake from the different food acquisition sources?
e) How do socioeconomic factors influence micro and macronutrient intake?

Objectives

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

i) Determine the relationship between crop commercialization and agricultural income.
ii) Analyze the differences in macro and micro-nutrient intake between the urban and rural households.
iii) Examine the effect of commercialisation on macro and micronutrient intake.
iv) Determine the effects of crop commercialization on calorie and micronutrient intake from the different food sources.
v) Examine the socio-economic factors that influence macro and micro-nutrient intake among the farming households.

Contribution

While previous studies have analyzed the effects of commercialization on productivity and income, the implications of such commercialization on household nutrition have received much less attention. This study adds to the literature on the impacts of crop commercialization on nutrient intake by analyzing household calorie and micronutrient intake for 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 approach is used to address issues of endogeneity.

As a departure from studies on nutrition in the developing world, we assess both calorie and micronutrient intake given that a number of studies especially on nutrition outcomes in Sub Saharan Africa have often concentrated on calorie intake, mainly through staples (AGRA, 2016). However, malnutrition in all its forms—undernutrition, micronutrient deficiencies, and overweight and obesity have 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 results from reduced adult productivity in individuals who are malnourished (stunted) as children, resulting in premature adult mortality, loss in human capital investment, and increased health-care costs for malnutrition related non-communicable diseases. Malnutrition also presents intergenerational consequences and when nutrition status improves, it helps break the intergenerational cycle of poverty, generates broad-based economic growth, and leads to a host of positive consequences for individuals, families, communities, and countries (AGRA, 2016).

In Uganda, while the contribution of the agricultural sector to GDP has declined from 51 percent in 1992/93 to approximately 23 percent, it still remains a key sector in the provision of employment, foreign exchange earnings and most importantly, a source of food and nutrition security for the country (MoFPED, 2016). In terms of employment, the sector employs about 77 percent of the rural adult population, and 89 percent for the poorer households (World Bank, 2015). Against this background, this study seeks to establish whether government policies and programmes on market oriented agricultural productivity enhancement are contributing to improved indicators of household nutrient intake.

This investigation is very critical, given previous experiences on policies aimed at boosting agricultural production in Africa. For instance, the food shortages which were experienced in Malawi during the mid-2000s saw the introduction of the 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 current investigation is crucial 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 do not consistently afford them. This, notwithstanding the fact that their nutritional value is proven and known. This is occurring amidst the fact that while ensuring 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 such issues in light of the ongoing agricultural commercialization efforts in Uganda.

Policy context of agricultural commercialization and nutrition

Sub-Saharan Africa and South Asia and are two regions of the world with the highest concentration of undernutrition (Gillespie et al., 2015). However, it is worth noting that bulk of this under nourished population primarily depends on agriculture as a source of livelihood. Agriculture is a critical sector in any attempts towards sustained reduction in undernutrition and 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, improve access to and sustainability of markets, 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 instance, 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, increasing the share of farm production that is marketed and creating off farm and on farm employment (Adong et al., 2014; Kasirye, 2013).

The National Agriculture Advisory Services (NAADS) as a pillar of the PMA was a significant contributor towards agriculture 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 commercialized farmer at district and or sub county level plus nuclear farmers at the national level to ensure 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. NAADS also supports farmers to get organized into groups along a common identifiable farming interest. This was done with the 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) program. 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. Market stability was to be 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 Prosperity for All program whose aim is to ensure that all households earn a minimum of 20 million shillings (US$ 6000) annually through the effective selection of profitable farm enterprises.

The foregoing discussion provides a highlight of 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 undernutrition, it is yet to realize this potential (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 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. This can be the case as Herforth and Ahmed (2015) found that the 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 to 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 instance, Levitt et al. (2009) in a comparative assessment of priorities and perceptions of malnutrition in Afghanistan found that 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 being through income generation (the primary motivation behind the policy initiatives towards agricultural commercialisation), household food production, education, and women's empowerment.

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. We draw on evidence from Uganda and position it within the literature from other regions of the world on the agriculture-nutrition nexus. The study highlights four key issues. First, the need to improve knowledge and perception of what constitutes a good diet which in turn, results in better nutrition, the link between agricultural production, income and nutrition, the role of gender relations in driving agricultural production, household expenditure and its impact on nutrition, and finally, the link between agricultural policy and health policy in generating system-wide incentives for decisions and actions to become nutrition sensitive.

2. Literature review

The early works on the nutrition outcomes of agricultural commercialization 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 were observed to have opposite effects both between and within countries. Such studies focused their 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). Over time however, the current cropping systems no longer have a strict dichotomy between crops as cash and non-crops. Subsequently, studies especially by the International Food and Policy Research Institute (IFPRI)[1] 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, this cohort of studies (See von Braun et al., 1989) examines 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 limited resources (such as land, labor 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 positively impact household nutrition. 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, and even within food stuffs. 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 the 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 pursing higher cost diets rather than simply use the acquired income to increase nutrient intake (von Braun and Kennedy, 1994).

Some studies on the impact of agricultural commercialization on the 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 caloric intake and child caloric 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. 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[2].

With respect to the gender impacts, Duflo and Udry (2004) found that an increase in crops cultivated by women in Cote d'Ivoire increased household food expenditures, while an increase in agricultural output grown by men had mostly no impact. Preliminary evidence from a cross country study on Tanzania Uganda and Malawi indicates that female-headed households participate less but tend to sell larger shares of their production, conditional on participation (Carletto et al., 2017). The complex set of linkages which characterize the commercialization of agriculture and its impact on household nutrition only points to 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; van den Bold et al., 2013) As such, policies geared at enhancing beneficial outcomes while minimizing the adverse ones following such transformation must of necessity play a key role.

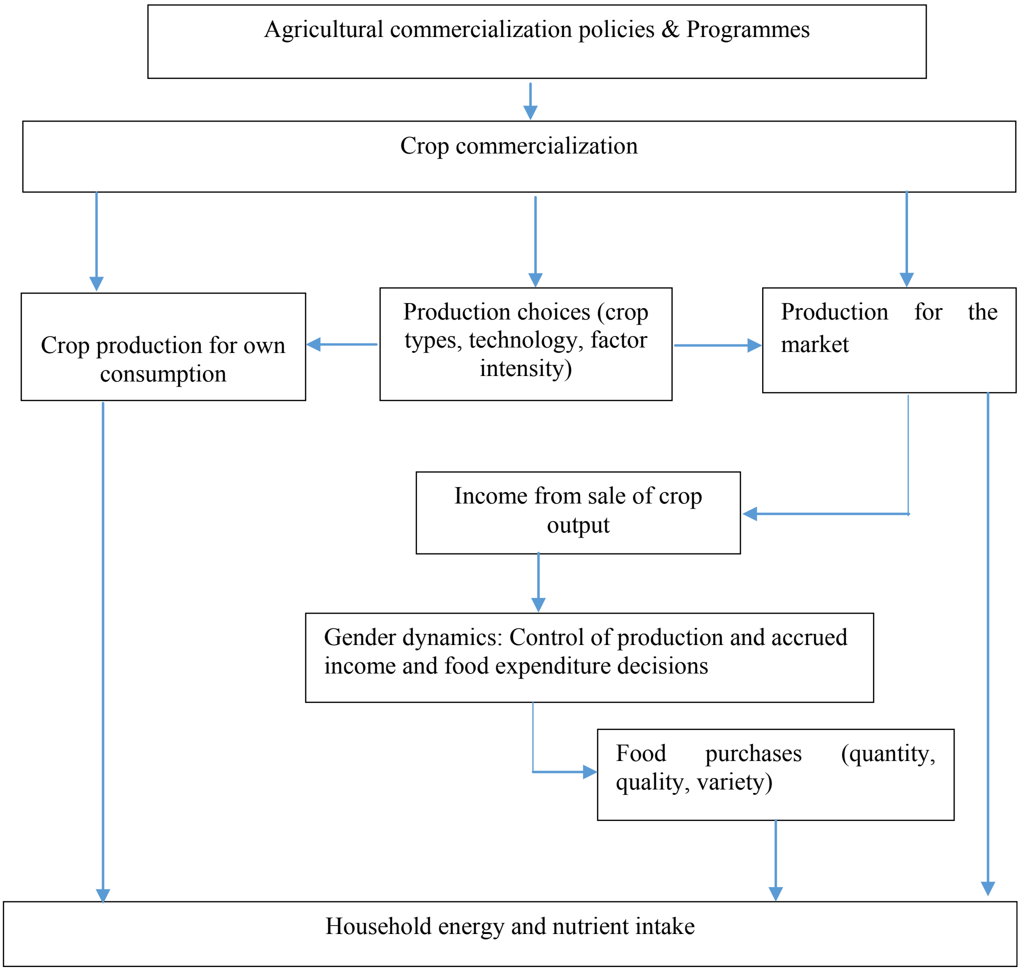
The foregoing review of the link between agricultural commercialization and nutrition reveals that the findings can be as inconclusive as they can be mixed. As such, this study sheds light on this issue given the role which agricultural commercialization[3] can play in the socioeconomic transformation 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. Basically, the introduction of policies and programmes aimed at increasing crop production and providing channels through which the resulting output can be marketed, are expected to lead to crop commercialization. In this study, objective 3 of the National Agricultural Policy that seeks to "promote specialization in strategic, profitable and viable enterprises and value addition forms the basis for the different programmes that have been pursued in order to drive agricultural commercialization. These include: The Poverty Eradication Action Plan (PEAP), the Plan for Modernization of Agriculture (PMA), the National Agricultural Advisory Services (NAADS), the Rural Development Strategy (RDS), and the Prosperity for All programme. The resulting production and market orientation from the afore-mentioned programmes are expected to affect household nutrition through the various channels. For instance, market sales can reduce the availability of own-produced foods and thus limit consumption through the own crop production pathway. However, a fall in food consumption from own production may be prevented through food purchases from the market through income generated from the sold crops. Evidence shows that commercialization is typically associated with income gains through agricultural intensification and use of better technology (von Braun and Kennedy 1994; Muriithi, and Matz 2015; Ogutu et al., 2017). Commercialization may also influence the types of crops grown or the livestock species kept on the farm all of which have implications for nutrition. Closer market integration allows farmers to better harness their comparative advantage, so that higher levels of specialization are generally expected.

A focus on the production of non-food cash crops could further reduce the availability of own-produced foods for consumption. Yet, in specific situations, it is also possible that farmers further diversify production, especially when markets for certain niche products that are not traditionally grown for own consumption emerge (Tipraqsa and Schreinemachers, 2009). In an African context, the levels of commercialization, types of crops grown, and technologies used can also have important effects on gender roles within the household. Subsistence food crops are often produced and controlled by women, while cash crops are typically controlled by men (von Braun et al., 1994; Fischer and Qaim, 2012). 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 (Hoddinott and Haddad 1995; Chege et al., 2015). Thus, commercialization may potentially have a negative partial effect on household nutrition through the gender pathway.

Figure 1: Crop commercialization and household nutrition



Source: Adopted from von Brown et al. (1990); Ogutu et al. (2017)

4. Methodology

Data

The study uses data from the 2013/14 wave of the Uganda National Panel Survey (UNPS). The survey captures data on agricultural production, household food consumption and a range of other socioeconomic, 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 focuses 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.

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. In this study, we follow Kirimi et al. (2013) where the household utility function is specified as:

$$U = \varphi(X_i, X_m, l; D_h) \tag{1}$$

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_i 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.

Empirical estimation strategy

The analysis starts by estimating the overall effect of commercialization on calorie and micronutrient intake with equation (2). Formally:

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

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 Equivalence (see Appendix A1). 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 instance, 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.

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 ordinary least squares (OLS) would produce unbiased estimates 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 instance, unobserved heterogeneity could occur through differences in farmers' ability or entrepreneurial skills, which are difficult to measure in the data. Potential for endogeneity of the commercialization variable (CCI_i) was tested through a control function (see Wooldridge, 2015; Smith and Blundell, 1986; Rivers and Voung, 1988). This approach entails predicting residuals from a first-stage model of the determinants of commercialization, and using the predicted residual term as an additional regressor in the nutrition outcome model in equation (2). Formally:

$$CC_i = \alpha_0 + \alpha_1 ncycle_i + \alpha_2 X_i + \epsilon_i \tag{3}$$

This control function approach requires at least one valid instrument in the first-stage regression. In this case, we use the variable ncycle which is the number of motorcycles in a 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.

Choice of instrument

As earlier on noted, 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 market place. Hence, the more are the motorcycles in a parish, the better is the market access situation.

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 in detail, we estimated the different models in equation (2). This 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. On the other hand, the effects of commercialization on calorie and micronutrient consumption from own-produced foods will 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 in the foregoing.

Nutrition data and measurement

The literature presents various measures of assessing nutrition among households, including clinical measures, anthropometric measures, food consumption-based measures, among others (de Haen et al., 2011). In this study, the data used includes a food consumption recall, capturing the quantities of different food items consumed by all household members over a 7 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). In terms of micronutrients, we focus on vitamin A, zinc, iron and calcium.

We computed the calorie and micronutrient consumption at household level by adult male equivalence (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 percapita household consumption is inferior to the disaggregated approach that uses the "adult male equivalent" method, as percapita household consumption overestimates dietary energy in single and multi-person households. We use minimum consumption thresholds to characterize undersupplied households (FAO, WHO and UNU, 2001; IOM 2006). An individual's intake is considered to be inadequate when it consumes less than 2750 kcal per AE and day and 50g per AE per day for proteins. This would also be the case if its intake of vitamin A is less than 1000µg of retinol equivalents (RE). For zinc and iron, the thresholds are 14mg and 27mg respectively while calcium is 1000mg. Section 5 follows with the empirical results and analysis.

Summary statistics

From the summary statistics in Table 1, the average household both rural and urban sells approximately 71% of its total farm output.

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

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

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 be sold 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, the commercialization has translated into improved household welfare from a nutrient intake point of view. It is interesting to note that while the urban based households own more land with an acreage that doubles that of their rural counterpart. 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 the large land owners. In fact, the larger land owners are the urban based many of whom have their land under fallow. It is these that usually rent out to those that wish to actively engage in agriculture.

Table 2 presents summary statistics for the nutrition indicators. All sampled households perform well with respect calorie, calcium and protein intake. Essentially, Ugandan households, rural and urban alike consume food stuff that is rich in proteins and calories, and this is quite clearly demonstrated in the data.

The nutrition challenge is with respect to micronutrient intake where the levels are not as high compared to calories and protein, where intake is above three quarters of the recommended intake. Micronutrient intake is still low, save for vitamin A at the national level. 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, 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 nutrition indicators compared to their urban counterparts. This finding is contrary to the expectation given that commercialization results in food items being available in the market. As such, conditional on income, nutrition knowledge and market access, urban households should purchase the right food stuff.

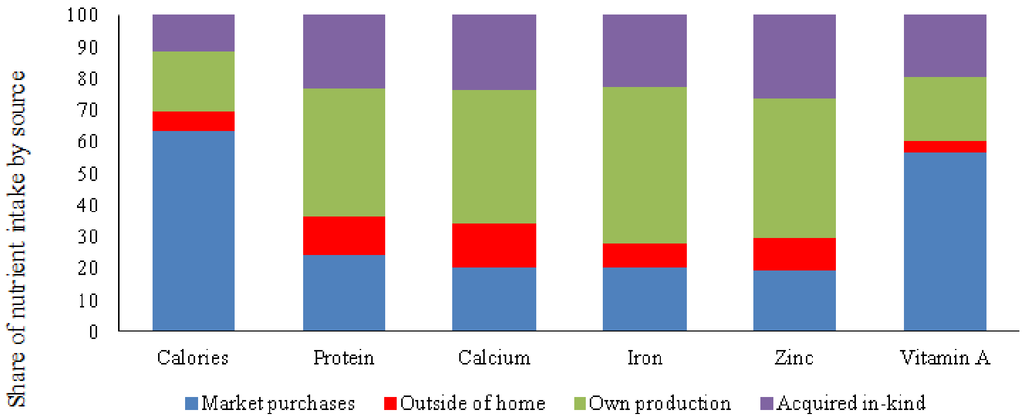
Figure 2 shows a breakdown of the sources of household calorie and micronutrient intake. Much of the intake of protein, zinc, calcium and iron is derived from own production while market purchases are an important source of calories and vitamin A. For protein, calcium, iron and zinc, market purchases and consumption in-kind also play a role in their intake. These findings serve to reinforce the role of commercialization in improving nutrient intake given the fact that it provides an opportunity for households to improve their diets either from their own production or through market purchases. Market oriented production gives the opportunity to access a variety of food stuff beyond what is produced with households. Given this finding, controlling for everything else, both household income and own production are critical for improving household nutrition. The nutrient intake by food group is presented in Table A2 in the Appendix.

Table 2: Summary statistics for total nutrient intake based on Adult Male Equivalent

Variable	National	Urban	Rural			National	Urban	Rural
		Mean		Median	**Recommended**	Mean	Adequacy	**(%)**
Total caloric 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 analytic weighted before the summary statistics were computed. Energy and macro and micronutrients 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), 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 recommended based on the FAO/WHO recommended daily nutrient intake. The computations are based on food intake from a 7-day recall. Standard deviations in parentheses.
Source: Author's computations from LSMS-ISA data based on the recommended thresholds

Figure 2: Share of nutrient intake by food acquisition source



Source: Author's computations from LSMS-ISA data

5. Empirical results and discussion

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 micronutrients 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)

continued next page

Table 4 Continued

	CCI	Calories	Protein	Calcium	Iron	Zinc	Vitamin A
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
	(0.842)	(4.193)	(0.126)	(3.959)	(2.765)	(2.999)	(4.548)
Log likelihood	142.817						
Adj-R2	-	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: Author's computations

As explained in section 5, 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 for endogeneity of commercialization in the second stage (see Table 5). In Table 4, the results in column 1 show that rural based households on average engage less in production for sale. 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 commercialised than their female counterparts. 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 found to be negative for all the nutrient intake indicators. However, rural households were found to have better intake for some of the micronutrients such as calcium, iron and zinc, but perform less than the urban households in Vitamin A and calorie intake. This could be attributed to the fact the bulk of vitamin A nutrients and calories are derived from market purchases (see Figure 2). From Table 4, commercialization has a negative and significant effect on micronutrient intake. These findings suggest that commercialization may not primarily result in improved household micronutrient intake. This could be attributed to the choice of food grown, the failure to translate the resulting agricultural income into purchasing nutrient rich food stuff and some sociocultural considerations that inhibit the intake of certain foods, irrespective of their nutritional value. This is consistent with some of the evidence on the agricultural commercialization-nutrition nexus (see Carletto et al., 2017).

Table 5: Endogeneity test results for the crop commercialization model based on the 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: Author's computations from LSMS-ISA 2014 data

Table 6 presents results for the impact of crop commercialization on household crop income and how that can in turn has effects on nutrient intake. The findings show positive effects of commercialization on the 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. Crop income is positive for the rural households as expected. Rural households also have better nutrient intake compared to their urban counterparts.

Crop income has a positive effect on calories as well as other measures of micronutrient intake. This finding is in line with that of Bellin (1994) where a positive relationship between commercialisation, income and nutrient intake was found. Households under the freehold land tenure system are in a position to maximise all their gains from crop production since they face no costs of using their land compared to other land tenure systems. The results also show that households with younger heads generate higher incomes from agriculture compared to their older counterparts. In addition, their intake of micronutrient rich food is also higher if the heads are educated and female.

Generally, male headed households perform poorly on nutrient intake and generation of crop income. Fischer and Qaim (2012) find that male-controlled income is often spend less 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.

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 households 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)

continued next page

Table 6 Continued

Variables	Crop income	Calories	Protein	Calcium	Iron	Zinc	Vitamin A
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-R2	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: Author's computations

Effects of commercialization on nutrient intake by food source

In this section, we present results of the effects of commercialization on household nutrient intake by food source. Table 7 presents results of the effects of commercialization on nutrient intake from purchased foods.

A unit percentage point increase in the level of commercialization increases calorie consumption from purchased foods by 0.58 units/AE/day. Ogutu et al. (2017) in his study on Kenya found that the benefits of commercialization resulted in increased consumption of both calorie and micronutrients from purchases. In Uganda's case, we see that the impact is only on calorie intake. This finding is in line with the postulation in our conceptual framework where in cases where that primarily purchase energy-dense foods may 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 (see Table 3). In addition, food consumption data shows that the bulk of calories are derived from purchased food stuff. The proportion of planted area has a negative effect on nutrient intake, suggesting that while the farm produce is sold, the resulting income is not necessarily spent on purchasing nutrient rich food stuff. Male headed households have better nutrient intake from food purchases.

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 households 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	0.043	-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)	-0.243**	-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-R2	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: Author's computations

The results in Table 7 suggest that commercialization has positive but weakly significant effects only on the consumption of calories.

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 households 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-R2	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: Author's 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. However, the resulting income is not necessarily spent on nutrient rich foods as the results in Table 7 show. Duflo and Udry (2004) indicate that income from different crops may serve distinct purposes within the household and thus have different impacts on nutrient intake. Carletto et al. (2017) notes that while income is crucial for improving nutrient intake, its rise may not necessarily result in improvements household nutrient intake. If it is to happen, households must be deliberate about obtaining nutrient rich food. This condition they note, is not easily satisfiable due to differences in income elasticities of household members. In addition, a high marginal propensity to spend on food does not necessarily imply a high marginal propensity to consume nutrient rich food. Households may often choose to obtain a "diversified" higher cost diet following a rise in income than directing the accrued income to pursue nutrient rich diets.[4] In line with the previous findings on the role of own production in contributing to micronutrient intake, we see that vitamin A intake from own production is higher for rural households, due to the fact that this micronutrient is sourced largely from own production. It is interesting to note that while male headed households had positive effects on nutrient intake from purchased food stuff, the converse is true for intake from own production. As expected, farm assets play a critical role in contributing to nutrient intake from own production. Households with older heads have lower intake of nutrients from own production.

6. Conclusion

While studies on agricultural commercialization show that the policy 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 through which the observed effects are realized. Christiaensen (2017) in their review of Africa's agriculture shows that while market participation remains widespread, the extent of agricultural commercialization is limited, without clear benefits for nutritional outcomes. In this paper, we find that nutrient intake following commercialization depends on several pathways. In the context of Uganda and Africa generally, the effects of commercialization are rooted in the socioeconomic and cultural settings of the population. We find that commercialization generally presented negative effects on nutrient and caloric intake.

Overall, three important policy implications emerge from this study. First, agricultural commercialization is beneficial with respect to income generation. Second, the rural based households are less commercialised on average. This dampens the potential nutrition benefits from market oriented agricultural production as availability of food in the market is one of the primary pathways for improved nutrition. The current government policy on credit and agricultural inputs provision through the programme code-named "Operation Wealth Creation" is one such intervention that can help improve rural household market participation. Third, while commercialization results in crop income generation, nutrient intake is adversely affected. This may call for interventions such as public sensitization as to what constitutes a good diet.

Notes

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

2. This is the dilemma which smallholder farmers who have switched to sugarcane production in Eastern Uganda quite often face.

3. In this study, we focus on agricultural crop commercialization.

4. von Braun et al. (1989) observe that there are cases of malnutrition where households are not even aware of the problem based on their comparisons with the rest of other members in the community.

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Appendix

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

Sex	Age (years)	Energy requirements (kcal/d)	AME	Household	Individual AME (AME ÷ Household AME)	Individual consumption (g/d), AME	Individual consumption (g/d), PC
AME							
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 (Weissell 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

Table A2: Mean nutrient intake, by food group

Food group	Calories	Calcium	Protein	Iron	Zinc	Vitamin A
Cereals	2515.34	376.56	72.54	9.48	7.22	828.94
Roots & Tubers	2380.53	360.47	71.49	8.85	6.84	827.78
Sugar and sweets	2496.61	383.71	71.04	9.13	6.91	874.4
Pulses	2420.69	374.32	73.64	9.32	6.97	779.76
Nuts	2627.57	436.91	77.91	10.28	7.91	792.09
Vegetables	2412.00	379.39	73.02	9.19	7.06	814.59
Fruits	2715.16	403.23	76.74	10.01	7.72	975.91
Meat & Poultry	2643.16	419.97	83.00	10.10	8.04	994.27
Milk and diary	2514.65	498.18	78.24	9.09	7.37	709.31
Fat & Oil	2326.43	334.91	67.48	8.33	6.36	744.71
Beverages	2667.54	388.27	82.29	9.57	7.37	899.36

Source: Author's computations

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