Dipartimento di Scienze Sociali
ed Economiche

Sapienza
Università di Roma

ISSN 2385-2755
Working papers
(Dipartimento di scienze sociali ed economiche)
[online]

WORKING PAPERS SERIES

DIPARTIMENTO DI

SCIENZE SOCIALI ED ECONOMICHE

n. 2/2017

Market chain participation and food security: the case of the Ugandan maize farmers

Author/s:

Pierluigi Montalbano, Rebecca Pietrelli, Luca Salvatici

Sapienza – University of rome
P.le Aldo Moro n.5 – 00185 Roma   T (+39) 06 49910563 F (+39) 06 49910231
CF 80209930587 - P.IVA 02133771002

Market chain participation and food security: the case of the Ugandan maize farmers

P. Montalbano[1], R. Pietrelli[2] and L. Salvatici[3]

Abstract

An assessment of the links between market chain participation and food security is hampered by a scant empirical literature, mostly based on case studies. Our goal is to deal with this issue by providing a sound identification strategy using the WB LSMS-ISA panel data 2009-12 for Uganda and controlling for self-selection. We show that both the level and the variability of Ugandan maize farming households' food consumption is affected by market choice. However, contrary to common wisdom, intermediaries do not play a major role in farmers' welfare. This empirical evidence is consistent with the theoretical prediction that also in Sub-Saharan Africa modern food chains tend to reinforce vertical coordination across actors and the enforcement of contracts, thus reducing the market power of intermediaries.

Keywords: maize, value supply chain, panel, Uganda.

JEL classification: Q12; O12; D12; C33

Acknowledgments: The authors thank all the participants in the 4th Congress of the Italian Association of Agricultural and Applied Economics (AIEAA) in Ancona, Italy (June, 2015) and the 2nd SITES/IDEAS Annual Conference in Florence, Italy (September 2015) The usual disclaimers apply. This work was supported by the European Union's Seventh Framework program FP7/2007-2011 under Grant Agreement No. 290693 FOODSECURE - Exploring the Future of Global Food and Nutrition Security. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission or representing FAO policy or the views of the FAO.

[1]Department of Economics and Social Sciences, Sapienza University of Rome (IT) & Department of Economics, University of Sussex (UK); pierluigi.montalbano@uniroma1.it

[2]Food and Agricultural Organization of the United Nations; rebecca.pietrelli@fao.org

[3]Department of Economics, University of Roma Tre and Manlio Rossi-Doria Centre for Economic and Social Research; luca.salvatici@uniroma3.it

1. Introduction

The market for food staples remains by far the most important in many agriculture-based economies and transforming countries because staples take up a major share of household food expenditures and account for the bulk of the agricultural gross domestic product. Therefore, integrating smallholders into traditional markets or improving aspects of informal supply chains is likely to have strongly pro-poor outcomes because of this sector's broad base (Burch *et al.*, 2007). In this context, Sub-Saharan (SSA) economies are undergoing a vast and rapid process of rural transformation characterized by the increasing importance of agri-food chains and multinational food companies, increased demand for high-value products, and increasing food prices at the global level (McCullough *et al.*, 2008; Swinnen and Maertens, 2007; Maertens and Swinnen, 2015). This type of structural change in SSA agricultural markets is increasingly characterized by vertical co-ordination where buyer agents simultaneously control production, increase sales and reduce costs and risks. There are concerns about the actual benefits of small-holder rural farmers' participation in this new agricultural system in terms of welfare, poverty and food security. On the one hand, small farmers are given new opportunities to access global markets and international standards as providers of intermediate goods/services (Minten *et al.*, 2009; Cattaneo *et al.*, 2013; Swinnen, 2014). On the other hand, vertical coordination mechanisms and consolidation at the buyer end of export chains could amplify the bargaining power of large agro-industrial firms and food multinationals. This strengthens the capacity of these companies to extract rents from the chain to the detriment of contracted smallholder suppliers in the chains (Warning and Key, 2002). On top of this, the performance of food markets is often hampered by poor infrastructure, inadequate support services and weak institutions, pushing up transaction costs and price volatility.

In this general framework, a key issue regards the effective role played by farmers' choices, in terms of commercialization/market participation, in food security. Although investigations into the importance of shifting from staple to cash crops on household food consumption date back to the Nineties (Fafchamps, 1992; Von Braun, 1995), empirical evidence on the relative impact on food security of farmers' different selling strategies is scant and mainly based on case studies (Muriithi and Matz, 2015; Hagos and Geta, 2016; Awotide *et al.*, 2016). Assessing the causal impact of market participation along the chain on food security is not straightforward: different crops have special features which can affect the relationship between selling strategies and food security; farmers' characteristics have also been seen to influence their selling strategy (Fafchamps and Hill, 2005). This is also the case for a number of close complementary issues such as the new opportunities (but also the new challenges) related to vertical integration (e.g., via contract farming arrangements)[4] as well as the ambiguous role of intermediaries and public policies in assembling markets.[5] Because of chronic scarcity of data, the empirical evidence on the impact of contract farming participation on households' food security is rare and mainly based on cross-sectional data (Minten *et al.*, 2009; Barrett *et al.*, 2012; Bellemare, 2012; Bellemare and Novak, 2016), whereas the potential of intermediaries to exercise market power, as non-competitive rent extractors, is more a matter of common wisdom than one that is systematically investigated. Relevant exceptions in this respect are Fafchamps and Hill (2005); Sitko and Jayne (2014); Muratori (2016). Furthermore, a number of external factors prevent the modeling of agricultural markets and price transmissions using traditional competitive settings (Sexton, 1990): e.g., weak regulatory institutions and inadequate infrastructures (transportation, logistics, electricity, telecommunication capabilities, etc.) (Hazell *et al.*, 2010; Markelova *et al.*, 2009).

Our aim is to shed light on this issue by providing a solid identification strategy that assesses the causal relationship between rural farmers' commercialization/market participation and food security. To this end, instead of relying on case studies and/or "ad hoc" data collections, we use panel data from the World Bank Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA). Specifically, we focus on Ugandan maize farming households and take advantage of the three wave panel data of the Ugandan LSMS-ISA for the period 2009-12. This helps us to control for both crops' and households' heterogeneity in the selling strategy as well as for households' self-selection. The main drawback to this choice is that we are forced to measure food security only in terms of availability and stability of maize farmers' food consumption.[6]

The choice of maize in Uganda as the object of our empirical analysis is justified by several reasons: i) maize is the most natural candidate for looking at small-holder farmers' food security since it is produced both for home consumption and as a cash crop; ii) maize is assuming increasing importance in the Ugandan economy because of the growing costs of traditional staple food (e.g., plantains); iii) the Ugandan maize market has been completely liberalized since government intervention through its parastatals (the Produce Marketing, and Food and Beverage Boards) ceased in the 1990s and farmers are free from constraints when choosing their selling strategy; iv) maize is a key activity for many small-scale farming households and is predominantly grown by farmers at the subsistence level; v) Uganda is among the least well-nourished

[4] Contract farming is the institution wherein a processor contracts the production of an agricultural commodity out to a grower.

[5] In this work we use the generic term "intermediaries" to identify a broad set of categories that have a role in linking farmers with the market such as traders, middlemen, and assemblers.

[6] Unfortunately, the available data do not provide adequate information on the access and utilization dimensions that generally come with availability and stability in assessing household food security.

countries in the world and its hunger situation is considered to be serious (Shively and Hao, 2012). In this respect, maize also provides some insight into the additional trade-off between home consumption and cash which is not available for other crops. However, for the sake of comparison, a comparative analysis is available in Section 5.3 for other crops as well.

Our results show that both the level and the variability of maize farmers' food consumption (our proxies for food security) are affected by their selling strategy. We also show that farmers are reactive to shocks. However, we find that, contrary to common wisdom, intermediaries do not play a role in farmers' welfare. This empirical evidence, supported by a number of robustness checks, is consistent with the theoretical prediction that modern food chains tend to reinforce vertical coordination across actors and the enforcement of contracts actually reduces the market power of intermediaries. Thanks to the standard format of the WB LSMS-ISA surveys, the same identification strategy - with amendments to take into account the different nature of crops and institutional systems as well as the national peculiarities of the various market chains - can be applied for other crops and African countries covered by the WB LSMS-ISA project.[7] In addition to the extension of the analysis to other countries and/or crops, future revisions and/or integration of the World Bank surveys would allow further investigations into related issues, e.g., contract farming.

The paper is organized as follows: Section 2 reports the state of the art of the empirical evidence on the effects of smallholder farmer participation in GVCs; Section 3 describes the Ugandan maize market chain; Section 4 provides a detailed description of the Ugandan WB LSMS-ISA survey data; Section 5 presents the identification strategy, comments on the results and provides some sensitivity analysis and Section 6 concludes and presents the main policy implications of the work.

2. Review of the literature: the empirical evidence

Our analysis is related to different strands of the literature. On the one hand, there are the analyses focusing on types of markets and marketing systems. The complexity of the market system typically reflects the volume and value of trade, the types of products being traded, and the number of market actors who want to make use of the system. Types of exchange include barter, roadside stalls, fixed marketplaces, traveling salespersons, retail stores, auctions, commodity exchanges, stock exchanges, future markets, and online marketplaces such as eBay (Robbins, 2011). In broad terms, there are three basic market types: (i) "informal" markets, which have few regulations and often no taxation; (ii) more regulated "formal" markets,

[7] Panel data are currently available for the following African countries: Ethiopia, Malawi, Nigeria, Tanzania and Uganda.

which operate using standard weights and measures and where transactions are agreed upon based on clearly defined legal frameworks; and (iii) structured public markets that are organized by public sector buyers who offer standardized contractual buying arrangements with specific conditions, e.g., buying a percentage of the total procurement from smallholder farmers (Ferris *et al.*, 2014).

Much of the academic literature has been keen to emphasize the shift from traditional wholesale markets to modern food systems. This type of structural change in markets is characterized by vertical co-ordination, where a high degree of buyer drivenness allows driving agents to simultaneously control production, increase sales and reduce costs and risks. Better prices, improved efficiency, higher standards and rejection of sub-standard produce are frequently cited as factors that make modern markets better than informal chains. In this respect, traditional systems are perceived to be inefficient and disorganized. For the majority of smallholder farmers in developing countries though, the most accessible markets are informal and trade up to 80-90% of the agricultural goods. Quite remarkably, a new breed of literature (mainly from country case studies) is emerging which counters the conventional arguments regarding modern food systems. There are also suggestions that traditional and modern markets complement each other (Ferris *et al.*, 2014).

Numerous factors affect farmers' roles in the value chain. These factors include location and business maturity within a target area, as well as access to infrastructure, agricultural services, irrigation and production technologies. Furthermore, in many developing countries, other obstacles add to resource constraints and threaten competitiveness such as weak regulatory institutions, poorly designed and implemented sanitary and phytosanitary regulations, inadequate transportation, power and water infrastructure, and the absence of important value chain actors (Hazell *et al.*, 2010; Markelova *et al.*, 2009). Overcoming the commercialization barrier requires an upgrading process that includes investment in local infrastructure, the strengthening of business services, and an improvement in farmer skills. On the other hand, the challenge is not merely to create linkages to lucrative markets, but also to adequately assess smallholder conditions, including their market options and methods of optimizing their market performance, all while ensuring that that these options are manageable for the smallholders. In their selling strategy, farmers interact with different intermediaries and/or with large processing, trading and retailing firms or directly with the State and parastatals who manage assembly markets. Market failures could be related to both imperfect spatial price transmission (i.e., transmission between international and domestic prices) and imperfect vertical price transmission (i.e., transmission of prices from consumers to producers) (Swinnen and Vandeplas, 2014). According to this strand of literature, several agricultural markets are oligopolistic or oligopsonistic and concentrated processors capture welfare against small and dispersed farmers (Sexton, 2013; Muratori, 2016; Swinnen and

Vandeplas, 2011, 2014; Kikuchi *et al.*, 2015; Mesa and Gómez, 2011; Fałkowski, 2010; Osborne, 2005). On the other hand, Sitko and Jayne (2014) provide evidence against the claim that strong public policies would be justified when farmers do not receive a remunerative price for their sales. Other authors highlight that asymmetry in price transmission is not due to exploitation of market power, but to vertical coordination, increasing returns to scale, the risk mitigating behavior of agents and the degree of processing (Swinnen and Vandeplas, 2014; Wohlgenant, 2001; Weldegebriel, 2004; McCorriston *et al.*, 2001; Wang *et al.*, 2006). In particular, the more stages in vertical market structure, the lower the pass-through of price changes along the value chain, irrespective of exploitation of market power by agents (Peltzman, 2000; McCorriston and Sheldon, 1996; Wang *et al.*, 2006). Small and medium-sized producers are generally not well positioned to respond to changes in market structures and are thus marginalized (Dolan and Humphrey, 2004; Lee *et al.*, 2012; Maertens and Swinnen, 2009). Some of the most discussed cases, namely the fruit and vegetable export sectors in Kenya and Senegal, are characterized by large shifts from smallholder to large-scale farming or, in the case of the Senegal tomato export sector, completely based on exporter-owned agro-industrial production (Maertens *et al.*, 2012). Similar shifts, although mostly partial, are observed in other regions and countries such as Latin America, other African countries, and the Russian Federation (Beghin *et al.*, 2015).

There are studies that provide conflicting evidence. For instance, Fafchamps *et al.* (2005), using survey data from three African countries, Benin, Madagascar, and Malawi, find that, contrary to expectations, there is little evidence that returns to scale exist in agricultural markets and hence little scope for vertical integration. This is the case of the horticulture sector in Africa and the horticulture sector and animal production in Asia (see, *inter alia*, Minten *et al.* (2009), for Madagascar; Henson *et al.* (2005), for Zimbabwe; Handschuch *et al.* (2013), for Chile; Kersting and Wollni (2012), for Thailand; and Wang *et al.* (2009), for China). Moreover, the most recent empirical studies highlight mostly positive effects on small-holder farmers who are included in contract schemes (Barrett *et al.*, 2012; Bellemare, 2012; Bellemare and Novak, 2016) and high value export chains (see, *inter alia*, Minten *et al.* (2009) and Subervie and Vagneron (2013), for Madagascar; Handschuch *et al.* (2013), for Chile; Asfaw *et al.* (2009), for Kenya).[8] This is because standards can reduce transaction costs in the chain by reducing information asymmetries between buyers and suppliers (specifically, regarding quality, safety and other product characteristics). In this respect, market chain participation is supposed to be associated not only with increasing employment, better remunerated jobs,

[8] Contracts for quality production with local suppliers in developing countries not only specify conditions for delivery and production processes, but also include the provision of inputs, credit, technology, management advice, etc. (Minten *et al.*, 2009).

better use of resources, better governance and political stability, but also with increasing food security (Minten *et al.*, 2009; Cattaneo and Miroudot, 2013; Swinnen, 2014; Swinnen and Vandeplas, 2014).

Within this debate on spatial and vertical price transmission, the dominant narrative looks at intermediaries as non-competitive rent extractors rather than off-farm sources of income with positive spillovers for rural poverty reduction. The role of market intermediaries in crop marketing in most African countries has rarely been fully understood and they tend to be described as being exploitative. The rather unflattering perception of role market intermediaries (sometimes referred to as "briefcase" or "bicycle" traders) can be attributed in part to high distribution margins which tend to squeeze producer margins while increasing food prices for consumers(Coulter and Poulton, 2001). Some authors confirm the presence of large trader margins by looking at the limited effect of world prices increases on the producers. McMillan *et al.* (2002) find a limited transmission of the increased cashew export prices to farmers in Mozambique. Fafchamps and Hill (2008) find that when the export price of Ugandan coffee increases, the wholesale price increases whereas the farm-gate price does not. By using a field experiment with Indian potato farmers, Visaria *et al.* (2015) find significant average middlemen margins (up to 30% of the wholesale market prices). Recent evidence on the effect of improved price information through mobile phones and the internet is contrasting. While some papers (Aker and Fafchamps, 2010; Goyal, 2010) find a significant effect of IT on farm-gate prices and price dispersion, others (Fafchamps and Minten, 2012; Visaria *et al.*, 2015) do not find any effect on farm-gate prices and middlemen margins. In spite of this, intermediaries are in several instances the most accessible market channel for most smallholder farmers. Recent empirical analyses demonstrate that farmers' market access conditions in remote areas can also benefit from assembly traders' activities: by investigating the maize assembly sector in east and southern Africa, Sitko and Jayne (2014) find evidence of a high number of competitive traders per village and low margins between farm-gate and market prices.

Overall, the micro-level empirical evidence on the actual margins earned by intermediaries is still limited. Studies on the determinants of trader margins are scarce and conflicting. This conflicting evidence is mainly based on case studies and is plagued by the scattered nature of the available datasets (Montalbano *et al.*, 2015). Moreover, most of the quantitative assessments are based on cross-sectional data. Our attempt in the subsequent empirical analysis is to provide a sound identification strategy by using the available set of World Bank LSMS-ISA panel data. In Section 5, the pros and cons of our identification strategy will be analyzed in detail.

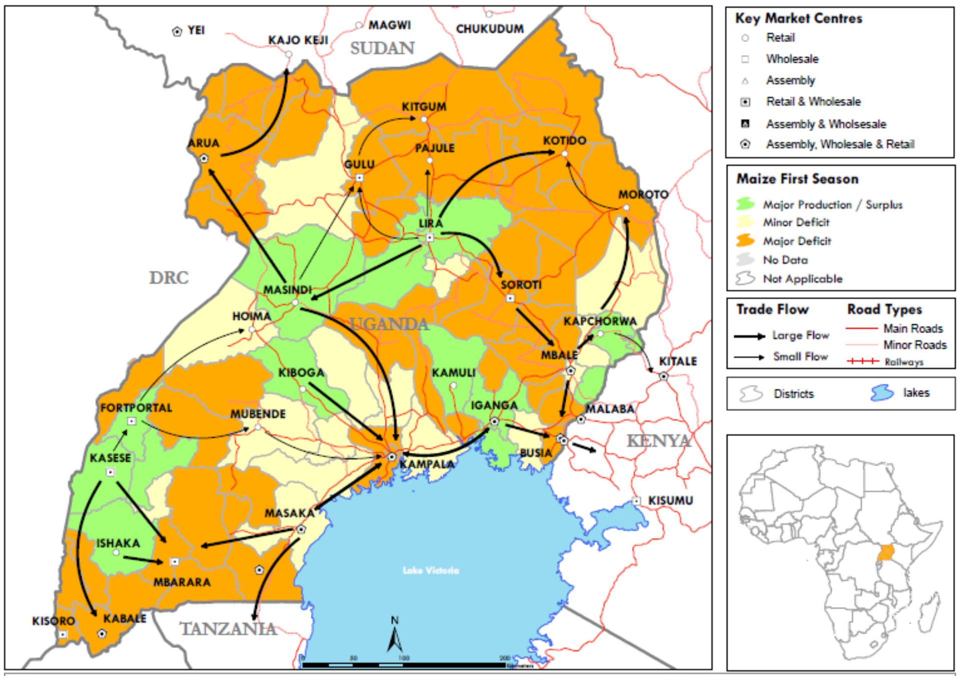
3. The Ugandan maize production and value chain

Maize is assuming increasing importance in the Ugandan economy.[9] It is nowadays the third main crop grown in the country, after banana and cassava. Furthermore, even if maize is not part of the traditional diet in Uganda, its consumption has recently increased, especially in urban areas, due to the growing costs of traditional staple food(USAID, 2010). Over 70% of maize is consumed as food and only about 10% is used as animal feed (Ahmed, 2012). The crop is grown in almost all Ugandan districts,[10] which implies that benefits from its production are widespread, albeit at varying levels (refer to Fig.1 to see both major production areas and major deficits as well as the key market centers). This is because maize is considered easy to manage, resistant to water stress and adaptable to different soil types. It also offers flexibility: it can be grown either as pure stand or in association with other crops through inter-cropping or mixed cropping (Ugandan Ministry of Agriculture and Fisheries, 2010). Consequently, it has become an important part of the country's farming system, with over half of the production area being mixed or associated stand (NRI/IITA, 2002).

[9] Maize production more than doubled between 1990 and 2013, from 0.8 million tons to 2.3 million tons (Ahmed and Ojangole, 2014).

[10] Deininger and Okidi (2003) register that 75% of villages countrywide were found to grow maize and in 61% of these virtually every household grew maize

Figure 1: Production and market flows map: Uganda maize



Source: USAID and FEWSNET (2013)

Maize production is a key activity for many small-scale farming households and it is predominantly grown by farmers on a subsistence level.[11] It is thus crucial to farming households' food security and has surpassed coffee and cotton as key income earners in the country. Kiiza *et al.* (2011) indicate that 55% of households reported that food self-sufficiency is the prime reason for venturing into maize production. When food security is measured in terms of calorie intake, over 40% of the calories consumed in both rural and urban areas are obtained from maize, with more than 60% in some districts (Ugandan Ministry of Agriculture and Fisheries, 2010). It also generates income for a range of direct and indirect players of off-farm activities along the value-chain.[12] These include domestic input stockists, traders and/or distributors, millers and/or other processors, exporters and transporters. Maize production has both forward and backward linkages

[11]95% of maize production in Uganda is grown by small-scale farmers. Subsistence ones account for up to 75% of maize production and over 70% of marketable surplus (USAID, 2010).

[12]Here we define value chain as the full range of activities required to bring food production to the final customers, including trade (Kaplinsky and Morris, 2001).

with other sectors, which have benefited local communities. For instance, the increased adoption of high yielding maize varieties has fostered the demand for complementary inputs, generating an increase in the number of input dealers within the farming communities (Ugandan Ministry of Agriculture and Fisheries, 2010).

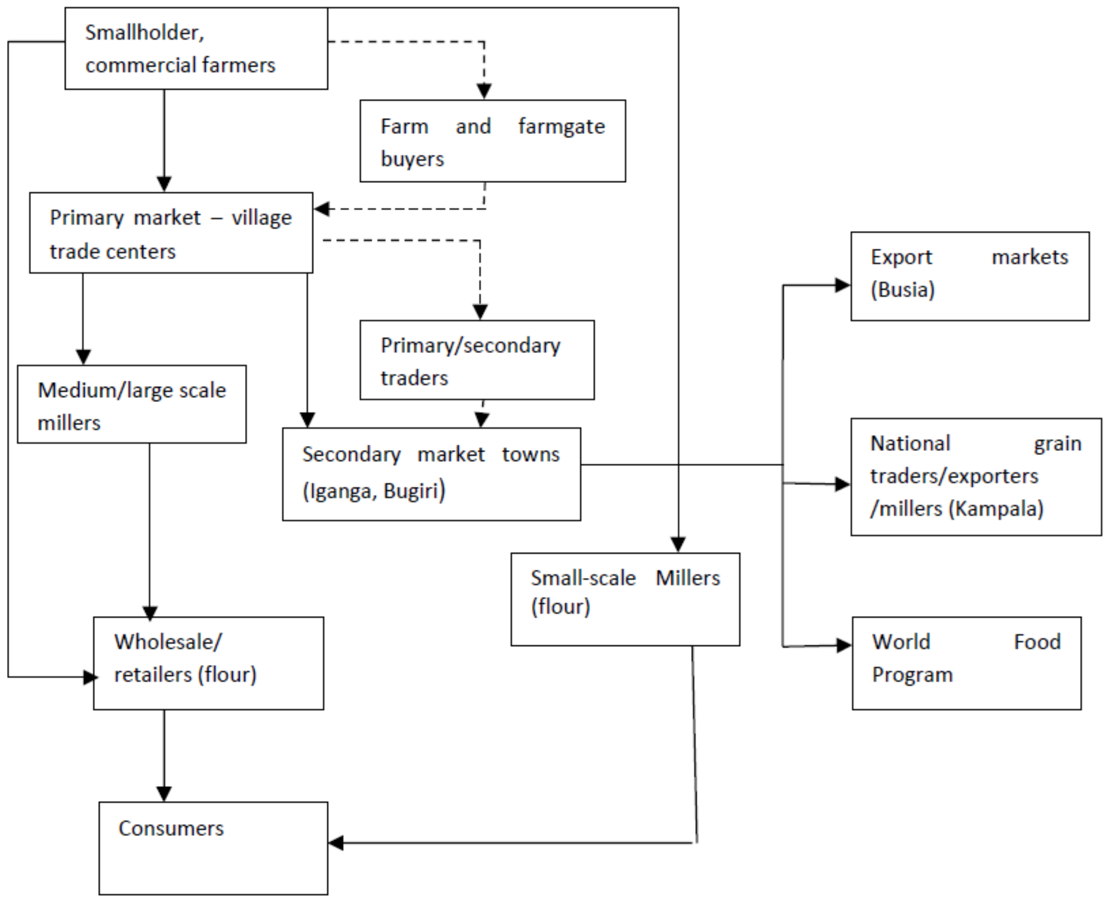
Maize is produced under a low input/output system with most areas of the country capable of producing two crops per year. Maize farmers usually engage in multi-crop activities (beside maize, groundnuts, coffee, rice and beans) and other livestock enterprises and benefit from off-farm sources of income (i.e., masonry work, teaching, trading, councilor, welding, and boda-boda riding). Access to market information is still inadequate beyond the farm gate. The major sources of this market information among farmers are traders and fellow farmers. The majority of farmers store maize in their houses for short periods, due to a lack of adequate storage and cash needs. The maize market is open and maize is easy to sell, but farmers have rated it as poor due to low and unstable prices (Ugandan Ministry of Agriculture and Fisheries, 2010). This is attributable to the fact that the Government has been implementing private sector friendly policies and has abandoned any attempt to keep control of agricultural markets (USAID, 2010). There are no more State trading companies operating in competition with the private sector or acting as major buyers and guarantors of a minimum farm-gate price. Similarly, price control is no longer practiced by the government. There is no export duty on maize (as well as other agricultural products), nor has the government instituted any bans or other restrictions on trade in food commodities (local monetary authorities also pursue a flexible exchange rate policy regime).[13] As such, all prices are determined by the market (World Bank, 2009). The export market for Ugandaâs maize is mainly regional among the East Africa Community (to see the main trade flows, refer once again to Fig.1). Demand for maize in the Great Lakes Region (Kenya, DRC, Southern Sudan and Rwanda) has provided Uganda with significant export opportunities: about 14-20% of total production since 1990 (FEWSNET, 2011). Estimates indicate that the Kenyan market accounts for more than 50% of Uganda's total maize exports. Although exporters must have a fumigation certificate, a phytosanitary certificate and a quality standards certificate, informal (unofficial) cross-border trade with neighboring countries (especially towards Kenya but also DRC, Southern Sudan, Rwanda and Tanzania) has been increasing in recent years (Ahmed and Ojangole, 2014).

The transactions involved in the marketing of maize are complex. The main channels for the commodity flow include (i) from farmers (farm gate) to agents/traders/village markets in rural areas; (ii) from rural

[13] Bank of Uganda interventions in the foreign exchange market are mainly intended to dampen short term volatility in the exchange rate (Bank of Uganda, 2011)

markets to secondary markets in regional towns (iii) from urban markets to major buying centers outside the district and (iv) the export market. Figure 2 depicts a typical maize supply chain in Uganda as reported in Ahmed and Ojangole (2014).

Figure 2: The maize value chain in Uganda



Source: Adapted by Ahmed and Ojangole (2014) from USAID (2010) and PMA (2009), World Bank (2009)

The main buyers of maize traded in sub-counties (smaller administrative units in the districts) are rural agents who gather maize from the numerous scattered farmers, often located in inaccessible rural areas, and sell it to urban traders and processors. Sometimes farmers sell maize directly to primary markets as well. Urban traders and processors are found in major urban centers in the production areas. Their main activities include networking with rural agents, serving as a market outlet for farmers, and collecting maize grain before selling it to the various clients, including institutions and processors (mostly millers), located in the districts. The processors carry out activities such as cleaning, de-stoning, drying, fumigating and milling into flour. Large-scale processors are only found in Kampala. The main ones include: (i) the World

Food Program, (ii) the Uganda Grain Traders (UGT), (iii) the Masindi Seed and Grain Growers Association (MSGGA), and (iv) the Uganda National Farmers Federation (UNFFE). They buy their maize from urban traders and large-scale traders from the western, central and eastern regions and sell it to relief agencies or export to regional markets. Transport costs are the major marketing cost and, therefore, are key in determining the prices offered to farmers by rural traders. The relative share of transportation cost in total marketing costs averages 84% in Uganda (Zorya, 2009). These costs are quite high because a maize bag often passes through a number of markets before reaching the final consumer in large cities and thus requires loading and unloading at each intermediate stop (Ahmed and Ojangole, 2014).

Once the options available to Ugandan farming households for selling maize have been clarified, a straightforward research question is whether there are differences in food security between farmers adopting different selling strategies: i.e., selling maize at the farm gate ("off the market chain") or relying on intermediaries, namely local or district traders, ("inside the market chain"). It is worth emphasizing that within the Ugandan market chain, we are not able to distinguish formal markets, governed by high quality and food safety standards (including domestic supermarket), export chains and processing industries, from informal markets such as traditional supply chains (e.g., wholesale and local wet markets). Nonetheless, we can check whether there are differences in farmer food security between farmers selling to local or district traders (i.e., roughly speaking, in terms of position along the selling chain and/or closeness to the final markets). This will provide an indirect measure of the incidence of distortions and/or transaction costs. Both the above research questions require a sound identification strategy and are subject to self-selection. Before presenting the details of this identification strategy in Section 5 it is useful to provide additional details on the data used in the empirical analysis.

4. Data

Our data come from the Uganda Living Standards Measurement Study - Integrated Survey on Agriculture (ULSMS-ISA), implemented by the Uganda Bureau of Statistics in collaboration with the World Bank. The survey sample includes 3,123 Ugandan households selected from the Uganda National Household Survey 2005/06 and is representative at national, urban/rural and regional levels. The sample is visited three times, in 2009/10, 2010/11 and 2011/12 respectively.[14]

[14]The response rate at household level with respect to the baseline in 2005/06 is quite high, 83.5% in 2009/10; 82.1% in 2010/11 and 75.4% in 2011/12 respectively. In order to minimize attrition between rounds, all the baseline (2005/06 UNHS) households and individuals have been traced irrespective of whether they moved from the original location. Furthermore, 20% of households were selected from each Enumeration Area to trace and interview their split-offs, which became part of the panel

We use two sets of data: household-level data and agricultural data. The household-level data include modules related to household characteristics (composition, demographics, education and household amenities), household welfare and consumption expenditures. Using the latter, we are able to construct a measure of household food consumption per capita to be used as a dependent variable for our empirical investigations[15]. The main advantage of the LSMS-ISA project is the presence of an extended agricultural questionnaire. This allows us to investigate in detail the characteristics of small-holder farmers by crop (i.e., household crop production, farming inputs, practices, etc.). Although the household survey is carried out annually, the agricultural questionnaire is administrated by cropping seasons (two each year) to capture the agricultural variability across seasons. Thanks to the agriculture questionnaire, we are also able to assess market participation and the position of each farmer. Specifically, farmers provide evidence of their main commercial partners on the basis of their answers to the following specific question: "'who bought the largest part of maize sold by the household"'?[16] Consistently with the maize market chain described in the previous section, we use the possible answers to the above question to categorize the farmers participation and position in the market chain as follows:

- farmers selling maize *only* to local consumers; neighbors/relatives; others are classified as selling maize off the market chain;
- farmers selling maize to local consumers *and* to private traders in *local market/village* are classified as selling maize to the market chain with an upstream position (i.e., distant from the final markets);
- farmers selling maize to local consumers, local traders and private traders in *district markets* and/or to the Government[17] are classified as selling maize inside the market chain with a more downstream position (i.e., close to the final markets).

Table 1 reports the number of sampled Ugandan maize farmer households for the various possible categories. As shown in the table, the majority of net-producer farmer households participate in the maize market chain (less than 20% of them sell maize "off the market"). Among the participants, the majority of farmer households sell maize upstream (i.e. distant from the final markets). Approximately the same shares

household in the subsequent rounds.

[15]The food consumption is deflated and expressed at 2012 monetary value by using the CPI from the World Bank website: http://data.worldbank.org/indicator/FP.CPI.TOTL

[16]Agricultural questionnaire -Section 5A and 5B, respectively for the first and second crop season. Possible answers are the following: 1) Government/LC; 2) Private trader in local market/village; 3) Private trader in district market; 4) Consumer at market; 5) Neighbor/Relative; 6) Other (specify).

[17]In line with the characteristics of the Ugandan market, the percentage of households answering to sell maize to the government or others is negligible.

are confirmed in the sub-sample of farmers interviewed 3 times between 2009 and 2012 used as a balanced panel in our empirical analysis (see lower section of 1). Note that since our focus is on investigating market participation, we exclude the overwhelming majority of farmers producing maize only for home consumption from the analysis.

Table 1: Ugandan LSMS-ISA sample of maize net-producer farmers by market participation and position 2009/12

	Number of households	
Tot. households	8,541	
Farmer households producing maize	4,695	
Net-producer of maize:	1,832	
Selling strategy:		
1. *only* to district trader	128	**Downstream: 245**
2. to local consumers *and* to district trader	38	
3. to local trader *and* to district trader	73	
4. to local consumers *and* trader *and* to district trader	6	
5. *only* to local trader	1,131	**Upstream: 1,262**
6. to local consumers *and* to local trader	131	
7. *only* to local consumers	325	**Outside the VC: 325**
Panel HHs Net-producer of maize:	480	
Selling strategy:		
1. *only* to district trader	39	**Downstream: 86**
2. to local consumers *and* to district trader	12	
3. to local trader *and* to district trader	32	
4. to local consumers *and* trader *and* to district trader	3	
5. *only* to local trader	271	**Upstream: 316**
6. to local consumers *and* to local trader	45	
7. *only* to local consumers	78	**Outside the VC: 78**

5. Identification strategy and results

5.1. Identification strategy

The aim of our empirical analysis is to investigate whether there is a causal relationship between farmers' food security and their participation (and position in relation to the final markets) in the maize market chain. Our identification strategy follows the consolidated empirical literature that looks at the farmers' consumption in any period as a linear econometric specification[18] of a variety of observable household characteristics such as demographics, education and occupation, as well as the place of residence and a set of characteristics related to the surrounding economic environment and, finally, a set of unobservable factors such as abilities and motivations. In this empirical literature, the above set of observable and unobservable household characteristics are considered as proxies for several factors among which household preferences and composition, expectations on future income, current physical assets, precautionary savings and ability to smooth consumption (Deaton, 1992; Browning and Lusardi, 1996; Chaudhuri, 2003; Dercon, 2005). We

[18]The log normality of consumption is standard in the applied literature. Although this is generally assumed from the log normality of income, Battistin *et al.* (2009) demonstrate empirically that the distribution of consumption across households is even closer to log normal than that of income.

amend this linear econometric specification of farmers' consumption with a market chain participation variable. To this end, we use both a dummy variable (i.e., a variable assuming the value of 1 if the household participates in the market chain and 0 otherwise) and a self-reported measure of the share of maize actually sold in the market by farmers. While the share variable may provide additional details on the quantities actual sold by farmers participating in the market chain (and is not constrained by the identification strategy of the movers, see below), the dummy variable overcomes a possible measurement error in the quantity of maize sold that is self-reported by farmers. Specifically, we estimate the following linear relationship:

$$FS_{h,t} = \alpha_h + \gamma_t + \alpha_h * t + \phi_1 chain_{h,t} + \boldsymbol{\delta} X_{h,t} + \epsilon_{h,t} \tag{1}$$

where: $FS_{h,t}$ is alternatively the natural log of household food consumption per capita and the squared difference of food consumption from its mean value. The use of both variables lets us test whether farmers' market participation is associated with both the level and the variability of food consumption. *chain* is the variable of interest. Rejecting H(0): $\phi_1 = 0$ in equation (1) implies that market participation has an impact on household food security. $X_{h,t}$ is the vector of controls for household heterogeneity. It includes observable household, geographical and time characteristics. To control for unobservables, we exploit the panel dimension of the data by inserting in the regression a set of α_h controls for household fixed effects and a set of γ_t time fixed effects. Finally, we control for time variant unobservable confounders by using a linear time-trend specific for each household $\alpha_h * t$.[19] This allows us to control not only for household ability, but also for household time varying experience (linearly changing over time). These additional controls help capture further latent variables potentially able to explain both why a household sells maize to different partners and its level of food security, thus greatly reducing potential endogeneity bias in the "chain coefficient" (i.e., our parameter of interest).

To test the effect of the selling position with respect to final markets, we use the following slightly different specification:

$$FS_{h,t} = \alpha_h + \gamma_t + \alpha_h * t + \phi_1 Upstream_{h,t} + \phi_2 Downstream_{h,t} + \boldsymbol{\delta} X_{h,t} + \epsilon_{h,t} \tag{2}$$

The description of specification 1 also applies to specification 2 with the exception of ϕ, our main coeffi-

[19]Note that the use of the household-specific trend with year fixed effects is possible with a minimum number of three waves since household-specific trend imposes the inclusion of n-2 dummies in the specification. Consequently, in this case, we can only use the balanced sample of 480 households interviewed three times.

cient of interest, that it is now split into two different coefficients:

1. ϕ_1 is the coefficient attached to the new chain variable "upstream", which is alternatively a dummy or a share for selling maize to local traders and (possibly) local consumers (i.e., far away from the final market/exports);
2. ϕ_2 is the coefficient attached to the new chain variable "downstream"', which is alternatively a dummy or a share for selling maize to district traders and (possibly) local traders and consumers (i.e., closer to the final market/exports).

Rejecting H(0): $\phi_1 = \phi_2$[20] implies that supply chain position impacts on household food security. Specifically, in equation (2), ϕ_1 and ϕ_2 explain how the selling position (downstream or upstream) contributes to the above market participation effect.

One relevant implication of the fixed effect specification is that it only identifies the effect of variables changing over time since it is estimated through a demeaned transformation of each variable. In other words, it means that the effects of our multicategory dummies for market participation and position are estimated in our model by exploiting the time-variation of the households that change their selling choice over time, for example, by selling maize outside the market chain in 2009/10 and inside it in 2010/11 or vice versa[21] This caveat does not apply for the estimates in shares. In this perspective, the latter can be seen as a further robustness check for our identification strategy. Table A.1 in the Appendix provides a look into how many farmers move from one selling group to another over the course of the panel by decomposing our panel into between and within variations. The between variation shows how many farmers have been in that selling category at least once, whereas the within variation shows how many farmers have always been in that selling category (the latter is thus a measure of stability of the selling status of the farmers). As shown in table A.1 more than 30% of the overall households actually gained access to the market over the course of the panel whereas almost 60% of the market sellers actually moved upstream in the same period. This guarantees sufficient empirical evidence for our identification strategy, even in the case of the multicategory dummy strategy. Furthermore, table A.2 provides the outcomes of the conventional Levene's test - centered at the mean - for equality of variances between the non-movers and the movers (that is, those who changed previous downstream and/or upstream choices). Results suggest that movers and non-movers do not have structurally different main characteristics and confirm that our multicategory dummy identification strategy

[20]The third possible dummy, regarding the choice to sell outside the market, is omitted to avoid the dummy variable trap. This implies that the dummy for selling maize only outside the market chain is used as a reference category also in this empirical exercise

[21]These dummies will be zero for any farmer i who does not change its selling point over the course of the panel.

is also appropriate.[22]

Table 2 shows the main descriptive statistics of the sub-sample of Ugandan net-producer maize farmer households.[23] As shown in the table, farmer households that are closer to the final market show, on average, a higher level of food consumption per capita and are less subject to shocks. In a nutshell, they are more food secure. On the other hand, it is apparent as well that households with a differentiated selling strategy show clear heterogeneity in their structural characteristics too. This is evident if we look at their maize production and selling conditions (farmers selling closer to the final markets show, on average, larger numbers in maize acreage, harvest, selling quantities and unit price) as well as at the characteristics of their production inputs (farmers selling closer to the final markets use, on average, more pesticides, fertilizers, and improved seeds; they also hire more labor and, of course, face higher transport costs). There is also a strong polarization in their geographical location but no significant heterogeneity in their household characteristics (such as size, gender and age of the household head, education and facilities).

Thus, we acknowledge that a selectivity issue may arise in assessing this relationship, e.g. farmer households may self select both in their market participation and in their position with regard to the final markets mainly on the base of the characteristics of production (such as the quantity of harvested maize, the use of fertilizers, the use of improved quality of seeds, etc.). Simply including these additional observable characteristics in our main equation may indeed introduce additional endogeneity in the analysis if there are omitted variables that affect both household food security and market participation and position simultaneously. Additionally, households may have unobservable characteristics that can also influence both their food security and their market participation and position. To control for self-selection, we thus opt for a control function approach by adding into the main regression the estimated residual of a first stage equation(ρ) where a set of variables related to maize inputs has been included as an exclusion restriction.[24] This residual is by definition uncorrelated with the endogenous variable and provides an unbiased estimator that is generally more precise than the IV estimator (Wooldridge, 2010). In doing so, we follow the approach by Lee (1982) and we estimate, in a first step, a Linear Probability Model (LPM)[25] of selling maize inside the market chain

[22]The Levene's test is similar to the standard one-way Anova test, but is insensitive to the violation of normality assumption. As shown in table A.2 the null hypothesis of equal distribution between the two groups cannot be rejected for most of the selected variables.

[23]Table A.3 in appendix shows the same summary statistics for the sample of 480 panel households.

[24]In principle, we could consider more general selection biases (e.g., crop choice or net-selling position). However, it is worth recalling that our goal here is not to derive consistent estimates for the population of farmers, but rather to derive unbiased evidence of the relevance of market participation within a specific group.

[25]This lets us estimate the marginal effects of the continuous variables and also account for endogeneity bias by means of household, year and fixed effects which would otherwise act as a perfect classifier in a probit framework. Probit coeffcients of the same equation are, as expected, larger in magnitude and more significant. However, they show consistent signs in the estimated relations. They are available upon request.

Table 2: Summary statistics of net-producer maize farmers by market chain participation and position

	Mean values		
	Only outside the VC	Upstream	Downstream
Household Food security			
(log) Food consumption pc	12.376	12.380	12.454
	(0.779)	(0.733)	(0.609)
Squared difference of (log) food consumption pc	0.173	0.163	0.136
	(0.616)	(0.412)	(0.297)
Income			
(log) Income pc	12.601	12.673	12.685
	(0.905)	(0.901)	(0.937)
Share wage employment: agriculture and fishing	0.054	0.047	0.041
	(0.146)	(0.149)	(0.131)
Share wage employment: non-farm activities	0.086	0.071	0.059
	(0.217)	(0.196)	(0.181)
Share transfers	0.028	0.045	0.028
	(0.161)	(0.151)	(0.103)
Share non-agricultural business	0.138	0.142	0.169
	(0.271)	(0.335)	(0.358)
Share own-farm production of crop	0.564	0.575	0.575
	(0.411)	(0.414)	(0.432)
Share livestock and fishing production	0.112	0.105	0.108
	(0.338)	(0.295)	(0.311)
Share other	0.014	0.013	0.017
	(0.086)	(0.078)	(0.092)
Maize production and sale			
Maize acreage	1.174	1.095	1.356
	(1.144)	(1.016)	(1.001)
Use of pesticides (dummy)	0.037	0.116	0.174
	(0.189)	(0.321)	(0.380)
Use of fertilizers (dummy)	0.012	0.040	0.054
	(0.110)	(0.197)	(0.226)
Use of improved seeds (dummy)	0.138	0.188	0.260
	(0.346)	(0.391)	(0.440)
Hire labor (dummy)	0.369	0.461	0.545
	(0.483)	(0.499)	(0.499)
Transport cost (UShs)	886.259	2,691.153	6,840.120
	(7,543.133)	(31,089.450)	(26,104.640)
Harvested maize (Kg)	1,898.435	3,269.049	3,902.799
	(3,189.155)	(6,420.443)	(6,730.110)
Consumed maize (Kg)	705.624	920.989	881.732
	(998.781)	(2,253.267)	(1,386.008)
Sold maize (Kg)	1,043.129	1,751.885	2,316.673
	(2,787.349)	(3,129.768)	(3,795.620)
Unit price (UShs per Kg)	764.595	803.293	1,125.877
	(2,847.338)	(2,894.757)	(3,134.366)
Household characteristics			
HH size	6.326	6.635	6.950
	(2.853)	(3.176)	(3.273)
Female HH head	0.163	0.156	0.095
	(0.370)	(0.363)	(0.294)
Married HH head	0.785	0.797	0.888
	(0.412)	(0.402)	(0.316)
Age HH head	46.400	45.893	44.021
	(14.700)	(14.479)	(13.293)
Average years of education	4.242	4.504	4.489
	(2.250)	(2.426)	(2.439)
Electricity	0.016	0.029	0.038
	(0.124)	(0.168)	(0.191)
Improved water	0.745	0.714	0.729
	(0.437)	(0.452)	(0.445)
Location dummies			
Center	0.123	0.256	0.331
	(0.329)	(0.437)	(0.471)
East	0.194	0.336	0.178
	(0.396)	(0.473)	(0.383)
North	0.378	0.187	0.380
	(0.486)	(0.390)	(0.486)
West	0.305	0.221	0.112
	(0.461)	(0.415)	(0.315)

Standard deviation in parenthesis.

based on farmer characteristics, maize characteristics, households, year and regional fixed effects. We then include the residuals from LPM in equation (1) to control for selection.

5.2. Results

Before reporting the estimates for equations 1 and 2, it is worth looking at the first stage outcomes (table 3). As expected, some of the variables related to maize production included as exclusion restrictions are significantly associated with the probability of being part of the market chain and some of them are significantly correlated with the farmers' market position too. Specifically, with regard to market chain participation, as expected, a large quantity of harvested maize is strongly associated with a higher probability of participating in the market chain (but this is not proportional to the dimension of maize acreage). With regard to the position in the market chain, the use of improved quality seeds is significantly associated with a more upstream position whereas larger production plots are more likely to be associated with selling closer to the final markets. The latter result is consistent with that of Fafchamps and Hill (2005) which finds that Ugandan farmers producing coffee are more likely to travel to the final market when a large quantity is sold, whereas the upstream position of farmers using improved seeds can be associated with contract farming arrangements(Bellemare and Novak, 2016). Note that neither the geographical location dummies nor the farmers' actual distance to the markets actually play a significant role in the commercialization patterns, whereas year dummies do. Specifically, year 2011 is associated with a high probability of being part of the market chain whereas both year dummies 2010 and 2011 are associated with a lower probability of selling maize downstream (compared with year 2009 which is the reference category), probably because of the general drop in international prices after the 2007/08 spike. We take these first stage outcomes into account in the subsequent empirical analysis.

Table 4 shows the outcomes of the main regression (equation 1) reporting, in columns 1a and 1b, the baseline specification including household, geographical and time controls; in columns 2a and 2b an additional specification with the same controls plus the household-specific time trend; in columns 3a and 3b, a further specification with the same controls as columns 2a and 2b plus the selection correction (ρ). Specifications in columns a use a dummy for market participation (yes=1); specifications in columns b use the share of maize sold within the market chain.

Comparing the "chain coefficients" across columns in 4 we can see that the "market participation effect" would be downward biased if we do not provide additional controls. This is especially true when the time trend is missing (columns 1a and 1b) whereas, as expected, columns 3a and 3b that include all the available controls show the best fit for the data. Note also the lack of significance of the LMP residual (ρ) highlighting

Table 3: LPM of maize market chain participation and position

	(1) Selling inside VC	(2) Selling upstream	(3) Selling downstream
Use of fertilizers	0.0463	0.218	-0.172
	(0.123)	(0.167)	(0.137)
Use of pesticides	-0.0487	0.0210	-0.0698
	(0.0749)	(0.102)	(0.0832)
Hire labour	0.0290	0.00324	0.0257
	(0.0515)	(0.0699)	(0.0572)
Use of improved seeds	0.0300	0.191**	-0.161**
	(0.0594)	(0.0807)	(0.0661)
Harvested maize	0.0665***	0.0493	0.0172
	(0.0227)	(0.0308)	(0.0252)
Maize acreage	-0.0385*	-0.0755**	0.0370
	(0.0233)	(0.0317)	(0.0259)
HH size	0.104	0.0520	0.0521
	(0.0862)	(0.117)	(0.0958)
Age of HH head	-0.416	-1.083*	0.667
	(0.433)	(0.587)	(0.481)
Female HH head	0.133	0.194	-0.0616
	(0.0942)	(0.128)	(0.105)
Married HH head	-0.158	-0.169	0.0107
	(0.190)	(0.258)	(0.211)
Average education	-0.0840	0.0197	-0.104
	(0.0644)	(0.0874)	(0.0716)
Electricity	0.421	-0.512	0.934**
	(0.413)	(0.560)	(0.459)
Improved source of water	0.0223	0.0262	-0.00389
	(0.0637)	(0.0865)	(0.0708)
Distance to market	-0.213	0.657	-0.869
	(0.841)	(1.142)	(0.935)
Central	-0.0946	0.654	-0.749
	(0.634)	(0.861)	(0.705)
East	-0.128	-0.276	0.149
	(0.522)	(0.709)	(0.580)
North	0.456	-0.204	0.660
	(0.712)	(0.966)	(0.791)
Year 2010	-0.0745	0.0819	-0.156***
	(0.0467)	(0.0634)	(0.0519)
Year 2011	0.100*	0.232***	-0.132**
	(0.0555)	(0.0753)	(0.0617)
Constant	2.883	1.935	0.947
	(3.983)	(5.406)	(4.427)
Observations	478	478	478
R-squared	0.501	0.441	0.424

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
The specifications control for HH fixed effect.
The excluded regional dummy is West.
The excluded year dummy is 2009.
The continuous variables are expressed in logarithm.

Table 4: Panel regression of maize market chain participation on (log) food consumption per capita

	(HH and year FE)		(HH and year FE + HH trend		(HH and year FE + HH trend + selection correction)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Selling inside VC	0.147*		0.233*		0.244*	
	(0.0767)		(0.129)		(0.129)	
Share maize sold inside VC		0.156**		0.351***		0.354***
		(0.0753)		(0.131)		(0.130)
HH size	-0.712***	-0.718***	-0.841***	-0.853***	-0.717***	-0.731***
	(0.111)	(0.111)	(0.198)	(0.195)	(0.208)	(0.205)
Age of HH head	-0.128	-0.127	-0.207	-0.180	-0.529	-0.481
	(0.563)	(0.563)	(0.751)	(0.740)	(0.790)	(0.779)
Female HH head	-0.115	-0.107	-0.178	-0.179	-0.0911	-0.0969
	(0.123)	(0.122)	(0.168)	(0.164)	(0.181)	(0.178)
Married HH head	0.0980	0.0840	0.0353	0.0653	0.00659	0.0434
	(0.267)	(0.266)	(0.702)	(0.688)	(0.695)	(0.681)
Average education	0.0937	0.0900	-0.0739	-0.0561	-0.185	-0.163
	(0.0825)	(0.0824)	(0.165)	(0.162)	(0.172)	(0.169)
Electricity	0.612	0.602	1.692	1.422	1.982	1.681
	(0.542)	(0.542)	(1.268)	(1.255)	(1.338)	(1.327)
Improved source of water	0.0325	0.0353	0.133	0.159	0.219	0.243*
	(0.0828)	(0.0826)	(0.139)	(0.137)	(0.145)	(0.143)
Distance to market	0.0597	0.0593	-1.576	-1.437	-1.737	-1.582
	(1.112)	(1.111)	(2.658)	(2.620)	(2.638)	(2.600)
Year 2009	-0.0125	-0.00757				
	(0.0649)	(0.0650)				
Year 2010	-0.501***	-0.500***	-0.512***	-0.502***	-0.576***	-0.562***
	(0.0587)	(0.0586)	(0.0595)	(0.0588)	(0.0860)	(0.0849)
ρ (1)					-0.627	-0.570
					(0.646)	(0.631)
Constant	13.93***	13.96***	68.25	74.69	82.50	90.34
	(4.524)	(4.518)	(90.83)	(89.53)	(93.09)	(91.81)
Observations	475	475	475	475	473	473
R-squared	0.700	0.701	0.836	0.841	0.843	0.848

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
All the specifications control for household fixed effect and regional dummies.
The excluded year dummy in specification (1) is year 2011.
Specifications (2) and (3) control for HH specific year trend. The year dummies reduce to n-2=1 (year 2010).
Specifications (3) use bootstrapping method to correct standard errors for generated regressors.
The continuous variables are expressed in logarithm.
Specifications (a) use VC dummies while specifications (b) use the share of maize sold.
The excluded category of specifications (a) is selling maize only outside the VC.
The excluded category of specifications (b) is the share of maize sold outside the VC.

the absence of sampling error in the first stage equation. The striking feature of this first empirical exercise is that a positive relationship between market participation and farmers' consumption significantly holds in all the specifications. Specifically, net to self-selection and controlling for both time variant observable and unobservable factors (column 3a), Ugandan farmers who participate in the maize market chain register, on average and ceteris paribus, a per capita consumption which is 28%[26] higher than farmer households, with the same characteristics, who sell maize "off the market".

Table 5 reports the estimated coefficients for eq.2. As already stated, this specification splits the market participation variable into two variables: upstream and downstream, respectively, indicating the relative distance of each farmer from the final markets. Specifically, an upstream position indicates that farmers' market participation does not overtake the local level whereas a downstream position indicates that farmers' market participation reaches the district level. As in eq. 1 the reference category sells maize "off the market". The significant positive coefficient of selling upstream with respect to the reference category - which is confirmed both for dummies and shares - and the very similar impacts in terms of magnitude

[26]This is computed with reference to the dummy variable which is considered more reliable than self-reported shares. Specifically, exp(0.244) - 1*100=28%. In the case of shares this "market effect" would be higher, i.e., above 42%.

(always about 30% higher than similar farmers' counterparts for each kg of maize sold in the market chain)[27] confirm our previous results. As before, the coefficients associated with the first stage residuals (ρ) are not significant showing the absence of sampling error in the first stage equation. However, the difference between the coefficients of selling maize upstream or downstream with respect to the final markets is not statistically significant (-0.079 and standard error 0.123) indicating that there are no meaningful differences in terms of food consumption between selling strategies.[28] In short, while this further empirical test confirms that market participation matters, it does not support the view that a selling strategy closer to the final market should be seen as preferable. This implicitly supports the argument for efficient intermediaries.

Table 5: Panel regression of maize market chain selling position on (log) food consumption per capita

	(HH and year FE)		(HH and year FE + HH trend		(HH and year FE + HH trend + selection correction)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Selling upstream	0.143*		0.241*		0.264**	
	(0.0778)		(0.131)		(0.131)	
Selling downstream	0.165*		0.179		0.184	
	(0.0951)		(0.166)		(0.167)	
Share maize sold upstream		0.147*		0.362***		0.381***
		(0.0765)		(0.135)		(0.134)
Share maize sold downstream		0.206**		0.307*		0.286
		(0.103)		(0.175)		(0.175)
HH size	-0.713***	-0.719***	-0.847***	-0.857***	-0.689***	-0.700***
	(0.112)	(0.111)	(0.199)	(0.196)	(0.212)	(0.209)
Age of HH head	-0.142	-0.153	-0.171	-0.157	-0.112	-0.0490
	(0.566)	(0.564)	(0.757)	(0.745)	(0.912)	(0.898)
Female HH head	-0.113	-0.101	-0.178	-0.184	-0.0943	-0.106
	(0.123)	(0.123)	(0.168)	(0.165)	(0.182)	(0.178)
Married HH head	0.0980	0.0830	0.0265	0.0608	-0.0336	0.00827
	(0.267)	(0.266)	(0.704)	(0.691)	(0.697)	(0.684)
Average education	0.0958	0.0942	-0.0810	-0.0655	-0.286	-0.276
	(0.0829)	(0.0827)	(0.166)	(0.165)	(0.199)	(0.196)
Electricity	0.594	0.553	1.739	1.464	2.779*	2.538
	(0.546)	(0.547)	(1.274)	(1.265)	(1.558)	(1.544)
Improved source of water	0.0324	0.0364	0.131	0.156	0.231	0.254*
	(0.0829)	(0.0827)	(0.139)	(0.138)	(0.146)	(0.144)
Distance to market	0.0751	0.113	-1.518	-1.381	-2.093	-1.943
	(1.115)	(1.114)	(2.668)	(2.633)	(2.691)	(2.652)
Year 2009	-0.0145	-0.0144				
	(0.0653)	(0.0657)				
Year 2010	-0.500***	-0.501***	-0.516***	-0.505***	-0.648***	-0.636***
	(0.0588)	(0.0587)	(0.0605)	(0.0594)	(0.110)	(0.109)
ρ (2)					-0.731	-0.682
					(0.654)	(0.642)
ρ (3)					-1.337	-1.325
					(0.986)	(0.965)
Constant	13.94***	13.88***	72.55	81.75	150.6	168.8
	(4.531)	(4.524)	(91.47)	(91.75)	(118.1)	(116.6)
Observations	475	475	475	475	473	473
R-squared	0.700	0.701	0.836	0.841	0.845	0.849

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
All the specifications control for household fixed effect, year fixed effect and regional dummies.
The excluded year dummy in specification (1) is year 2011.
Specifications (2) and (3) control for HH specific year trends. The year dummies reduce to n-2=1 (year 2010).
The continuous variables are expressed in logarithm.
Specifications (a) use VC dummies while specifications (b) use the share of maize sold.
The excluded category of specifications (a) is selling maize only outside the VC.
The excluded category of specifications (b) is the share of maize sold outside the VC.

Table 6 reports the outcome of the same identification strategy, testing this time the impact of maize farm household selling strategy on the volatility of food consumption (proxied by the squared mean difference

[27]This is obtained with reference to the coefficient for the dummy upstream in column 3a by computing (0.264) - 1*100=30%. As before, in the case of shares, the estimated "market effect" is greater, above 45%.

[28]The difference between downstream and upstream position is not significant also when we substitute the dummy with the share of maize sold (table 5, column 3b). In this case, the difference is -0.094 and standard error is 0.149.

of household per capita consumption from its mean). The table shows that farmers who participate in the market chain also show a reduction in food consumption volatility. Note that this result is statistically significant when we add to the model the household time trend - proxying market participation with sold shares (column 2b) - and the residuals from the first stage LPM to control for self-selection (column 3a and 3b).

Table 6: Panel regression of **volatility** of (log) **Food Consumption** pc on **VC participation**

	(HH and year FE)		(HH and year FE + HH trend		(HH and year FE + HH trend + selection correction)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Selling inside VC	-0.0381		-0.141		-0.161*	
	(0.0486)		(0.0887)		(0.0895)	
Share maize sold inside VC		-0.0572		-0.244***		-0.253***
		(0.0477)		(0.0893)		(0.0893)
HH size	-0.125*	-0.122*	-0.00873	0.00271	-0.0614	-0.0494
	(0.0706)	(0.0706)	(0.136)	(0.133)	(0.144)	(0.141)
Age of HH head	-0.143	-0.148	0.0872	0.0619	0.356	0.321
	(0.357)	(0.357)	(0.516)	(0.506)	(0.547)	(0.537)
Female HH head	0.0518	0.0512	0.122	0.128	0.0440	0.0505
	(0.0779)	(0.0776)	(0.115)	(0.112)	(0.125)	(0.122)
Married HH head	-0.138	-0.136	0.286	0.277	0.308	0.290
	(0.169)	(0.169)	(0.482)	(0.471)	(0.481)	(0.470)
Average education	0.0878*	0.0886*	0.0684	0.0573	0.131	0.116
	(0.0523)	(0.0522)	(0.113)	(0.111)	(0.119)	(0.116)
Electricity	0.135	0.146	-0.209	0.0119	-0.663	-0.433
	(0.344)	(0.344)	(0.870)	(0.859)	(0.926)	(0.915)
Improved source of water	-0.0784	-0.0788	-0.130	-0.147	-0.167*	-0.184*
	(0.0525)	(0.0524)	(0.0954)	(0.0937)	(0.100)	(0.0987)
Distance to market	-0.0213	-0.0210	-0.0559	-0.163	0.137	0.0229
	(0.705)	(0.704)	(1.824)	(1.792)	(1.825)	(1.793)
Year 2009	-0.0251	-0.0274				
	(0.0412)	(0.0412)				
Year 2010	0.102***	0.0995***	0.116***	0.108***	0.177***	0.167***
	(0.0372)	(0.0372)	(0.0409)	(0.0402)	(0.0595)	(0.0585)
ρ (1)					0.657	0.626
					(0.447)	(0.435)
Constant	1.103	1.125	-5.492	-10.99	2.128	-3.841
	(2.869)	(2.864)	(62.34)	(61.23)	(64.42)	(63.31)
Observations	475	475	475	475	473	473
R-squared	0.624	0.625	0.759	0.768	0.766	0.774

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
All the specifications control for household fixed effect, year fixed effect and regional dummies.
The excluded year dummy in specification (1) is year 2011.
Specifications (2) and (3) control for HH specific year trends. The year dummies reduce to n-2=1 (year 2010).
Specifications (3) use bootstrapping method to correct standard errors for generated regressors.
The continuous variables are expressed in logarithm.
Specifications (a) use VC dummies while specifications (b) use the share of maize sold.
The excluded category of specifications (a) is selling maize only outside the VC.
The excluded category of specifications (b) is the share of maize sold outside the VC.

Table 7 provides the estimated coefficients of farmers' position on the volatility of food consumption. As before, while selling in the market chains lowers the volatility of consumption (and this is significantly associated with an upstream position compared with respect the reference category of selling "off the market chain"), the effect of different selling strategies along the market chain is not statistically significant (it is equal to -0.014 with standard error 0.085).

To summarize, our empirical outcomes show, on the one hand, that market participation significantly and consistently matters in increasing the availability and stability of food consumption (our proxies of food security) of Ugandan maize farmer households: selling maize in the market chain is associated both with an increase in average food consumption and a reduction in its volatility with respect to selling the same product "off the market" (i.e., at the farm gate). On the other hand, our results do not support the view

Table 7: Panel regression of **volatility** of (log) **Food Consumption** pc on **VC position**

	(HH and year FE)		(HH and year FE + HH trend		(HH and year FE + HH trend + selection correction)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Selling upstream	-0.0337		-0.137		-0.164*	
	(0.0493)		(0.0898)		(0.0909)	
Selling downstream	-0.0576		-0.160		-0.178	
	(0.0603)		(0.114)		(0.115)	
Share maize sold upstream		-0.0521		-0.239**		-0.259***
		(0.0485)		(0.0920)		(0.0924)
Share maize sold downstream		-0.0840		-0.260**		-0.254**
		(0.0652)		(0.120)		(0.121)
HH size	-0.124*	-0.121*	-0.0106	0.00123	-0.0896	-0.0768
	(0.0707)	(0.0707)	(0.137)	(0.134)	(0.147)	(0.144)
Age of HH head	-0.128	-0.133	0.100	0.0707	0.00455	-0.0309
	(0.359)	(0.358)	(0.520)	(0.510)	(0.631)	(0.619)
Female HH head	0.0501	0.0482	0.122	0.127	0.0536	0.0585
	(0.0781)	(0.0779)	(0.116)	(0.113)	(0.126)	(0.123)
Married HH head	-0.138	-0.135	0.283	0.275	0.330	0.313
	(0.169)	(0.169)	(0.483)	(0.473)	(0.483)	(0.472)
Average education	0.0855	0.0864	0.0658	0.0538	0.207	0.194
	(0.0526)	(0.0524)	(0.114)	(0.113)	(0.138)	(0.135)
Electricity	0.154	0.172	-0.192	0.0279	-1.273	-1.058
	(0.346)	(0.347)	(0.875)	(0.865)	(1.078)	(1.065)
Improved source of water	-0.0782	-0.0794	-0.130	-0.149	-0.177*	-0.195*
	(0.0526)	(0.0525)	(0.0957)	(0.0942)	(0.101)	(0.0994)
Distance to market	-0.0379	-0.0501	-0.0348	-0.142	0.521	0.386
	(0.707)	(0.706)	(1.833)	(1.801)	(1.863)	(1.830)
Year 2009	-0.0228	-0.0237				
	(0.0414)	(0.0417)				
Year 2010	0.101***	0.1000***	0.114***	0.107***	0.230***	0.221***
	(0.0373)	(0.0372)	(0.0415)	(0.0406)	(0.0762)	(0.0749)
ρ (2)					0.688	0.668
					(0.453)	(0.443)
ρ (3)					1.236*	1.209*
					(0.683)	(0.666)
Constant	1.101	1.168	-3.927	-8.334	-54.30	-60.92
	(2.872)	(2.868)	(62.83)	(62.78)	(81.78)	(80.44)
Observations	475	475	475	475	473	473
R-squared	0.624	0.625	0.759	0.768	0.768	0.776

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
All the specifications control for household fixed effect, year fixed effect and regional dummies.
The excluded year dummy in specification (1) is year 2011.
Specifications (2) and (3) control for HH specific year trends. The year dummies reduce to n-2=1 (year 2010).
Specifications (3) use bootstrapping method to correct standard errors for generated regressors.
The continuous variables are expressed in logarithm.
Specifications (a) use VC dummies while specifications (b) use the share of maize sold.
The excluded category of specifications (a) is selling maize only outside the VC.
The excluded category of specifications (b) is the share of maize sold outside the VC.

that the choice of the selling point along the market chain is also significant. In other words, we find no evidence of lower consumption perspectives between farmers who sell at the local markets and those who participate in urban markets. These empirical outcomes are consistent with the view that assembly trading can be considered a competitive market intermediary service, even for farmers located in remote regions, probably because of the high incidence of transport costs, especially for farmers unable to achieve sufficient economies of scale in production (to lower the unit cost of transport). In this perspective, our results extend to Uganda the same findings as Sitko and Jayne (2014) regarding the positive role of the maize assembly sector in East and Southern Africa (specifically in Kenya, Zambia, Malawi and Mozambique) and contradict the common belief that local traders prey on farmers by offering prices well below prevailing market prices. The access to market offered by local traders can be better than what farmers would receive at the nearest wholesale or retail market. Our results also show the presence of self-selection bias proving that household and farm production characteristics ultimately drive the farmers' decision regarding the selling point (in this perspective, our results are consistent with those of Fafchamps and Hill (2005) when we show that larger farmers are more likely to sell closer to the final markets).

5.3. Sensitivity and robustness checks

Since our dummy strategy identifies the coefficient of interest thanks to the farmers who change their selling decisions (in and out of the market chain) over the course of the panel, the registered heterogeneity in their food consumption can be collinear to unobservable shocks (positive and negative). Proxying such unobservable shocks by means of year fixed effects, we effectively register that the decision to enter the market chain is significantly associated with year fixed effects. Specifically, table A.4 shows that Ugandan small-holder farmers are less likely to move in the market chain in 2010/11 than in 2009/10. This can be attributed to the general drop in international prices of maize after the spike in 2007/08 or other meaningful time variant shocks that affect the maize market chain. However, net to this effect, those farmers who move in the market chain are seen to be better off in terms of food consumption. As shown in Table A.5, the same year fixed effect is positively and significantly correlated with the decision to move upstream, thus far away from the final markets. Also in this case, however, the decision to move upstream does not seem to matter in terms of food consumption. In short, while there is empirical evidence that external unobservable (at least to the researchers) time varying shocks (captured by our time variant fixed effects) are likely to matter in the moving decision, they cannot explain the statistical differences in food consumption (both in terms of averages and variances) across the various selling strategies that we registered in our previous analysis. Thus, we believe we have properly identified what we are looking for: i.e., that the selling strategy (i.e., the decision to participate in a market chain) actually matters for the food security of small-holder farmers, irrespective of the determinants of the moving decision.

Furthermore, it can be useful to give a comparative look at the relation between food consumption and market participation for other commodities that are considered important for the food security of Ugandan farmers. For instance, it can be instructive to look at plantains and cassava which, together with maize, cover over 40% of the overall calorie intake of Ugandan households (Ahmed and Ojangole, 2014). Specifically, farmers selling maize usually harvest and sell cassava using the same selling strategy whereas plantains can be considered the typical staple commodity and the decision to sell them to the market is hampered by the perishable nature of the commodity. Tables A.6 and A.7 in the Appendix show, respectively, the estimated food consumption coefficients of both equations 1 and 2 for cassava (tables A.8 and A.9 show the same estimates on food consumption volatility). Tables A.10 and A.11 show the same food consumption estimates for plantains (tables A.12 and A.13 the same estimates for plantains on food consumption volatility). As expected, outcomes show that the empirical results for cassava are perfectly consistent with those for maize, whereas those for plantains show the opposite sign. This confirms once again the robustness of our identification strategy in investigating the impact, *ceteris paribus*, of maize market participation on food security. Due to the perishable nature of plantains, the same selling strategy does not apply in the case of plantains and in the latter case, the best option for small-holder farmers is to sell them at farm gate. Also in this case, however, the decision regarding the selling point is not relevant for both average and volatility of food consumption confirming that a neutral role is played by the intermediaries.[29]

6. Conclusions

The relative costs and benefits of market channels are poorly understood and include many assumptions that lack sufficient empirical evidence to support them. When talking about helping smallholders increase welfare, it is often said that linking them into high value export chains offers one of the best solutions to decreasing rural poverty. However, there is a clear difference between trends identified in the literature (e.g. market modernization) and reality in the developing world where most small farmers continue to market their goods through traditional informal channels and wet markets. By presenting a sound empirical identification strategy this paper challenges the conception that market chains are a danger and intermediaries exploit

[29]The effect on average food consumption of selling plantains downstream compared with upstream is 0.140 and standard error is 0.105 (0.120 and standard error 0.163 for shares), whereas the same coefficients on food consumption volatility are not significant (see table A.13).

agricultural producers by extracting rents along the chain. In this perspective, this paper contributes to building the case for linking farmers to markets.

Our results show that farmers who were able to sell their periodic surpluses in local village, district, and national markets are better off in terms of food security irrespective of the extent to which the maize value chain has been modernized. In this perspective, even participation in an informal value chain seems to be preferable to a choice to remain outside the chain. Another major implication of our analysis is that the Ugandan maize value chain appears to be quite competitive. This does not imply that it could not suffer from (over) wide marketing margins and poor market integration. Farmers in most African countries face huge challenges that hinder their ability to take advantage of existing and emerging market opportunities. These marketing challenges directly depress farm incomes and thereby dampen the potential for the agricultural sector to be an engine of growth and create multiplier effects that would otherwise contribute to broader economic transformation processes. Accordingly, improving and modernizing the marketing system can increase market efficiency and foster competitiveness with imports, and reduce losses and risks. Market modernization, in addition to improving basic transport, includes marketing information systems, commodity exchanges, and price-risk management. On the other hand, even if it is still true that earnings from farming activities for maize producers in Uganda are likely to be depressed by a combination of factors (such as high trade/transport costs or high post harvest losses), limited access to lucrative segments in the value chain or more generally inadequate market power do not seem to be among them.

In order to improve market linkage for farmers, there should be a change in the buying and selling culture from the "occasional" and "opportunistic" sales transactions of individual farmers at farm gate to a more consistent sales approach that builds individuals or group relationships with known trading partners, such as a company, an extension agent, a farmer organization or a chain facilitator. Accordingly, the major policy implication of our analysis is to establish market linkage projects in emerging economies to support greater integration of farmers within value chains. A major reason that prevents farmers from entering value chains is that they are often limited in size and produce volume, and the cost for most buyers and sellers is prohibitive. Other reasons that inhibit market participation are high transaction costs, lack of adequate storage, product wastage and losses, limited access to trade finance, and weak regulatory institutions. Consequently, finding ways to link smallholder farmers to markets should be considered a critical part of any long-term development strategy to reduce hunger. The nature and pace of market development differs across food staples (e.g., cereals), traditional bulk export commodities (e.g., coffee or cocoa), and higher-value products (e.g., dairy or fruits). The goal should not necessarily be to link small-holder farmers with the highest value or most dynamic markets, but to invest in ways that enable specific types of farmers, and communities of farmers, to access markets that match their capacities, production, investment, and risk profiles. In this respect, another important implication of our work is that, contrary to common wisdom, intermediaries do not hamper farmers' food security. This is consistent with the theoretical prediction that modern food chains that tend to reinforce vertical coordination across actors actually reduce the market power of intermediaries.

References

Ahmed M. (2012) Analysis of incentives and disincentives for rice in uganda, *Technical notes series, MAFAP, FAO, Rome*.

Ahmed M. and Ojangole S. (2014) Analysis of price incentives for maize in Uganda., Technical report, Technical notes series, MAFAP, Rome FAO.

Aker J.C. and Fafchamps M. (2010) How does mobile phone coverage affect farm-gate prices? evidence from west africa, *University of California, Berkeley. http://www. aeaweb. org/aea/2011conference/program/retrieve. php*.

Asfaw S., Mithöfer D. and Waibel H. (2009) Eu food safety standards, pesticide use and farm-level productivity: The case of high-value crops in kenya, *Journal of Agricultural Economics*, 60, 3, 645–667.

Awotide B.A., Karimov A.A. and Diagne A. (2016) Agricultural technology adoption, commercialization and smallholder rice farmersâ welfare in rural Nigeria, *Agricultural and Food Economics*, 4, 1, 1–24.

Bank of Uganda (2011) Report on the domestic resource cost ratios for selected export commodities 2009/10, Technical report, Bank of Uganda, Kampala, Uganda.

Barrett C.B., Bachke M.E., Bellemare M.F., Michelson H.C., Narayanan S. and Walker T.F. (2012) Smallholder participation in contract farming: comparative evidence from five countries, *World Development*, 40, 4, 715–730.

Battistin E., Blundell R. and Lewbel A. (2009) Why is consumption more log normal than income? gibratâs law revisited, *Journal of Political Economy*, 117, 6, 1140–1154.

Beghin J., Maertens M. and Swinnen J.F. (2015) Non-tariff measures and standards in trade and global value chains, *Annual Review of Resource Economics*, 7.

Bellemare M.F. (2012) As you sow, so shall you reap: The welfare impacts of contract farming, *World Development*, 40, 7, 1418–1434.

Bellemare M.F. and Novak L. (2016) Contract farming and food security, *American Journal of Agricultural Economics*.

Browning M. and Lusardi A. (1996) Household saving: Micro theories and micro facts, *Journal of Economic literature*, 34, 4, 1797–1855.

Burch D., Lawrence G., Green G., Ichijo K., Nonaka I., Pimentel M., Bower J., Gilbert C., Couto Filho V., Flavio L. *et al.* (2007) *World Development Report 2008: agriculture for development.*, number E14 231, The World Bank.

Cattaneo O., Gereffi G., Miroudot S. and Taglioni D. (2013) Joining, upgrading and being competitive in global value chains: a strategic framework, *World Bank Policy Research Working Paper*, , 6406.

Cattaneo O. and Miroudot S. (2013) From global value chains to global development chains: An analysis of recent changes in trade patterns and development paradigms, *21st Century Trade Policy: Back to the Past*.

Chaudhuri S. (2003) Assessing vulnerability to poverty: concepts, empirical methods and illustrative examples, *Department of Economics, Columbia University, New York*.

Coulter J. and Poulton C. (2001) Cereal market liberalization in africa, in: *Commodity market reforms: lessons of two decades*, Akiyama T., Baffes J., Larson D. and Varangis P., eds., The World Bank.

Deaton A. (1992) *Understanding consumption*, Oxford University Press.

Deininger K. and Okidi J. (2003) Growth and poverty reduction in uganda, 1999–2000: Panel data evidence, *Development Policy Review*, 21, 4, 481–509.

Dercon S. (2005) *Insurance against poverty*, Oxford University Press.

Dolan C. and Humphrey J. (2004) Changing governance patterns in the trade in fresh vegetables between africa and the united kingdom, *Environment and planning A*, 36, 3, 491–509.

Fafchamps M. (1992) Cash crop production, food price volatility, and rural market integration in the third world, *American Journal of Agricultural Economics*, 74, 1, 90–99.

Fafchamps M., Gabre-Madhin E. and Minten B. (2005) Increasing returns and market efficiency in agricultural trade, *Journal of Development Economics*, 78, 2, 406–442.

Fafchamps M. and Hill R.V. (2005) Selling at the farmgate or traveling to market, *American journal of agricultural economics*, 87, 3, 717–734.

Fafchamps M. and Hill R.V. (2008) Price transmission and trader entry in domestic commodity markets, *Economic Development and cultural change*, 56, 4, 729–766.

Fafchamps M. and Minten B. (2012) Impact of sms-based agricultural information on indian farmers, *The World Bank Economic Review*, 26, 3, 383–414.

Fałkowski J. (2010) Price transmission and market power in a transition context: evidence from the polish fluid milk sector, *Post-communist economies*, 22, 4, 513–529.

Ferris S., Robbins P., Best R., Seville D., Buxton A., Shriver J. and Wei E. (2014) Linking smallholder farmers to markets and the implications for extension and advisory services, *MEAS Brief*, 4, 10.

FEWSNET (2011) Uganda. http://www.fews.net/pages/marketflowmap.aspx?gb=ugl=en, Technical report, FAO, Rome.

Goyal A. (2010) Information, direct access to farmers, and rural market performance in central india, *American Economic Journal: Applied Economics*, 2, 3, 22–45.

Hagos A. and Geta E. (2016) Review on small holders agriculture commercialization in ethiopia: What are the driving factors to focused on?, *Journal of Development and Agricultural Economics*, 8, 4, 65–76.

Handschuch C., Wollni M. and Villalobos P. (2013) Adoption of food safety and quality standards among chilean raspberry producers–do smallholders benefit?, *Food Policy*, 40, 64–73.

Hazell P., Poulton C., Wiggins S. and Dorward A. (2010) The future of small farms: trajectories and policy priorities, *World Development*, 38, 10, 1349–1361.

Henson S., Masakure O. and Boselie D. (2005) Private food safety and quality standards for fresh produce exporters: The case of hortico agrisystems, zimbabwe, *Food policy*, 30, 4, 371–384.

Kaplinsky R. and Morris M. (2001) *A handbook for value chain research*, volume 113, IDRC Ottawa.

Kersting S. and Wollni M. (2012) New institutional arrangements and standard adoption: evidence from small-scale fruit and vegetable farmers in thailand, *Food Policy*, 37, 4, 452–462.

Kiiza B., Pederson G. and Lwasa S. (2011) The role of market information in adoption of agricultural seed technology in rural uganda, *.International Journal of ICT Research and Development in Africa*, 2, 1, 30–47.

Kikuchi M., Haneishi Y., Tokida K., Maruyama A., Asea G. and Tsuboi T. (2015) The structure of indigenous food crop markets in sub-saharan africa: The rice market in uganda, *The Journal of Development Studies*, 1–19.

Lee J., Gereffi G. and Beauvais J. (2012) Global value chains and agrifood standards: challenges and possibilities for smallholders in developing countries, *Proceedings of the National Academy of Sciences*, 109, 31, 12326–12331.

Lee L.F. (1982) Some approaches to the correction of selectivity bias, *The Review of Economic Studies*, 49, 3, 355–372.

Maertens M., Minten B. and Swinnen J. (2012) Modern food supply chains and development: Evidence from horticulture export sectors in sub-saharan africa, *Development Policy Review*, 30, 4, 473–497.

Maertens M. and Swinnen J. (2009) Food standards, trade and development, *Review of business and economics*, 54, 3, 313–326.

Maertens M. and Swinnen J. (2015) Agricultural trade and development: A value chain perspective, Technical report, WTO Staff Working Paper.

Markelova H., Meinzen-Dick R., Hellin J. and Dohrn S. (2009) Collective action for smallholder market access, *Food policy*, 34, 1, 1–7.

McCorriston S., Morgan C. and Rayner A. (2001) Price transmission: the interaction between market power and returns to scale., *European review of agricultural economics*, 28, 2.

McCorriston S. and Sheldon I.M. (1996) The effects of vertical markets on trade policy reform, *Oxford Economic Papers*, 48, 4, 664–672.

McCullough E.B., Pingali P.L. and Stamoulis K.G. (2008) *The transformation of agri-food systems: globalization, supply chains and smallholder farmers*, Food & Agriculture Org.

McMillan M., Rodrik D. and Welch K.H. (2002) When economic reform goes wrong: cashews in mozambique, Technical report, National Bureau of Economic Research.

Mesa J.C.P. and Gómez E.G. (2011) Asymmetric margins in prices and retail supply chain integration: the spanish vegetable case, *Journal of International Food & Agribusiness Marketing*, 23, 3, 211–230.

Minten B., Randrianarison L. and Swinnen J.F. (2009) Global retail chains and poor farmers: Evidence from madagascar, *World Development*, 37, 11, 1728–1741.

Montalbano P., Nenci S. and Salvatici L. (2015) Trade, value chains and food security, background paper prepared for the state of agricultural commodity markets 2015–16. rome, fao.

Muratori L. (2016) Price gap along the ugandan coffee value chain, *DiSSE working paper Sapienza*, , 01/16.

Muriithi B.W. and Matz J.A. (2015) Welfare effects of vegetable commercialization: Evidence from smallholder producers in kenya, *Food Policy*, 50, 80–91.

NRI/IITA (2002) Transaction cost analysis report, Technical report, Prepared for the Plan for the Modernization of Agriculture. Natural Resources Institute Report No. 2708. pp 193.

Osborne T. (2005) Imperfect competition in agricultural markets: evidence from ethiopia, *Journal of Development Economics*, 76, 2, 405–428.

Peltzman S. (2000) Prices rise faster than they fall, *Journal of political economy*, 108, 3, 466–502.

Robbins P. (2011) *Commodity exchanges and smallholders in Africa*, IIED.

Sexton R.J. (1990) Imperfect competition in agricultural markets and the role of cooperatives: a spatial analysis, *American Journal of Agricultural Economics*, 72, 3, 709–720.

Sexton R.J. (2013) Market power, misconceptions, and modern agricultural markets, *American Journal of Agricultural Economics*, 95, 2, 209–219.

Shively G. and Hao J. (2012) A review of agriculture, food security and human nutrition issues in uganda, *Department of Agricultural Economics, Purdue University*.

Sitko N.J. and Jayne T. (2014) Exploitative briefcase businessmen, parasites, and other myths and legends: Assembly traders and the performance of maize markets in eastern and southern africa, *World Development*, 54, 56–67.

Subervie J. and Vagneron I. (2013) A drop of water in the indian ocean? the impact of globalgap certification on lychee farmers in madagascar, *World Development*, 50, 57–73.

Swinnen J. and Vandeplas A. (2011) Rich consumers and poor producers: quality and rent distribution in global value chains, *Journal of Globalization and Development*, 2, 2.

Swinnen J.F. (2014) Global agricultural value chains, standards, and development, *Robert Schuman Centre for Advanced Studies Research Paper No. RSCAS*, 30.

Swinnen J.F. and Maertens M. (2007) Globalization, privatization, and vertical coordination in food value chains in developing and transition countries, *Agricultural economics*, 37, s1, 89–102.

Swinnen J.F. and Vandeplas A. (2014) Price transmission and market power in modern agricultural value chains.

Ugandan Ministry of Agriculture A.I. and Fisheries (2010) Agricultural sector development strategy and investment plan: 2010/11-2014/15, Technical report, Ugandan Ministry of Agriculture, Animal Industry and Fisheries, Entebbe, Uganda.

USAID (2010) Market assessment and baseline study of staple foods, Technical report, Country Report-Uganda.

Visaria S., Mitra S., Mookherjee D. and Torero M. (2015) Asymmetric information and middleman margins: An experiment with indian potato farmers.

Von Braun J. (1995) Agricultural commercialization: impacts on income and nutrition and implications for policy, *Food policy*, 20, 3, 187–202.

Wang H., Dong X., Rozelle S., Huang J. and Reardon T. (2009) Producing and procuring horticultural crops with chinese characteristics: the case of northern china, *World Development*, 37, 11, 1791–1801.

Wang X., Tadesse H., Rayner T. *et al.* (2006) Price transmission, market power and returns to scale: A note, *University of Nottingham Discussion Papers in Economics*, , 06/07, 06–07.

Warning M. and Key N. (2002) The social performance and distributional consequences of contract farming: An equilibrium analysis of the arachide de bouche program in senegal, *World Development*, 30, 2, 255–263.

Weldegebriel H.T. (2004) Imperfect price transmission: is market power really to blame?, *Journal of Agricultural Economics*, 55, 1, 101–114.

Wohlgenant M.K. (2001) Marketing margins: Empirical analysis, *Handbook of agricultural economics*, 1, 933–970.

Wooldridge J.M. (2010) *Econometric analysis of cross section and panel data*, MIT press.

Zorya S. (2009) Eastern africa: A study of the regional maize market and marketing costs, *World Bank Report*, , 49831-AFR.

Appendix A. Tables & Figures

Table A.1: Summary statistics of the movers

	Overall		Between		Within
Market participation	Freq.	Percent	Freq.	Percent	Percent
Not participating to the market chain	78	16.25	57	33.73	46.78
Participating to market	402	83.75	167	98.82	85.23
Total	480	100	224	132.54	75.45
	Overall		Between		Within
Upstream	Freq.	Percent	Freq.	Percent	Percent
Not selling maize upstream	164	34.17	107	63.31	52.18
Selling maize upstream	316	65.83	162	95.86	69.86
Total	480	100	269	159.17	62.83
	Overall		Between		Within
Downstream	Freq.	Percent	Freq.	Percent	Percent
Not selling maize downstream	394	82.08	168	99.41	83.23
Selling maize downstream	86	17.92	68	40.24	42.89
Total	480	100	236	139.64	71.61

Table A.2: Outcomes of the Levene's robust test statistic for the equality of variances between "movers" and "non-movers"

	Levene's test centered at the mean	**Prob>F**
Household food security		
Food consumption pc	2.652	0.104
Squared difference of food consumption pc	2.232	0.136
Maize production and sale		
Maize acreage	0.061	0.805
Use of pesticides (dummy)	11.167	0.001
Use of fertilizers (dummy)	0.094	0.759
Use of improved seeds (dummy)	0.396	0.530
Hire labour (dummy)	4.664	0.032
Transport cost (UShs)	0.183	0.669
Harvested maize (Kg)	0.316	0.575
Consumed maize (Kg)	1.657	0.199
Sold maize (Kg)	4.018	0.046
Unit price (UShs per Kg)	0.402	0.526
Household characteristics		
HH size	0.169	0.682
Female HH head	0.001	0.977
Married HH head	1.051	0.306
Age of HH head	0.281	0.597
Average education	0.780	0.378
Electricity	0.331	0.565
Improved water	20.018	0.000
Distance to market	0.000	0.993

Table A.3: Summary statistics of panel households by market chain participation and position

	(1) Outside the VC		(2) Upstream		(3) Downstream	
	Mean	Difference Outside - Not	Mean	Difference Upstream - Not	Mean	Difference Downstream - Not
Household Food security						
Food consumption pc	262,673.4	-43,013.98*	305,472.7	19,404.37	306,470.9	9,250.041
	(188,546.5)		(185,288.7)		(183,462.2)	
(log) Food consumption pc	12.428	-0.163**	12.581	0.044	12.632	0.081
	(0.677)		(0.637)		(0.557)	
Squared difference of food consumption pc	0.224	0.019	0.221	0.038	0.146	-0.075*
	(0.411)		(0.369)		(0.238)	
Income						
Income pc	332,452.2	-129,499.7*	493,889.1	155,441.7***	343,596.3	-119,919.4*
	(357,050.2)		(546,073.1)		(631,417.5)	
(log) Income pc	12.401	-0.311***	12.738	0.223*	12.616	-0.059
	(0.881)		(0.881)		(0.839)	
Share wage employment: agriculture and fishing	0.054	-.017	0.039	-0.009	0.043	0.001
	(0.136)		(0.140)		(0.132)	
Share wage employment: non-farm activities	0.036	-0.017	0.061	0.028*	0.029	-0.027
	(0.147)		(0.178)		(0.125)	
Share transfers	0.019	-0.014	0.040	0.025*	0.011	-0.025
	(0.074)		(0.154)		(0.043)	
Share non-agricultural business	0.181	0.052	0.123	-0.039	0.1480	0.013
	(0.353)		(0.298)		(0.353)	
Share own-farm production of crop	0.648	0.013	0.628	-0.028	0.663	0.031
	(0.418)		(0.399)		(0.456)	
Share livestock and fishing production	0.049	-0.044	0.092	0.018	0.095	0.011
	(0.264)		(0.261)		(0.267)	
Share other	0.009	-0.003	0.013	0.0137	0.008	-0.003
	(0.055)		(0.086)		(0.034)	
Maize production and sale						
Maize acreage	1.109	-0.298**	1.367	0.024	1.556	0.239*
	(0.930)		(1.068)		(1.065)	
Use of pesticides (dummy)	0.038	-0.126***	0.164	0.061*	0.162	0.023
	(0.194)		(0.371)		(0.371)	
Use of fertilizers (dummy)	0	-0.032	0.038	0.032**	0.012	-0.018
	(0.000)		(0.191)		(0.108)	
Use of improved seeds (dummy)	0.089	-0.149***	0.231	0.048	0.267	0.064
	(0.288)		(0.422)		(0.445)	
Hire labour (dummy)	0.244	-0.246***	0.468	0.054	0.569	0.146**
	(0.432)		(0.499)		(0.498)	
Transport cost (UShs)	102.564	-3,219.326	2,137.342	-1,935.829	7,674.419	5,939.901***
	(905.822)		(16,933.97)		(31,813.22)	
Harvested maize (Kg)	2,194.397	-2,116.276***	4,295.731	962.789*	4,365.576	485.845
	(2,313.548)		(6,527.657)		(5,384.944)	
Consumed maize (Kg)	680.197	-288.319*	955.949	100.341	1,014.7	113.342
	(665.089)		(1,166.849)		(1,630.746)	
Sold maize (Kg)	1,185.549	-1,395.403**	2,566.576	621.592*	2,633.773	340.599
	(1,668.214)		(3,408.806)		(3,937.161)	
Unit price (UShs per Kg)	911.5681	-235.898	1,085.524	-69.097	1,375.066	323.979
	(2,592.993)		(3,179.402)		(3,243.986)	
Household characteristics						
HH size	6.395	-0.414	6.791	0.139	6.884	0.171
	(2.514)		(3.225)		(3.309)	
Female HH head	0.064	-0.043	0.108	0.022	0.105	0.006
	(0.246)		(0.311)		(0.308)	
Married HH head	0.923	0.025	0.898	-0.009	0.895	-0.008
	(0.268)		(0.302)		(0.308)	
Age of HH head	42.103	-2.903*	45.259	2.125*	44.069	-0.565
	(12.358)		(13.489)		(12.046)	
Average education	4.379	-0.184	4.599	0.189	4.437	-0.118
	(1.783)		(2.215)		(2.094)	
Electricity	0	-0.014	0.013	0.001	0.023	0.013
	(0.000)		(0.112)		(0.152)	
Improved water	0.718	-0.065	0.791	0.053	0.756	-0.021
	(0.453)		(0.407)		(0.432)	
Distance to market	3.334	0.035	3.274	0.088	3.388	-0.102
	(0.805)		(0.654)		(0.705)	
Location dummies						
Center	0.128	-0.151***	0.259	0.016	0.349	0.115**
	(0.336)		(0.439)		(0.479)	
East	0.218	-0.081	0.339	0.156***	0.151	-0.164**
	(0.416)		(0.474)		(0.361)	
North	0.295	0.094*	0.149	-0.199***	0.395	0.217***
	(0.459)		(0.356)		(0.492)	
West	0.359	0.138***	0.253	0.026	0.105	-0.169***
	(0.483)		(0.436)		(0.308)	
Obs.	78		316		86	

Standard deviation in parenthesis.
For each variable, the differences between the mean values by household participation and position are reported.
*** denotes statistical significance of the mean difference at 1%, ** at 5%, and * at 10%.

Table A.4: Probability of entering the MAIZE market chain (selling inside the market chain at t but not at t-1

	(1) Entering the market
Use of fertilizers	-
Use of pesticides	-0.561
	(0.519)
Hire labour	-0.539**
	(0.246)
Use of improved seeds	-0.0100
	(0.303)
Harvested maize	-0.319***
	(0.122)
Maize acreage	0.114
	(0.105)
HH size	-0.181
	(0.208)
Age of HH head	0.291
	(0.353)
Average education	0.216
	(0.231)
Electricity	-
Improved source of water	-0.00188
	(0.248)
Distance to market	-0.0399
	(0.156)
Central	-0.100
	(0.352)
East	0.264
	(0.300)
North	-0.138
	(0.293)
Year 2010	-0.479**
	(0.227)
Constant	0.838
	(1.642)
Observations	298
Log-likelihood	-101.822
Pseudo R-squared	0.133

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.5: Probability of moving upstream the MAIZE market chain (selling downstream at t but not at t+1)

	(1) Changing downstream
Use of fertilizers	-
Use of pesticides	0.187
	(0.338)
Hire labour	0.314
	(0.222)
Use of improved seeds	0.0539
	(0.239)
Harvested maize	-0.0136
	(0.104)
Maize acreage	0.0423
	(0.106)
HH size	-0.110
	(0.194)
Age of HH head	0.209
	(0.341)
Average education	0.147
	(0.223)
Electricity	0.292
	(0.905)
Improved source of water	-0.218
	(0.229)
Distance to market	-0.0756
	(0.166)
Center	0.271
	(0.325)
East	-0.124
	(0.341)
North	0.805***
	(0.310)
Year 2010	0.388*
	(0.209)
Constant	-2.065
	(1.664)
Observations	301
Log-likelihood	-108.798
Pseudo R-squared	0.105

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.6: Panel regression of CASSAVA market chain participation on food consumption

	(HH and year FE)		(HH and year FE + HH trend		(HH and year FE + HH trend + selection correction)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Selling inside VC	0.156*		0.233*		0.242*	
	(0.0815)		(0.129)		(0.129)	
Share maize sold inside VC		0.157*		0.351***		0.353***
		(0.0803)		(0.131)		(0.129)
HH size	-0.700***	-0.706***	-0.841***	-0.853***	-0.717***	-0.731***
	(0.118)	(0.118)	(0.198)	(0.195)	(0.209)	(0.206)
Age of HH head	-0.198	-0.198	-0.207	-0.180	-0.486	-0.439
	(0.588)	(0.588)	(0.751)	(0.740)	(0.779)	(0.768)
Female HH head	-0.147	-0.137	-0.178	-0.179	-0.0369	-0.0492
	(0.139)	(0.138)	(0.168)	(0.164)	(0.212)	(0.209)
Married HH head	0.0984	0.0797	0.0353	0.0653	0.121	0.145
	(0.332)	(0.332)	(0.702)	(0.688)	(0.701)	(0.689)
Average education	0.109	0.105	-0.0739	-0.0561	-0.176	-0.154
	(0.0863)	(0.0863)	(0.165)	(0.162)	(0.170)	(0.167)
Electricity	0.625	0.619	1.692	1.422	1.970	1.665
	(0.554)	(0.554)	(1.268)	(1.255)	(1.340)	(1.329)
Improved source of water	0.00795	0.0115	0.133	0.159	0.234	0.256*
	(0.0876)	(0.0875)	(0.139)	(0.137)	(0.150)	(0.148)
Distance to market	0.0149	0.0147	-1.576	-1.437	-1.727	-1.571
	(1.136)	(1.136)	(2.658)	(2.620)	(2.638)	(2.601)
Year 2009	-0.0230	-0.0181				
	(0.0689)	(0.0691)				
Year 2010	-0.505***	-0.505***	-0.512***	-0.502***	-0.578***	-0.563***
	(0.0616)	(0.0616)	(0.0595)	(0.0588)	(0.0891)	(0.0880)
ρ (1)					-0.636	-0.572
					(0.681)	(0.666)
Constant	14.31***	14.35***	75.26	82.74	88.27	97.40
	(4.666)	(4.665)	(94.08)	(92.70)	(96.84)	(95.54)
Observations	430	430	430	430	428	428
R-squared	0.693	0.693	0.826	0.832	0.834	0.839

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.7: Panel regression of CASSAVA market chain position on food consumption

	(HH and year FE)		(HH and year FE + HH trend		(HH and year FE + HH trend + selection correction)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Selling upstream	0.152*		0.241*		0.264**	
	(0.0828)		(0.131)		(0.131)	
Selling downstream	0.173*		0.179		0.180	
	(0.0993)		(0.166)		(0.166)	
Share maize sold upstream		0.146*		0.362***		0.380***
		(0.0817)		(0.135)		(0.134)
Share maize sold downstream		0.205*		0.307*		0.280
		(0.107)		(0.175)		(0.175)
HH size	-0.701***	-0.707***	-0.847***	-0.857***	-0.693***	-0.705***
	(0.118)	(0.119)	(0.199)	(0.196)	(0.211)	(0.208)
Age of HH head	-0.211	-0.224	-0.171	-0.157	-0.0930	-0.0377
	(0.591)	(0.590)	(0.757)	(0.745)	(0.883)	(0.870)
Female HH head	-0.145	-0.129	-0.178	-0.184	-0.0189	-0.0357
	(0.139)	(0.139)	(0.168)	(0.165)	(0.213)	(0.210)
Married HH head	0.0997	0.0848	0.0265	0.0608	0.0884	0.120
	(0.333)	(0.333)	(0.704)	(0.691)	(0.703)	(0.691)
Average education	0.111	0.109	-0.0810	-0.0655	-0.278	-0.268
	(0.0868)	(0.0866)	(0.166)	(0.165)	(0.197)	(0.194)
Electricity	0.609	0.571	1.739	1.464	2.816*	2.566
	(0.558)	(0.559)	(1.274)	(1.265)	(1.575)	(1.563)
Improved source of water	0.00788	0.0129	0.131	0.156	0.255*	0.276*
	(0.0877)	(0.0876)	(0.139)	(0.138)	(0.151)	(0.149)
Distance to market	0.0286	0.0701	-1.518	-1.381	-2.029	-1.868
	(1.139)	(1.140)	(2.668)	(2.633)	(2.679)	(2.641)
Year 2009	-0.0248	-0.0255				
	(0.0694)	(0.0699)				
Year 2010	-0.504***	-0.506***	-0.516***	-0.505***	-0.659***	-0.646***
	(0.0617)	(0.0617)	(0.0605)	(0.0594)	(0.117)	(0.116)
ρ (2)					-0.829	-0.774
					(0.700)	(0.688)
ρ (3)					-1.406	-1.378
					(1.038)	(1.017)
Constant	14.31***	14.26***	79.61	90.63	150.0	170.0
	(4.674)	(4.671)	(94.73)	(95.32)	(116.2)	(115.3)
Observations	430	430	430	430	428	428
R-squared	0.693	0.694	0.827	0.832	0.836	0.841

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.8: Panel regression of CASSAVA market chain participation on food consumption volatility

	(HH and year FE)		(HH and year FE + HH trend		(HH and year FE + HH trend + selection correction)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Selling inside VC	-0.0414		-0.141		-0.159*	
	(0.0491)		(0.0887)		(0.0894)	
Share maize sold inside VC		-0.0675		-0.244***		-0.252***
		(0.0483)		(0.0893)		(0.0893)
HH size	-0.142**	-0.138*	-0.00873	0.00271	-0.0621	-0.0496
	(0.0712)	(0.0712)	(0.136)	(0.133)	(0.144)	(0.142)
Age of HH head	-0.0440	-0.0491	0.0872	0.0619	0.313	0.278
	(0.354)	(0.353)	(0.516)	(0.506)	(0.539)	(0.530)
Female HH head	0.0946	0.0960	0.122	0.128	-0.0135	-0.00325
	(0.0836)	(0.0831)	(0.115)	(0.112)	(0.147)	(0.144)
Married HH head	0.0383	0.0492	0.286	0.277	0.188	0.177
	(0.200)	(0.200)	(0.482)	(0.471)	(0.485)	(0.475)
Average education	0.0629	0.0641	0.0684	0.0573	0.121	0.107
	(0.0520)	(0.0519)	(0.113)	(0.111)	(0.118)	(0.115)
Electricity	0.117	0.131	-0.209	0.0119	-0.652	-0.420
	(0.334)	(0.333)	(0.870)	(0.859)	(0.927)	(0.917)
Improved source of water	-0.0746	-0.0744	-0.130	-0.147	-0.184*	-0.200*
	(0.0528)	(0.0526)	(0.0954)	(0.0937)	(0.104)	(0.102)
Distance to market	-0.0483	-0.0461	-0.0559	-0.163	0.128	0.0126
	(0.684)	(0.683)	(1.824)	(1.792)	(1.826)	(1.794)
Year 2009	0.00701	0.00403				
	(0.0415)	(0.0415)				
Year 2010	0.121***	0.118***	0.116***	0.108***	0.180***	0.169***
	(0.0371)	(0.0370)	(0.0409)	(0.0402)	(0.0617)	(0.0607)
ρ (1)					0.671	0.635
					(0.471)	(0.459)
Constant	0.698	0.710	6.988	0.296	15.59	8.392
	(2.811)	(2.805)	(64.58)	(63.40)	(67.03)	(65.90)
Observations	430	430	430	430	428	428
R-squared	0.592	0.594	0.700	0.711	0.708	0.719

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.9: Panel regression of CASSAVA market chain position on food consumption volatility

	(HH and year FE)		(HH and year FE + HH trend		(HH and year FE + HH trend + selection correction)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Selling upstream	-0.0363		-0.137		-0.164*	
	(0.0498)		(0.0898)		(0.0907)	
Selling downstream	-0.0625		-0.160		-0.176	
	(0.0598)		(0.114)		(0.115)	
Share maize sold upstream		-0.0618		-0.239**		-0.258***
		(0.0492)		(0.0920)		(0.0922)
Share maize sold downstream		-0.0939		-0.260**		-0.250**
		(0.0642)		(0.120)		(0.120)
HH size	-0.141**	-0.137*	-0.0106	0.00123	-0.0885	-0.0753
	(0.0713)	(0.0713)	(0.137)	(0.134)	(0.146)	(0.143)
Age of HH head	-0.0266	-0.0348	0.100	0.0707	-0.0526	-0.0850
	(0.356)	(0.355)	(0.520)	(0.510)	(0.611)	(0.600)
Female HH head	0.0921	0.0918	0.122	0.127	-0.0161	-0.00862
	(0.0838)	(0.0834)	(0.116)	(0.113)	(0.148)	(0.145)
Married HH head	0.0367	0.0464	0.283	0.275	0.219	0.205
	(0.200)	(0.200)	(0.483)	(0.473)	(0.486)	(0.476)
Average education	0.0603	0.0615	0.0658	0.0538	0.207	0.194
	(0.0522)	(0.0521)	(0.114)	(0.113)	(0.136)	(0.134)
Electricity	0.138	0.157	-0.192	0.0279	-1.373	-1.152
	(0.336)	(0.336)	(0.875)	(0.865)	(1.089)	(1.077)
Improved source of water	-0.0745	-0.0752	-0.130	-0.149	-0.201*	-0.218**
	(0.0528)	(0.0527)	(0.0957)	(0.0942)	(0.105)	(0.103)
Distance to market	-0.0663	-0.0761	-0.0348	-0.142	0.498	0.359
	(0.686)	(0.685)	(1.833)	(1.801)	(1.853)	(1.820)
Year 2009	0.00938	0.00802				
	(0.0418)	(0.0421)				
Year 2010	0.120***	0.119***	0.114***	0.107***	0.246***	0.236***
	(0.0372)	(0.0371)	(0.0415)	(0.0406)	(0.0813)	(0.0800)
ρ (2)					0.782	0.757
					(0.484)	(0.474)
ρ (3)					1.362*	1.324*
					(0.718)	(0.701)
Constant	0.697	0.760	8.571	3.262	-40.91	-48.62
	(2.814)	(2.809)	(65.07)	(65.22)	(80.35)	(79.44)
Observations	430	430	430	430	428	428
R-squared	0.592	0.594	0.700	0.711	0.712	0.722

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.10: Panel regression of PLANTAINS market chain participation on food consumption

	(HH and year FE)		(HH and year FE + HH trend		(HH and year FE + HH trend + selection correction)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Selling inside VC	-0.0920		-0.279**		-0.287**	
	(0.0804)		(0.132)		(0.142)	
Share maize sold inside VC		-0.105		-0.220*		-0.254**
		(0.0685)		(0.113)		(0.121)
HH size	-0.781***	-0.782***	-0.687***	-0.712***	-0.700***	-0.724***
	(0.103)	(0.102)	(0.173)	(0.172)	(0.174)	(0.172)
Age of HH head	-0.275	-0.269	-1.816***	-1.823***	-1.760***	-1.763***
	(0.386)	(0.385)	(0.635)	(0.636)	(0.646)	(0.645)
Female HH head	-0.00479	-0.00145	0.0869	0.0893	0.128	0.139
	(0.0914)	(0.0913)	(0.104)	(0.105)	(0.109)	(0.109)
Married HH head	0.0874	0.0808	0.432	0.417	0.461	0.448
	(0.193)	(0.192)	(0.362)	(0.363)	(0.372)	(0.371)
Average education	0.0726	0.0722	0.140	0.135	0.107	0.0958
	(0.0625)	(0.0624)	(0.0918)	(0.0921)	(0.0955)	(0.0956)
Electricity	0.282	0.283	0.203	0.192	0.259	0.259
	(0.255)	(0.254)	(0.389)	(0.390)	(0.407)	(0.406)
Improved source of water	0.000305	0.000286	-0.0438	-0.0420	-0.0317	-0.0287
	(0.0731)	(0.0729)	(0.110)	(0.110)	(0.115)	(0.114)
Distance to market	-17.95	-17.81	-7.723	-10.30	-13.25	-16.03
	(17.26)	(17.22)	(35.07)	(35.02)	(36.18)	(36.06)
Year 2009	-0.201***	-0.200***				
	(0.0556)	(0.0555)				
Year 2010	-0.312***	-0.307***	-0.184***	-0.180***	-0.191***	-0.186***
	(0.0491)	(0.0491)	(0.0460)	(0.0464)	(0.0468)	(0.0469)
ρ (1)					0.233	0.271
					(0.477)	(0.481)
Constant	74.54	74.06	-256.1*	-238.8*	-223.5	-203.3
	(56.91)	(56.76)	(132.5)	(131.8)	(138.7)	(138.2)
Observations	537	537	537	537	534	534
R-squared	0.589	0.590	0.795	0.795	0.797	0.798

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.11: Panel regression of PLANTAINS market chain position on food consumption

	(HH and year FE)		(HH and year FE + HH trend		(HH and year FE + HH trend + selection correction)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Selling upstream	-0.0766		-0.246*		-0.262*	
	(0.0806)		(0.134)		(0.143)	
Selling downstream	-0.194*		-0.383**		-0.402**	
	(0.0988)		(0.154)		(0.166)	
Share maize sold upstream		-0.0992		-0.207*		-0.249**
		(0.0689)		(0.114)		(0.122)
Share maize sold downstream		-0.185*		-0.333*		-0.370*
		(0.112)		(0.183)		(0.195)
HH size	-0.774***	-0.775***	-0.668***	-0.703***	-0.609***	-0.639***
	(0.102)	(0.103)	(0.173)	(0.172)	(0.190)	(0.189)
Age of HH head	-0.297	-0.283	-1.840***	-1.839***	-1.932***	-1.938***
	(0.385)	(0.386)	(0.634)	(0.637)	(0.664)	(0.666)
Female HH head	-0.00775	-0.00217	0.0843	0.0888	0.127	0.141
	(0.0912)	(0.0913)	(0.104)	(0.105)	(0.108)	(0.109)
Married HH head	0.0608	0.0739	0.420	0.413	0.260	0.240
	(0.193)	(0.193)	(0.362)	(0.364)	(0.424)	(0.425)
Average education	0.0712	0.0729	0.127	0.130	0.0891	0.0867
	(0.0623)	(0.0624)	(0.0921)	(0.0924)	(0.0959)	(0.0960)
Electricity	0.266	0.276	0.152	0.154	0.166	0.176
	(0.254)	(0.254)	(0.390)	(0.393)	(0.410)	(0.413)
Improved source of water	-0.00733	-0.00618	-0.0474	-0.0471	-0.0822	-0.0840
	(0.0730)	(0.0733)	(0.110)	(0.110)	(0.125)	(0.125)
Distance to market	-18.98	-18.13	-11.96	-12.91	-24.29	-25.56
	(17.22)	(17.22)	(35.14)	(35.22)	(36.96)	(36.96)
Year 2009	-0.209***	-0.203***				
	(0.0556)	(0.0556)				
Year 2010	-0.327***	-0.315***	-0.200***	-0.190***	-0.276***	-0.269***
	(0.0496)	(0.0498)	(0.0474)	(0.0483)	(0.0875)	(0.0880)
ρ (2)					0.264	0.293
					(0.477)	(0.482)
ρ (3)					-0.503	-0.523
					(0.931)	(0.933)
Constant	78.03	75.16	-246.3*	-231.7*	-246.3*	-232.2
	(56.77)	(56.78)	(132.4)	(132.3)	(143.1)	(143.1)
Observations	537	537	537	537	534	534
R-squared	0.592	0.591	0.798	0.795	0.800	0.799

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.12: Panel regression of PLANTAINS market chain participation on food consumption volatility

	(HH and year FE)		(HH and year FE + HH trend		(HH and year FE + HH trend + selection correction)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Selling inside VC	-0.00426		0.00344		-0.00720	
	(0.0387)		(0.0651)		(0.0703)	
Share maize sold inside VC		0.0146		0.0363		0.0347
		(0.0331)		(0.0553)		(0.0600)
HH size	-0.109**	-0.110**	0.149*	0.144*	0.148*	0.144*
	(0.0494)	(0.0494)	(0.0849)	(0.0841)	(0.0860)	(0.0853)
Age of HH head	-0.0287	-0.0278	0.330	0.334	0.353	0.348
	(0.186)	(0.186)	(0.312)	(0.312)	(0.320)	(0.320)
Female HH head	-0.0617	-0.0619	-0.0555	-0.0580	-0.0586	-0.0616
	(0.0440)	(0.0440)	(0.0513)	(0.0513)	(0.0538)	(0.0539)
Married HH head	-0.0672	-0.0627	-0.474***	-0.471***	-0.456**	-0.460**
	(0.0929)	(0.0928)	(0.178)	(0.178)	(0.184)	(0.184)
Average education	-0.0376	-0.0374	-0.0987**	-0.0967**	-0.0941**	-0.0920*
	(0.0301)	(0.0301)	(0.0451)	(0.0452)	(0.0473)	(0.0474)
Electricity	-0.0284	-0.0256	0.125	0.123	0.150	0.137
	(0.123)	(0.123)	(0.191)	(0.191)	(0.202)	(0.201)
Improved source of water	0.0113	0.0122	0.0451	0.0461	0.0521	0.0505
	(0.0352)	(0.0352)	(0.0540)	(0.0540)	(0.0568)	(0.0567)
Distance to market	8.556	8.220	23.74	22.73	22.33	21.78
	(8.318)	(8.305)	(17.25)	(17.17)	(17.93)	(17.87)
Year 2009	-0.000913	-0.000564				
	(0.0268)	(0.0268)				
Year 2010	-0.0204	-0.0210	-0.0297	-0.0317	-0.0308	-0.0322
	(0.0236)	(0.0237)	(0.0226)	(0.0228)	(0.0232)	(0.0232)
ρ (1)					0.103	0.0603
					(0.237)	(0.238)
Constant	-27.62	-26.53	-88.23	-84.77	-81.46	-80.79
	(27.42)	(27.38)	(65.15)	(64.63)	(68.74)	(68.48)
Observations	537	537	537	537	534	534
R-squared	0.538	0.538	0.760	0.761	0.761	0.761

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.13: Panel regression of PLANTAINS market chain position on food consumption

	(HH and year FE)		(HH and year FE + HH trend		(HH and year FE + HH trend + selection correction)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Selling upstream	-0.000988		-0.00288		-0.0119	
	(0.0390)		(0.0664)		(0.0712)	
Selling downstream	-0.0259		0.0239		0.0142	
	(0.0478)		(0.0761)		(0.0828)	
Share maize sold upstream		0.0180		0.0329		0.0318
		(0.0332)		(0.0560)		(0.0606)
Share maize sold downstream		-0.0304		0.0660		0.0662
		(0.0539)		(0.0897)		(0.0970)
HH size	-0.107**	-0.106**	0.145*	0.142*	0.157*	0.153
	(0.0495)	(0.0495)	(0.0854)	(0.0845)	(0.0947)	(0.0940)
Age of HH head	-0.0334	-0.0354	0.334	0.339	0.330	0.327
	(0.186)	(0.186)	(0.313)	(0.313)	(0.332)	(0.331)
Female HH head	-0.0623	-0.0623	-0.0550	-0.0579	-0.0570	-0.0601
	(0.0441)	(0.0440)	(0.0515)	(0.0515)	(0.0541)	(0.0543)
Married HH head	-0.0729	-0.0666	-0.472***	-0.470***	-0.489**	-0.492**
	(0.0932)	(0.0929)	(0.179)	(0.179)	(0.212)	(0.211)
Average education	-0.0379	-0.0369	-0.0961**	-0.0954**	-0.0923*	-0.0915*
	(0.0301)	(0.0301)	(0.0455)	(0.0454)	(0.0479)	(0.0478)
Electricity	-0.0316	-0.0296	0.135	0.133	0.151	0.140
	(0.123)	(0.123)	(0.193)	(0.193)	(0.205)	(0.205)
Improved source of water	0.00970	0.00856	0.0458	0.0474	0.0441	0.0439
	(0.0353)	(0.0353)	(0.0542)	(0.0542)	(0.0624)	(0.0624)
Distance to market	8.338	8.041	24.57	23.42	21.88	21.26
	(8.327)	(8.305)	(17.36)	(17.29)	(18.45)	(18.39)
Year 2009	-0.00245	-0.00229				
	(0.0269)	(0.0268)				
Year 2010	-0.0236	-0.0254	-0.0267	-0.0289	-0.0401	-0.0410
	(0.0240)	(0.0240)	(0.0234)	(0.0237)	(0.0437)	(0.0438)
ρ (2)					0.103	0.0628
					(0.238)	(0.240)
ρ (3)					-0.0336	-0.0670
					(0.465)	(0.464)
Constant	-26.88	-25.91	-90.15	-86.65	-89.34	-88.26
	(27.45)	(27.38)	(65.39)	(64.94)	(71.44)	(71.22)
Observations	537	537	537	537	534	534
R-squared	0.538	0.539	0.761	0.761	0.761	0.762

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.14: Probability of entering the CASSAVA market chain (selling inside the market chain at t but not at t-1)

	(1) Entering the market
Use of fertilizers	-
Use of pesticides	-0.462
	(0.525)
Hire labour	-0.662**
	(0.262)
Use of improved seeds	0.0116
	(0.306)
harvested cassava	-0.246*
	(0.131)
Cassava acreage	0.166
	(0.114)
HH size	-0.196
	(0.213)
Age of HH head	0.311
	(0.366)
Average education	0.210
	(0.242)
Electricity	-
Improved source of water	0.00798
	(0.259)
Distance to market	-0.0770
	(0.162)
Center	-0.242
	(0.379)
East	0.258
	(0.309)
North	-0.0953
	(0.299)
Year 2010	-0.541**
	(0.234)
Constant	0.488
	(1.703)
Observations	278
Log-likelihood	-94.815
Pseudo R-squared	0.145

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.15: Probability of changing upstream in the CASSAVA market chain (selling downstream at t but not at t+1)

	(1) Changing downstream
Use of fertilizers	-
Use of pesticides	0.146
	(0.344)
Hire labour	0.298
	(0.229)
Use of improved seeds	-0.0118
	(0.247)
Harvested cassava	-0.00258
	(0.107)
Cassava acreage	0.0496
	(0.109)
HH size	-0.134
	(0.196)
Age of HH head	0.192
	(0.348)
Average education	0.114
	(0.227)
Electricity	0.385
	(0.918)
Improved source of water	-0.251
	(0.233)
Distance to market	-0.0309
	(0.175)
Center	0.295
	(0.332)
East	-0.206
	(0.353)
North	0.776**
	(0.312)
Year 2010	0.428**
	(0.214)
Constant	-2.077
	(1.697)
Observations	281
Log-likelihood	-104.036
Pseudo R-squared	0.109

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$