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ESSAYS ON POSITIONING IN VALUE CHAINS, PROXIMITY TO MARKETS AND DEVELOPMENT

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Executive Summary*

This thesis examines the relationship between value chain positioning, market proximity, and development. The research constituting this work focuses on the more recent debate in the development literature on market positioning and participation by farmers in rural developing areas. Although nowadays, crop commercialization is generally considered to have positive effects on development, the literature on the main determinants of this relationship still needs to reach definitive conclusions.

Market participation allows farmers to diversify their production, bringing significant advantages to small-scale producers, like access to new customers, lower costs, and business risk diversification. Nevertheless, this outcome could be very different in a risky environment like the one in developing countries. This scenario can be exacerbated (or eased) in agricultural product value chains. The literature has vastly debated how a market value chain is structured, but it has yet to discuss how it gets structured, especially at the farmer level.

From a "macro" point of view, the conceptual framework for (global) value chain participation and positioning stands on what was primarily outlined by Antràs & Chor in 2013 and 2018. At the "micro" level, particularly in development studies, the theoretical framework around positioning in VCs for smallholder farmers is still unsettled. At the same time, research on the links between market proximity and farmers' vulnerability to food security is scarce.

Drawing from both the new trade literature on value chains and the development literature on household development and food security, this thesis addresses, at multiple scales of analysis, the research question of whether there is a connection between value chain positioning and welfare, as well as how proximity to markets affects the relationship between resilience and food security. More specifically, this work delivers a theoretical framework for farmers' positioning in agricultural value chains; secondly, it explores the linkages across proximity to markets, resilience, and food security; finally, it tests whether better farmers' commercialization positioning both in terms of downstreamness in value chains and proximity to private companies, increases farmers' consumption as well as firms' productivity.

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* I hereby declare that this thesis has not been and will not be submitted in whole or in part to another university for the award of any other degree. Material included in Essay 2 has been incorporated in a working paper co-authored with my supervisors and Dr. Alessandra Garbero. However, the bulk of the original research presented in this thesis, including all the empirical applications in each of the following essays, is my own work.

The contributions of this thesis to the current literature are conceptual and empirical. Essay 1 provides a first indicator for farmers' positioning in value chains and tests its validity compared to its current alternatives. Based on a unique dataset, Essay 2 outlines the application of the Chaudhuri (2003) Vulnerability as Expected Poverty (VEP) framework to a subjective, non-monetary variable of food security and a new empirical approach using machine-learning techniques in the VEP calculation procedure. Lastly, Essay 3 goes beyond the boundaries of a sole-farmer value chain analysis with the integration in the analysis of a dataset focusing on firms, allowing to study the impacts of farming households' value chain positioning beyond the farm.

Although one cannot rely on *ad hoc* datasets for micro analyses on value chains, this work employs robust empirical methods and panel household data to test the validity of the proposed indicator. In addition, specifically in Essay 2, a mediation analysis estimates the indirect effect of resilience on food security volatility and vulnerability via proximity to markets (a standard proxy for market positioning in the development literature). Ultimately, the empirical assessment around the impact of farmers' value chain positioning is improved by the inclusion of spatial panel models accounting for spatial spillovers in their calculations (see Essay 3).

Essay 1 proposes a micro-level measure for the positioning of farmers in value chains (in the absence of information on farmers' inputs of production it turns out to measure positioning in "market chains") inspired by the conceptual framework outlined by Antràs and Chor (2013, 2018), leveraging for farming households' selling location and buyers. Using the World Bank's panel data for Ethiopia and Nigeria from "Living Standards Measurement Study: Integrated Surveys on Agriculture," this work also provides an empirical application of the proposed indicator showing how it performs better compared to the current alternatives at the micro-level. Secondly, by investigating the dynamics of farmers' food and total consumption over time and controlling for various household and production characteristics, as well as possible confounding factors, this Essay demonstrates that changes in farmers' welfare as proxied by food and total consumption, are positively affected by better positioning in the market chain.

Essay 2 advocates that proximity to final markets drives the link between resilience and food security. This work uses an exclusive dataset made available by the International Fund for Agricultural Development in 2017-2018 to contribute to the understanding of this impact. The paper applies a hybrid empirical approach combining machine learning algorithms with standard vulnerability approaches. Specifically, this work finds positive and statistically significant associations among proximity to markets, resilience, and food security. The work tests the plausibility of the exclusion restriction that market proximity does not affect food security fluctuations other than its impact on resilience capacity by implementing an instrumental variable approach. Moreover, using mediation analysis, this Essay reveals that market proximity accounts for a significant share of the positive correlation between household resilience and food security outcomes. The dampening role played by market proximity in decreasing welfare fluctuations is also confirmed when replacing food security outcomes with income ones. Overall, these findings suggest that policymakers should prioritize interventions to improve infrastructure and access to markets to boost household resilience and, in turn, decrease welfare fluctuations and vulnerability to food insecurity.

Essay 3 applies spatial panel regression models to a unique longitudinal dataset of firms and farmers' surveys. This work stands on the availability of two datasets of surveys conducted by the World Bank Living Standards Measurement Study (LSMS-ISA) and by the Central Statistics Agency of Ethiopia in three data collection waves between 2010 and 2016 in Ethiopia. Based on the farmers' positioning indicator developed in Essay 1, Essay 3 evaluates the welfare effects of positioning both in terms of market chains as well as geographical distance to firms with international exposure on farming households and its consequences on the productivity of local firms. Specifically, this paper tests the relationship between farmers' positioning in markets (estimated both in terms of geographical distance and positioning in value chains) and firms that import and export abroad, as well as the relationship between firms' closeness to farmers and their productivity levels. The key results are i) better farmers' positioning, both geographically to firms in global markets and in value chains, boosts households' welfare; ii) firms' proximity to farmers operating in value chains affects their total sales as well as productivity. These findings highlight how better farmer-to-firm and firm-to-farmer relationships represent a crucial means to foster local development.

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ESSAY 1

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PARTICIPATION OF FARMERS IN MARKET VALUE CHAINS: A TAILORED ANTRÀS AND CHOR POSITIONING INDICATOR+

Abstract

This work provides a micro-level measure of farmers' positioning in the market chain, inspired by the conceptual framework outlined by Antràs and Chor (2013, 2018). It leverages a farming household's selling location and buyers. Using the World Bank's panel data for Ethiopia and Nigeria from the 'Living Standards Measurement Study: Integrated Surveys on Agriculture,' this paper also provides an empirical application of the proposed indicator, demonstrating its superior performance compared to current alternatives at the micro-level. Secondly, by investigating the dynamics of farmers' food and total consumption over time and controlling for various household and production characteristics, as well as potential confounding factors, this work demonstrates that changes in positioning in the market chain positively affect farmers' food and total consumption levels. The results are confirmed through sensitivity testing and robustness checks.

Keywords: Global value chains, economic development, market chain, farming households

JEL-Codes: Q12; O12; C31, C23

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Introduction

The narrative of the effects of farmers' participation in global markets still needs to be clarified. A strand of the literature shows that smallholder farmers' participation in traditional markets has strong pro-poor outcomes due to a virtuous cycle of higher and more stable household income, higher consumption, greater food security, and improved nutrition (Bellemare, 2010; Montalbano et al., 2018). Another strand argues that market participation may be less beneficial to those who need help to realize the benefits of increased market orientation (von Braun, 1995; Sitko et al., 2014; Carletto et al., 2017). Nevertheless, despite the increased income and improved nutrition resulting from crop commercialization, not all farming households choose to commercialize their crops (Carletto et al., 2017). Specifically, smallholder farmers generally lack trust in markets and prefer to sell their crops to a local trader rather than to a more distant, institutional buyer (FAO, 2014). This is because when facing markets, they are more vulnerable to external shocks for two reasons: they are generally risk-averse regarding the prices of specific commodities (Bellemare et al., 2013), and they have little bargaining power.

Participation in market chains involves various activities necessary for delivering food production to customers, including trade (Kaplinsky & Morris, 2001). In development contexts, market participation is limited to lower-value activities, which restricts farmers' positioning to the backward stages of the market value chain (African Development Bank et al., 2014). Indeed, downward positioning in the market chain is associated with increased employment, better jobs, resources, governance, and food security (Minten et al., 2009; Cattaneo & Miroudot, 2013; Swinnen, 2014; Swinnen & Vandeplas, 2014). Antràs and Chor (2013) developed one of the main rationales behind positioning, building a model that establishes a dependence of downstream stages on those more distant or upstream, due to technological ordering in production (i.e., stages closer to the end consumers) dependent on those more distant from the final demand or upstream ones. Nevertheless, the literature on how most upstream sectors is structured in value chains remains sparse.

This work aims to connect the two main strands of literature on value chain positioning: i) the trade one on firms, mainly focused on the industrial positioning of suppliers along the (local and global) chain, inspired by the positioning framework proposed by Antràs and Chor (2013; 2018) for firms along the supply chain and ii) the development one on farmers, mainly focused on the rural farmers' commercialization choices and their implied positioning along the (local and global) food supply chain (see, *inter alia*, Migose et al., 2018; Minten et al., 2018, Montalbano et al., 2018). Specifically, this work contributes to the strand of the literature on farmers' positioning by providing a stand-alone measure of upstreamness and downstreamness of rural farmers in market value chains inspired by that proposed by Antràs and Chor (2013) for firms' positioning along the supply chain. The adaptation of Antràs and Chor's (2013) framework to the analysis of the positioning of farmers requires some assumptions and is subject to several caveats. First, only one 'node' of the chain is considered, assuming that farmers can be seen as a distinct category of 'firms.' Farmers who engage in selling their crops to multiple buyers within the same crop value chain, particularly those who transport their produce beyond their local village or district for sale, are presumed to occupy a more advantageous position within the crop value chain. This is due to the relatively lower opportunity costs associated with accessing such selling outlets. Additionally, in accordance with Antràs and Chor's theory (2013) regarding supply chain integration, farmers who sell crops with lower price elasticities of demand are considered to have a higher likelihood of being vertically integrated into value chains. This reflects the higher stability of supply-demand relationships for crops with lower price elasticities.

The validity of the proposed positioning indicator for microanalyses is empirically tested using a large panel dataset on Ethiopian households provided by the World Bank “Living Standards Measurement Study” (LSMS-ISA). Ethiopia is chosen due to the presence of a well-established commodity exchange market that facilitates testing complex farmers' market chain structures. An equivalent empirical testing is provided within the framework of the LSMS-ISA data for Nigeria. Furthermore, an empirical mirroring analysis is applied to examine the causal relationship between farmers' food quantity and market positioning for sensitivity testing. Similar to those in the case of food and total consumption, these results confirm the literature that argues for the effects of market positioning on yields of food quantity. In all the empirical applications, the proposed indicator demonstrated superior performance compared to the conventional counterparts typically used in the empirical literature, namely geographical distance to the main market and market chain positioning as a categorical variable.

In summary, this study addresses two key questions: "How do farmers position themselves within the crop market chain?" and "Does improved market chain positioning lead to higher consumption levels?" To answer these questions, the research introduces a novel micro-level measure of farmers' positioning in the market chain, drawing inspiration from the conceptual framework put forth by Antràs and Chor (2013, 2018). This measure considers factors such as the selling location and the buyers involved. Furthermore, the study applies this indicator empirically and finds that changes in market chain positioning have a positive impact on farmers' food and total consumption levels. The results are robust and supported by sensitivity testing and robustness checks.

The remainder of the essay is arranged as follows. Sections 2 describes the literature supporting the study and the theoretical framework. Section 3 presents the proposed indicator for market positioning at the micro-level. Section 4 analyzes the structure of crop value chains in the Ethiopian market. Section 5 exemplifies the empirical approach. Section 6 illustrates the data and reports descriptive statistics. Section 7 presents and discusses the empirical strategy and the results. Section 8 concludes the paper.

2. Literature Review

Agricultural commercialization has long been viewed as an effective strategy to reduce poverty in rural areas (de Janvry & Sadoulet, 2006; von Braun & Kennedy, 1994). Specifically, commercialization is broadly believed to influence rural households' nutritional status positively (von Braun & Kennedy, 1994). Smallholder farmers who enter the market via agricultural commercialization transition from self-subsistence agriculture to growing specific crops for sale (van Asselt & Useche, 2022). In addition, better market positioning facilitates specialization and technology adoption, leading to higher yields. This additional income from agricultural commercialization, market participation, and better market positioning enables smallholders to purchase adequate and healthy calories in the market, improving their nutrition (van Asselt & Useche, 2022).

Scholars agree that the way farmers participate in the market affects their food consumption. However, participation can take various forms and the literature is divided between those claiming a positive effect of vertical commercialization and those claiming a negative effect. For instance, Bellemare and Novak (2017) argue that farmers involved in contract farming experience a reduction of low-producing cycles. In contrast, Kirk et al. (2018) claim that income growth arising from the intensification of crops with low nutrients hampers the consumption of more nutritious food.

Market participation and positioning are affected by access costs and risk preferences (Jensen, 2010; Key et al., 2000; Svensson & Yanagizawa, 2009). Scholars controlling for such factors have long confirmed the positive effects on food security of better marketing choices and crop yields (Ochieng et al., 2016; Montalbano et al., 2018). Sustained agricultural productivity growth requires farmers to achieve greater crop response from fertilizer use by implementing a higher degree of knowledge about soil management and agronomy (Jayne et al., 2019). In this context, international agricultural trade may affect production constraints while influencing land-use patterns, land intensification, and deforestation (Minten et al., 2007). Smallholder farmers also face additional competitive bottlenecks that limit their involvement—low productivity, lack of standards compliance, and high transaction costs (Montalbano et al., 2015).

Nevertheless, cash-crop adoption has the potential to translate in-kind income to cash income (Kennedy & von Braun, 1995), which can, in turn, be used to purchase diversified goods and services (Pingali & Rosegrant, 1995; Romer, 1993). Vertical market integration is particularly relevant in developing economies characterized by market fragmentation, inadequate contract-enforcement mechanisms, and unstable political environments (Fackler & Goodwin, 2001). In these contexts, what drives market positioning is the type of crop buyer.

When selling their crops, farmers interact with intermediaries and large processing and retailing firms or directly with the state and parastatals that manage assembly markets. In competitive systems, spatial arbitrage lowers price differences across the market to the level of transaction costs (Fafchamps, 1992). However, this situation is rare in developing regions where various sources of imperfect spatial-price transmission affect the vertical transmission of prices (such as market power, transport and marketing costs, government intervention, or asymmetric information) affect vertical price transmission (Meyer & Cramon-Taubadel, 2004). Thus, agricultural markets tend to be oligopolistic or oligopsonistic (Kikuchi et al., 2016; Muratori, 2016; Sexton, 2013; Swinnen & Vandeplas, 2014).

Within this debate, the dominant narrative considers intermediaries as non-competitive rent extractors (Montalbano, et al., 2018). Market intermediaries (also called "briefcase" or "bicycle" traders) tend to decrease producer margins while increasing food prices for consumers (Coulter & Pouton, 2001). However, recent empirical studies highlight mostly positive effects from the role of intermediaries on smallholder farmers who are included in contract schemes (Barrett et al., 2012; Bellemare, 2010; Bellemare & Novak, 2017) and high-value export chains (Minten et al., 2009; Subervie & Vagneron, 2013).

The literature also focuses on the links between global and local value chains, attributing the effects on food consumption and productivity of farmers' participation in the former to the connection with the latter. On the one hand, according to Ríos Guayasamín (2016), value chains tend to capture deficiencies in local, traditional systems and strengthen existing farmers' markets. On the other hand, the links between global value chains (GVCs) and local value chains can create competition for land, labor, and other resources (Feyaerts et al., 2020). Producers complying with standards minimize the risk of being excluded from value chains; they do not necessarily receive higher prices than those supplying noncertified products (Gebreeyesus, 2015).

Global market standards for product characteristics reduce transaction costs within the chain by reducing information asymmetries between buyers and suppliers (Montalbano et al., 2018). Contracts checking for quality production with local suppliers in developing countries specify conditions for delivery and production processes and include the provision of inputs, credit, technology, and management advice (Minten et al., 2009). In this respect, better market positioning is associated with increasing employment, better-remunerated jobs, better use of resources, and food security (Cattaneo & Miroudot, 2013; Swinnen, 2014).

For local farmers, local value chain markets may perform better than GVCs (Wegerif & Martucci, 2019) or represent a step toward GVCs. For example, the effects of an increase in staple food prices vary according to a household's location in regard to local markets (D'Souza & Jolliffe, 2014). Indeed, a farmer's positioning in food distribution chains matters. However, more comprehensive evidence is required given the lack of attention to the issue (Feyaerts et al., 2020), highlighting the urgent need for a micro-level measure of value-chain positioning to aid future research. Better market positioning as an effective way to support welfare and productivity levels is a controversial proposition. If household consumption relies only on total earnings, all kinds of income would have the potential to improve food security (Montalbano et al., 2018). Deviations from this theory arise from multiple sources.

Selling agricultural production to only friends, neighbors, or both is traditionally considered a last-resort, low-productivity option for those facing high transaction costs and lacking a market or those who are highly risk-averse (Timmer, 1997). In particular, both fixed and proportional transaction costs significantly explain household behavior (Key et al., 2000). The relationship between transport costs and the choice of semi-subsistence production is confirmed by several empirical studies (Barrett, 2005; Osborne, 2005; Renkow et al., 2004). In such scenarios, markets fail to develop because global traders reinforce households' inclination toward semi-subsistence production through their limited efforts to reach those households. Furthermore, for most farmers in developing rural areas, interacting with markets is fraught with challenges, to the extent that many opt to limit their businesses to self-subsistence (Fackler & Goodwin, 2001; Fafchamps & Hill, 2005).

Plagued by the scattered nature of the available datasets, the existing evidence is mainly based on case studies and needs more theoretical frameworks for micro-analysis. The inconsistencies in the empirical and theoretical methods used for impact estimation make it difficult to compare results across or within countries (Montalbano et al., 2015). By developing a measure of market positioning for micro-analyses, this paper contributes to the debate concerning the relationship between different market participation nuances and food consumption.

3. The Proposed Positioning Measure

In general terms, positioning in value chains measures the distance between production and final demand (Montalbano & Nenci, 2022). The development and trade literature on value chains present different frameworks for this concept of distance.

In the development literature, a first approach of this concept is to consider distance as "*geographical distance*." Building on von Thünen's (1966) work on the "isolated state," the proximity to markets for agricultural products has garnered attention in the understanding of farmers' market participation (see, among others, Chamberlin & Jayne, 2013; Oosting et al., 2014; Marino et al., 2018). Development scholars often interpret geographical distance as a proxy for "remoteness by road", which is usually conceived as one of the main indicators of market access (Bagchi et al., 2021). Several studies highlight that distance plays a crucial role in farmers' decision-making process regarding the destination market (e.g., Poulton et al., 2006; Fischer & Qaim, 2012; Gyau et al., 2014; Kay, 2016; Corsi et al., 2017). Geographical distance has a significant impact on farmers' marketing choices, in turn determining the type of crop to cultivate (Bagchi et al., 2021).

The debate regarding the effects of market proximity on farmers' production and marketing strategies has been central to the discussions among development scholars (see, *inter alia*, Nanyeenya et al., 2007; Duncan et al., 2013; Gebreeyesus, 2015; Migose et al., 2018; Minten et al., 2018). Scholars seem to agree on the fact that remoteness and proximity to markets are relative terms; as such, they are influenced by context-specific factors like altitude and dryness (Reardon et al., 2009; Reardon & Timmer, 2014). Moreover, there exist factors going beyond mere geography, like the quality of infrastructure, which may hinder proximity to markets (Kyeyamwa et al., 2008; Mutambara et al., 2013). Therefore, even though it is easy to obtain, the measure of geographical distance from main markets is often overshadowed by other indicators of market proximity, such as “travel time,” that better denote additional factors as transaction costs (Vandercasteelen et al., 2018).

However, market proximity might not fully explain market participation (van der Lee et al., 2020). In many cases, geographical distance to end-markets does not adequately explain the intensification and participation patterns observed in rural markets, nor do other factors like travel costs or travel time (Minten et al., 2018). According to Kaplinsky and Morris (2001), three factors define value chains: key buyers, buying dynamics, and critical factors. Therefore, the basic notion behind better positioning in developing contexts rests on selling. In particular, if crop selling does not overtake the local level, then farmers are located upstream in the chain, whereas selling at or beyond the district characterize downstream positioning (Montalbano et al., 2018). As a result, another alternative measure of positioning in value chains is the one proposed by Montalbano et al. (2018), identifying positioning (upstream vs downstream) as a categorical variable; this would be later referred to as a “*Positioning Dummy*”, defined by the identity of the intermediaries acquiring the crop.

Regardless of the efforts in understanding value chain positioning in rural contexts, the development literature still lacks a solid theoretical framework for measuring value chain participation. Selling schemes as well as geographical distances represent too naïve measures of value chain positioning. Current “development” measures of value chain positioning are missing to account for a key factor of chains structuring, well known in the early literature of GVCs, quantities. According to the classic view of supply in trade literature, a producer who sell disproportionately to final consumers is considered to be more downstream in the chains with respect to the others (Nenci, 2020).

Trade economists have long been framing the dynamics between quantities and positioning in supply chains by looking at Input-Output (I-O) tables able to provide a detailed picture of inter-industry commodity trading. The trade literature on value chain positioning classically applies

I-O tables as the intellectual foundation and computation of any positioning measures (see, *inter alia*, Antràs et al., 2012; Fally, 2012; Antràs & Chor, 2013; Fally & Hillberry, 2015; Miller & Temurshoev, 2017; Wang et al., 2017). The main critique around I-O tables is that they only grasp a few nodes of the chain. For this reason, multiple I-O tables often converge to a unique table called the "World Input Output Table" (WIOT) providing a detailed picture of inter-industry commodity flows both within and across countries (see Table 1). In particular, a WIOT considers J countries and S sectors and contains information on intermediate purchases Z_{ij}^{rs} by industry in each country, the final-use expenditure F_i^r in each country on goods originating from each sector; the value added (VA_J^S).

Table 1: A World Input-Output Table

			Input use & value added							**Final use**			**Total use**
			Country 1			$\cdots$	Country J			Country 1	$\cdots$	Country J	
			Industry 1	$\cdots$	Industry S	$\cdots$	Industry 1	$\cdots$	Industry S				
Intermediate inputs supplied	Country 1	Industry 1	Z_{11}^{11}	$\cdots$	Z_{11}^{1S}	$\cdots$	Z_{1J}^{11}	$\cdots$	Z_{1J}^{1S}	F_{11}^{1}	$\cdots$	F_{1J}^{1}	Y_1^1
		$\cdots$	$\cdots$	Z_{11}^{rs}	$\cdots$	$\cdots$	$\cdots$	Z_{1J}^{rs}	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
		Industry S	Z_{11}^{S1}	$\cdots$	Z_{11}^{SS}	$\cdots$	Z_{1J}^{S1}	$\cdots$	Z_{1J}^{SS}	F_{11}^{S}	$\cdots$	F_{1J}^{S}	Y_1^S
	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	Z_{ij}^{rs}	$\cdots$	$\cdots$	$\cdots$	$\cdots$	F_{ij}^{r}	$\cdots$	Y_i^r
	Country J	Industry 1	Z_{J1}^{11}	$\cdots$	Z_{J1}^{1S}	$\cdots$	Z_{JJ}^{11}	$\cdots$	Z_{JJ}^{1S}	F_{J1}^{1}	$\cdots$	F_{JJ}^{1}	Y_J^1
		$\cdots$	$\cdots$	Z_{J1}^{rs}	$\cdots$	$\cdots$	$\cdots$	Z_{JJ}^{rs}	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
		Industry S	Z_{J1}^{S1}	$\cdots$	Z_{J1}^{SS}	$\cdots$	Z_{JJ}^{S1}	$\cdots$	Z_{JJ}^{SS}	F_{J1}^{S}	$\cdots$	F_{JJ}^{S}	Y_J^S
Value added			VA_1^1	$\cdots$	VA_1^S	VA_j^s	VA_J^1	$\cdots$	VA_J^S				
Gross output			Y_1^1	$\cdots$	Y_1^S	Y_j^s	Y_J^1	$\cdots$	Y_J^S		$\cdots$		

Source: Antràs and Chor (2018)

In this framework, the share of gross output in sector *r* in country *i* that is sold to the final consumer is equal to $\frac{F_i^r}{Y_i^r}$; this is a first measure of *upstreamness* in the chain. While the ratio $\frac{VA_j^s}{Y_j^s}$ can be considered a measure of *downstreamness* or, using Fally's (2012) terminology, the share of a country-industry's payments accounted for by payments to primary factors. Large values of both ratios are associated with higher levels of upstreamness or lower levels of downstreamness. Although quite informative in terms of size, these measures poorly release information around stage-positioning (Antràs & Chor, 2018). The main limitation of these simple measures is that they are unable to capture the heterogeneity in positioning coming beyond the logic of intermediate output and value added. In particular, these two basic measures may end up delivering exactly the same level of positioning in supply chains (Antràs & Chor, 2019).

In their seminal work on positioning in GVCs, Antràs and Chor (2018) suggest the inclusion in value chain positioning measures of an element ahead of mere quantities: the order number of the producing-stage in the chain. Following this logic, upstreamness in the chain, as developed independently by Fally (2012) and Antràs and Chor (2013) and consolidated in Antràs et al. (2012), is simply defined as the weighted average distance of a considered stage from the final demand; whether or not downstreamness, whose theoretical framework was originally proposed by Fally (2012), is envisaged as the weighted average distance from the primary factors of production. Antràs and Chor (2018; 2022) ultimately developed two main measures of positioning (see Section A.1 in the Appendix for further details), whose premises and applications have been more recently relaxed (Bolatto et al., 2018; Alfaro et al., 2019; Antràs & Chor, 2022).

Concisely, the authors define upstreamness, U, as an infinite sequence of production stages starting from the end of the chain to the beginning of it, where

$$U_i^r = 1 \times \frac{F_i^r}{Y_i^r} + 2 \times \frac{\sum_{s=1}^{S}\sum_{j=1}^{J} a_{ij}^{rs} F_j^s}{Y_i^r} + \cdots. \qquad [1]$$

In this equation, a_{ij}^{rs} represents the dollar amount of each country's sector needed to produce one dollar's worth of industry output in another country (i.e., $a_{ij}^{rs} = \frac{Z_{ij}^{rs}}{Y_j^s}$). It is important to note that each term in Equation [1] is multiplied by its production-staging distance from final use plus one. In this sense, being at final use implies having a production-staging distance value equal to one (one plus zero); hence why, higher values of U_i^r indicate a more upstream position in the chain.

Conversely, in downstreamness, counting of production-stages starts at the primary factors of production. Following the rationale of Equation [1] and expanding from the $\frac{VA_j^s}{Y_j^s}$ ratio, downstreamness from factors of production is defined as:

$$D_j^s = 1 \times \frac{VA_j^s}{Y_j^s} + 2 \times \frac{\sum_{s=1}^{S}\sum_{j=1}^{J} b_{ij}^{rs} VA_i^r}{Y_j^s} + \cdots; \qquad [2]$$

where b_{ij}^{rs} represents the dollar amount of each country's sector needed to produce one dollar's worth of industry output in another country (i.e., $b_{ij}^{rs} = \frac{Z_{ij}^{rs}}{Y_i^r}$).

At the "macro-global" level, value chains refer to the sequences of production stages leading to the final consumer good, with each stage adding value, e.g., production, processing, marketing, transportation, distribution (Gereffi & Fernandez-Stark, 2016). In domestic value chains, instead, companies produce goods that are either consumed domestically or exported to other countries. According to the classic GVCs literature following Johnson (2014), the only "global value added" contemplated in domestic value chains is the one embodied in exports. However, farmers participating in domestic value chains are able to leverage their comparative advantage at any stage of the chain (De Loecker et al., 2016; World Bank, 2019; De Loecker et al., 2020). Therefore, although entailing information on only one single node of the chain, the analysis of value chains at the farmer level involves numerous actors whose participation in value chains have numerous positive spillovers on the local economy and domestic agri-food value chains (Bellemare et al., 2022).

As such, the adaptation of Antràs and Chor's (2018) framework to the analysis of the positioning of farmers in value chains requires some assumptions and is subject to several limitations. First, at the micro-level, data does not usually permit the retrieval of further information on the market chain, such as the intermediate purchases or the value added generated by each line of crop selling to each buyer. Hence, one can only consider the flow of sequential outputs as no, or very few, information is provided on the ones of inputs. It is also important to clarify that without information on inputs one cannot compute the value added and hence cannot pretend to provide positioning in agricultural value chains rather a decomposition of selling positioning or commercialization positioning that is more sophisticated than those normally applied in the empirical literature.

In addition, agricultural value chains do not follow strict sequential stages like those defined in Atràs and Chor (2018) as "snakes" chains but are much closer to those referred as "flatter chains" or "spiders", with producers attaining inputs from multiple sources and selling through multiple channels. In particular, Baldwin and Venables (2013) famously introduced the term 'snakes' to refer to pure sequential value chains, in which each production stage obtains its inputs from a sole upstream stage. The authors (2013) also distinguish 'snakes' from 'spiders', which are flatter value chains in which each production stage may source from several upstream suppliers. The measures developed by Antràs and Chor in 2018 and summarized in Equation [1] and [2] apply to all production processes, both 'snake'-like as well as 'spider'-like processes.

Moreover, the issues of sequentiality in production has older roots than the seminal paper of Antràs and Chor in 2018. Caliendo and Parro (2015), for example, establish a quantitative framework across Input-Output linkages in models with a roundabout production structure without a clear sequentiality of production. Similarly, Bellemare and Barrett (2006) frame sequentiality of production specifically in agricultural markets by looking at the decision-making process of farmers. According to these two authors (2006), the sequentiality of farmers' decision-making process shapes power along the agri-food market chain by structuring it a sequential way. Specifically, when farmers decide simultaneously, then traders and other downstream actors on the chain hold uneven market power over farmers; whereas if farming households make these choices sequentially, by first deciding whether or not to participate in the market chain as either buyer or seller, and by then deciding how much to buy or sell and from whom to buy or sell, then farmers result to be less vulnerable (Bellemare and Barrett, 2006) and the chain more sequentially structured.

Finally, in 2017, in the Online Appendix[1] of their seminal paper "On the Geography of Global Value Chains", Antràs and Gortari (2017) replicate their obtained partial equilibrium model on the desired locations of production in non-sequential chains. More specifically, they consider a symmetric Cobb-Douglas technology with four stages contributing to the value added, but they assume that these four stages occur simultaneously. Assemblers in target country D have the possibility to source simultaneously each of the required four inputs. According to the authors (2017), the total absence of sequentiality of production leads to two important conclusions: (i) geographical distance from the final use matters; (ii) the frequency of domestic chains is more volatile with respect to changes in trade costs with respect to the case of sequential value chains. In particular, at the macro level, most remote countries are less likely to be a source of inputs than countries closer to the final use. Besides, the relative prevalence of domestic non-sequential value chains in destination country D declines much faster with trade cost reductions than in the case of domestic sequential value chains (Antràs and Gothari, 2017).

Moreover. there are some crops, like maize and cassava, which presents sequentiality traits more typical of their cropping process than others (Legesse & Gezmu, 2023; Masamha et al., 2018). These crops require a production flow that is sequential in nature like the provision of inputs, cultivation and harvesting, post-harvest handling and processing (Bamber et al., 2014). Even more important, according to Bamber et al. (2014) is the order of post-production activities like the marketing and distribution of the final product aiming to increase the shelf

[1] Available at https://data.nber.org/data-appendix/w23456/.

life of products, reducing losses and constituting a large share of the value-added in agricultural goods. However, this sequentiality may be severely hindered by uncoordinated or inefficient distribution channels inhibited by the lack of a market information system regarding production and prices (USAID, 2013). Besides, as in the case of maize, several food losses are recorded at the farm level before selling activities during shelling and storage practices (USAID, 2015).

The discussion around the sequentiality of production has lost importance even in the recent approaches proposed by Antràs and Chor themselves. In a more recent work, Antràs (2020) investigates value chains within a broader framework away from strictly sequential production processes and "macro" analyses. A new definition of participation in value chains also comes into place: a producer participates in value chains if it contributes value to at least one stage of the chain. This demarcation is clearly agnostic about the specific form of value added and the chain configuration (Antràs & Chor, 2022).

Moving beyond theory, the assumption of strictly sequential, value-adding production stages has severely lost its strength in the face of the latest patterns of global integration and value addition (Davis et al., 2018). Especially in developing regions such as sub-Saharan Africa, the production cycle require closer interaction between producers and suppliers, with activities undertaken in parallel rather than in sequence (Morris et al., 2012). As such, nowadays, especially at the micro level, "snake" sequential chains have left space to flatter and wider chains that still maintains some sort of sequential order but are more complex and involve activities taking in place in parallel. This is the case of farmers' value chains.

In this regard, a key driver of chain participation as well as structuring in value chains is vertical integration. Yet, vertical integration *per se* is not necessary for value chain participation as more often practitioners observe that farmers are part of a value chain even without a contract (Dihel et al., 2018). In this framework, the likelihood of vertical integration or the premises for it make farmers most likely to better position in the chain. In their groundbreaking work on GVCs structuring in 2013, Antràs and Chor devote great attention to vertical integration as defined by the price elasticity of demand of the good sold along the chain (see Section A.2 in the Appendix). Lower price elasticities of demand yield greater chances to be vertically integrated in the chain.

Given the discussion above, Table 2 proposes a rough adaptation of Table 1 for a generic farmers' market chain. Note that this cannot be considered as the micro counterpart of Table 1 as it does not include the flows of inputs but only the sequential distribution of outputs. Likewise, at the micro level, in agricultural value chains, given the current data available, one can only focus on one node of the chains, i.e., farmers. The structuring of agricultural value chain relies on the role of intermediaries as production processes do not pertain to the sole farm level, but largely expand in the post-harvest process, spreading from storage to selling at wholesalers. Similarly, value chains in agriculture are crop-specific, as such, any positioning measurement needs to be evaluated separately for each crop market.

Table 2: Agricultural Value Chain Illustration Table

	Household Final Crop Sold			**Total Crop Sold per Household**
	Buyer 1	...	*Buyer S*	
Household 1	C_1^1	…	C_1^S	Y_1
…	…	C_i^r	…	Y_i
Household J	C_J^1	…	C_J^S	Y_J
Total Crop Sold per Buyer	C^1	…	C^S	

As suggested in Antràs & Chor (2019), a naïve measure of market positioning comes from simply reducing the measure proposed by Antràs et al. (2012) to the share of a farmer output sold to final consumers. Hence, positioning in crop selling chain is simply the share of crop sold by each farming, C_i^r, with respect to the total crop sold along the chain, Y.

3.1 A Micro-level Downstreamness Indicator À la Antràs and Chor

Theoretical research at micro-level has received less attention, even though chain construction is no less important for understanding the actor chain's performance (Antràs & Chor, 2022). This is because, at the micro-level, there is a fundamental data limitation. Usually, the available data does not allow for the retrieval of additional information on the market chain, including intermediate purchases or the value added at each selling stage to each buyer.

Indeed, there has been a recent wave of studies proposing measures of firms' participation in GVCs; however, they lack a unified framework. Among these studies, some of them result in a firm's participation index similar to the one envisioned in the input-output based literature (Veugelers et al., 2013; Giunta et al., 2022; Nenci et al., 2022) using as proxy of a firm's participation in GVCs the percentage of imported intermediates over total inputs. Although ending up with different metrics, those studies share a certain degree of common ground based on the assumption that a two-way trade flow is essential to qualify the participation to GVCs.

Building upon these seminal papers, this study proposes a modified positioning indicator for agricultural value chains that focuses on farmers. In agricultural value chains, farmers trail a sequence of intermediaries through which crops pass from farmers to processors and then retailers and, engage in different value-adding opportunities (Mussema et al., 2021; Lu et al., 2015). As already mentioned, in farmer's value chains, selling position is interpreted in view of Montalbano et al. (2018) as the identity of the intermediary to whom farming households sell their crops along the chain. Based on the reasoning of these authors, commercialization stages are numbered based on the downstream position of the acquiring intermediary in the chain (i.e., more downstream intermediaries are associated with higher values of Selling Position). Specifically, based on Table 2, the proposed measure can be expressed as:

$$D_i^r = \text{Selling Position n. 1} \times \frac{C_i^r}{Y} + \text{Selling Position n. 2} \times \frac{C_i^r}{Y} + \cdots; \qquad [3]$$

where the first integer term indicates the Selling Position number (i.e., the chain positioning of acquiring intermediaries), C_i^r equals the quantity of crop sold by each household, and Y is the total quantity of that crop sold along the crop-selling chain.

In brief, positioning in value chains can be seen as the extent to which one takes to arrive at final demand (Mancini et al., 2023). However, there are features such as distance and output buyers, commonly discussed in the development literature, that are not considered in the existing trade literature on firms in GVCs; as well as there are aspects of it like quantities sold which are not considered in the development literature.

In brief, there are three main reasons explaining why the current measures for chain positioning, coming from the development and trade literature on value chains, are not working: (i) lack of a "stand-alone" indicator ending up with chain-feature-specific estimates; (ii) lack of information completeness leading to fragmented interpretations; (iii) lack of consideration for vertical integration generating an exogenous boost in positioning.

3.2 An Amended Micro-Level Downstreamness Indicator À la Antràs and Chor

In particular, the proposed à la Antràs and Chor measure in Subsection 3.1 presents some important caveats requiring additional specifications to be made. First, despite the inclusion of Selling Position in the chain, the measure considers only to *whom* the crop is sold but not *where* it is sold (i.e., if outside/inside the village, the district or the region). Secondly, there is no concern in Equation [3] for the fact that farmers sell to multiple buyers/stages in the chain.

Farmers geographically closer to final markets are facing smaller transport costs and have the potential to gain extra profits than those more distant; it is, thus, worth exploring the welfare effect of positioning, net to geographical distance. Nevertheless, positioning in value chains is highly affected by trade costs. Specifically, in GVCs, there exists, on average, a negative association between changes in trade costs and positioning (Mancini et al., 2023). Hence, it sounds contradictory that, at micro level, there are farmers willing to travel outside their own region to sell their crop to a distant buyer. The underlying reasons around the choice of choosing a distant buyer are well-known in the literature thanks to seminal work of Fafchamps and Hill (2005). According to the authors, first, the choice of selling crop to a distant buyer is non-linear across wealthy and poor farmers; secondly, it seems to be determined by factors going beyond mere transaction costs like the shadow value of time and crop quantities to be sold. Farmers selling large quantities are more likely to sell to a distant buyer given the increasing returns in their own transport (Fafchamps & Hill, 2005). Taken together, one could easily argue that farmers selling to a more distant buyer are able to attach to these selling outlets lower opportunity costs than their counterparts selling just locally and, show better levels of performance; thus, they are more likely to be integrated vertically in the chain (Minten et al., 2019).

One must also consider what is the demand of the crop defining the chain under analysis. Price elasticities of demand are crucial in structuring value chains. According to Antràs and Chor's (2013), if the quantity demanded faced by the final buyer is sufficiently elastic downward vertical integration will occur in the final stages of the supply chain; otherwise, it will occur upward. Following up this theory, farmers selling crops with low price elasticities of demand (as it is commonly the case for all agricultural commodities) are more likely to be vertically integrated in the market chain. Moreover, following common economic wisdom, lower price elasticities imply more stable quantities demanded making vertical integration mechanisms safer investment opportunities than those in unstable markets. To this end, there is the need to further amend Selling Location to incorporate price elasticity of demand, ρ, as a tuning parameter.

Finally, the proposed indicator does not ponder on the reality that farmers sell their crop to multiple buyers in the crop value-chain and that some buyers of agricultural products may relate to the same stage of the crop selling chain, arising several lateral chains beyond the main vertical one (Liverpool-Tasie et al., 2021). Longer chains with more production steps presume lengthier calculations and bigger value ranges for the proposed downstreamness indicator than shorter ones. A stand-alone measure for positioning in value chains needs to weigh up for the fact the farmers' positioning must be comparable independently from the number of buyers or the length of the chain. A viable way to sort this out is to transform the indicator in Equation [3] from a "stage" indicator to an "index-score" indicator.

In brief, the micro-level downstreamness indicator à la Antràs and Chor in Equation [3] needs to be amended in order to develop a "stand-alone" indicator, coping with information completeness of its alternatives, as well as considering the chances for farmers to be vertically integrated in the chain, as follows:

$$D_i^r = p_i^r \times \frac{C_i^r}{Y} \times l_i^{r\,1/(1-\rho)}; \qquad [4]$$

where p_{ij}^{rs} equals $\frac{Selling\ Position\ Number}{Total\ Number\ of\ Selling\ Positions}$, l_{ij}^{rs} equals $\frac{Selling\ Location\ Number}{Total\ Number\ of\ Selling\ Locations}$, C_i^r equals the quantity of crop sold, and Y equals the total quantity of that crop sold along the crop market selling chain. It is important to note that farming households are commonly involved in multiple crop value chains. Hence, the resulting positioning value attached to them will be the average of their positioning score in each single crop selling chain.

The mathematical formulation of the proposed indicator draws inspiration from Antràs and Chor's (2018) "stage" positioning indicator. The equation (Equation [4]) used in this study yields values between 0 and 1, reflecting the standard inelasticity range [0; 1] of price elasticities. A value of 0 indicates perfect price demand inelasticity, while a value of 1 represents unitary price elasticity. The scores obtained from the indicator exhibit significant variation, as they are highly sensitive to factors such as selling position, quantity sold, selling location, and the price elasticity of demand.

A final remark needs to be made on the reasoning behind the turning parameter 1/(1- ρ). Following consumer demand theory, the results from output optimization have negative compensated own-price responses (Deaton & Muellbauer, 1980). These compensated own-price elasticities are, as predicted by theory, negative for the vast majority of commodities. Price elasticities of demand that are close to minus one suggests that the considered commodities are own-price unitary elastic (Tafere et al., 2010). In this context, crops usually report very low values of price elasticities of demand with maize and sorghum among the ones with lower values. Following Antràs and Chor (2013)'s theory (see Section A.2 in the Appendix for further details), price elasticity of demand ρ, is transmuted in Equation [4] as the tuning parameter 1/(1- ρ). This tuning parameter is equal to one, the lower the values of price elasticity demand (the usual case for crops). Hence, as theorized by Antràs and Chor (2013), farmers selling crops with lower elasticity values generally present higher chances to be vertically in the chain but also tuning parameters closer to one; whether farmers selling commodities with higher elasticities have lower chances to be vertically integrated in the chain and higher tuning parameters resulting in lower values of downstreamness (see Equation [4]).

The rationale behind the emphasis on price elasticity of demand stems from the understanding that buyers, particularly those operating in market chains with high demand volatility, may adopt a dual sourcing strategy. This strategy involves maintaining a select group of "reliable" farmers to cater to stable demand, while relying on spot purchases from local farming households to address unexpected surges in demand (Cajal-Grossi et al., 2023). Therefore, ensuring demand stability becomes a crucial aspect of the buyer-seller relationship. In rural settings where formal contracting institutions are limited, long-term relationships between farmers and buyers, characterized by informal agreements based on the future value of the relationship, prove mutually beneficial (Macchiavello, 2022). As highlighted by Macchiavello and Morjaria (2021), selling crops to well-established processors yields greater profitability compared to home-processing. Thus, beyond theoretical foundations, price elasticities of demand have substantial empirical implications for farmers' commercialization strategies and their positioning in the market.

In conclusion, the proposed amended indicator comprises features and elements of both strands of literatures like "selling position" and a measure of "selling location" or distance from the development literature; as well as the "crop ratio" and the production-stage distance structure in the equation from the trade literature on value chains. Moreover, a leading factor in Antràs and Chor (2013)'s seminal paper on value chain structuring is enhanced for consideration: the price elasticity of demand. Price elasticity of demand is added as a tuning parameter in the equation.

To illustrate the proposed indicator in a more relatable manner, let's consider the example of a farmer selling a substantial quantity of wheat, which is a crop with low demand elasticity, to a private company located outside their district. This scenario proves beneficial for both parties involved: from the farmer's perspective, selling to a private company guarantees predictable and well-defined profits from their farming activities. On the company's side, sourcing wheat from local farmers is generally more cost-effective than acquiring it from abroad. Moreover, the farmer's opportunity cost of selling outside the district is lower compared to selling to a closer but less profitable outlet (often considered the "easy-instinctive choice"). For the company purchasing the crop, the more stable or inelastic the demand for wheat, the greater the likelihood of establishing a contractual agreement and vertically integrating this selling-buying activity.

In brief, the proposed amended positioning indicator is built based on the advancement steps the literature has recently taken on positioning. In particular, the indicator is raised and amended through the following stages:

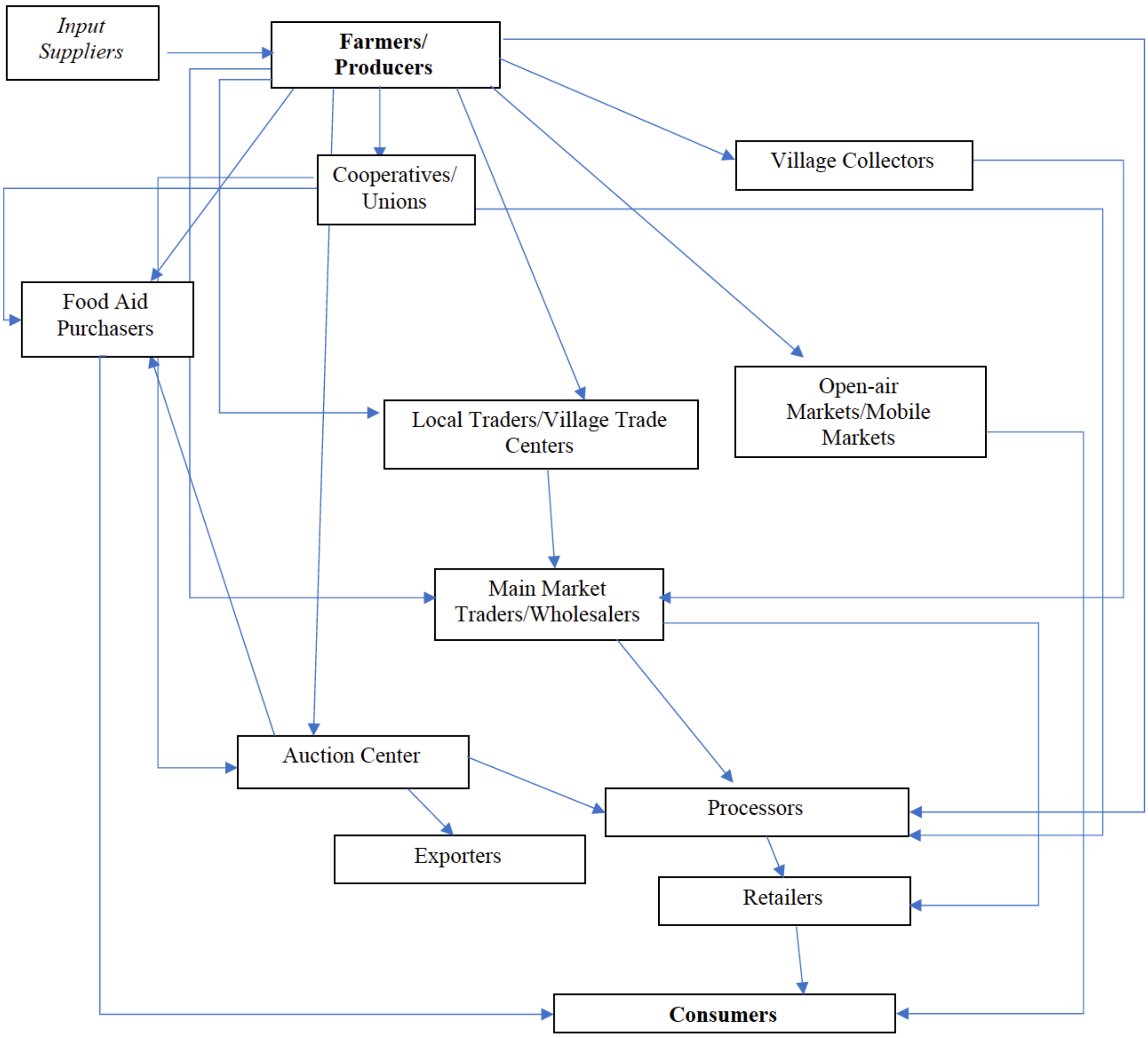
1) positioning is defined through the simplest version of positioning in commercialization reducing Antràs et al. (2012) to the share of total gross output $\frac{F_i^T}{Y}$;
2) the proposed indicator accounts for the novelties of Antràs and Chor (2013; 2018) introducing production-staging as a key assumption in the equation in point one intended as the identity of the intermediary acquiring the crop like in Montalbano et al. (2018). But the assumption of sequential production stages is relaxed on the basis of more recent approaches, global integration and value addition, that are agnostic about the specific form of value added and the chain configuration (Antràs & Chor, 2022; Davis et al., 2018);
3) it adds a new feature to the flow of reasoning performed by previous scholars on positioning by considering not only to *whom* the crop is sold but also *where* it is sold (i.e., if outside/inside the village, the district or the region);
4) price elasticity of demand is also considered given its relation to the chances of being vertically integrated along the chain;

5) the proposed measure also accounts for the fact that farmers often sell to multiple buyers in the value chain by reducing the final amended measure to a score dividing both the value of both position number and selling location by their totals.

4. Mapping Crop Value Chains in Ethiopia and Nigeria

Figure 1 visually illustrates the market outlets available to smallholder farmers during the harvest season, illustrating the various pathways through which their products can reach end consumers. It serves as a reference to understand the complexity of the market chain and the various opportunities for farmers to sell their produce.

Figure 1: A Standard Crop Value Chain in Ethiopia and Nigeria



Source: Author's adaptation from Gabre-Madhin & Goggin (2006); Ayele et al. (2021); Rashid & Negassa (2013), Gashaw & Kibret (2018); FAO (2020); Babama'aji et al. (2022).

Value chain operators are defined as those who own the product at any stage in the chain (Audet-Bélanger et al., 2013). The mapping of agricultural value chains should start at the input level (Ugonna et al., 2015). Seeds, fertilizers, pesticides, and herbicides are the production inputs mainly supplied by agricultural development agencies and/or private input suppliers (Ayele et al., 2021). Farmers are the actors who play the major role in production, from soil preparation to final harvesting of the crop. These actors are involved in land preparation, planting, cultivation, weeding, harvesting, postharvest management, and transportation of the produce to the nearest market (Gomez & Thivant, 2017; Adesiji et al., 2022). Depending on market conditions, smallholder farmers have access to a variety of market outlets for their products. As shown in Figure 1, during harvest, they may sell directly to rural consumers, village collectors, primary cooperatives, and/or district wholesalers.

In Nigeria and Ethiopia, farmers are integrated in agricultural value chains through multiple layers (Babama'aji et al., 2022; Ayele et al., 2021). In particular, Village collectors form the first layer as they are the crop buyers closest to farmers. Village collectors are the middlemen who meet farmers at their farm gates or along the roadside to buy the freshly harvested crop and transport it to wholesalers and/or retailers in the district market (Ayele et al., 2021).

Agricultural cooperatives and processors holding the chain by being the most vertically integrated actors. Cooperatives offer storage for their crop free of charge (USAID, 2017) and purchase crops from farmer. They resell farmers' crops to processors, exporters, and/or local food aid agencies (Gabre-Madhin & Goggin, 2006). Wholesale markets are generally located in main districts/towns and acquire crop directly from farmers or through village middlemen. Wholesalers sell products to processors and/or retailers (USAID, 2017) and have better access to storage and communication (Ayele et al., 2021).

Private companies play a crucial role for firms in both Nigeria and Ethiopia, offering improved downstream positioning in the market chain and serving as reliable outlets for selling crops. Engaging in supply chains contributes not only to higher incomes but also facilitates technology spillovers that enhance income stability and food security (Barrett et al., 2017). Furthermore, selling to private companies can generate positive spillover effects through neighboring farms' activities and characteristics, as well as interactions with other farm suppliers (Case, 1992; Bandiera & Rasul, 2006; Matuschke & Qaim, 2009).

Moreover, aside from the actors described above, two important additions should be made: mobile markets and commodity exchange markets. First, several shorter chains exist due to initiatives like farmers' markets or open-air food fairs (FAO, 2020); such is the case of mobile markets. Secondly, commodity exchanges in Africa epitomize a means for linking smallholder farmer linkages to markets, particularly formal markets.

The Ethiopian Commodity Exchange (ECX) was founded in 2008. ECX aims to connect suppliers and exporters more efficiently and transparently (Gashaw & Kibret, 2018) and differently from most of the commodity exchanges in Africa, it was government-driven since its creation (Robbins, 2011). Based on standard crop contracts, ECX was constructed as a trading platform for buyers and sellers.

Nigeria, instead, has three commodity exchanges with only one government-lead, the Nigerian Commodity Exchange (NCX), previously known as the Abuja Securities and Commodity Exchange (ASCE). Established a few years earlier, in 2006, ASCE started a massive effort to get commodity trading off the ground through the settlement of a new infrastructure (Arvanitis, 2014). This new system involved key elements like a trading platform, a warehousing system, a clearing and settlement mechanism as well as an arbitration and price information system. Despite the effort, trading developed on a very small scale and was limited to a few crops such as maize and soybeans (Rashid et al., 2009).

In conclusion, some crop value chains have fewer steps, making them shorter, while others convey several actors and are thus longer. Farmers may sell at different stages of the chain, highlighting different positions in relation to the final end-user. Finally, factors beyond the control framework of the value chain control framework may influence farmers' positioning and market participation, particularly in natural disasters such as drought or floods (Biggeri et al., 2018). For example, in 2011, several floods were reported in Ethiopia.[2]

5. Empirical framework

The empirical application will empirically test the performance of the proposed amended indicator compared to its alternatives, namely physical distance to the main market, selling downstreamness as a categorical variable, the share of total gross output or the basic à la Antràs

[2] According to the Famine Early Warning Systems Network by USAID, in August 2011, 650 households were displaced because of floods.

and Chor micro-level positioning indicator. The construction of the indicator proposed in the previous section Relies on two primary measures: (i) selling location and (ii) selling position. The selling location is provided by the data itself and does not require a preliminary analysis; the selling position, however, is constructed based on the type of crop buyer.

The type of buyer (or market outlet) to whom farmers decide to sell their crops is crucial in determining their market participation and positioning. According to Montalbano et al. (2018), selling the crop to neighbors or relatives implies being outside the value chain while reaching the local market represents the initial step in the market chain's selling line, and bringing a product directly to the main market or a private company is most difficult and presumably a potentially more profitable option within the market chain (subject to testing). Therefore, the market's highest or most downward position also epitomizes high management skills for selling crops, such as mobile markets and auction markets.

Thus, in this context, selling the crop to a local market is approximated to the notion of upstreamness (and it is supposed to be less rewarding) whereas downstream means selling the crop to a private trader in a district market or the government (and it is supposed to be more rewarding). Following this reasoning and Figure 1, farmers' market outlets are ordered according to their crop buyer or selling method.

Given the insufficient observation per each category in the considered datasets, seven position groups are then constructed as follows:

- Outlet n.1: Roadside → Selling Position n.1
- Outlet n.2: Agricultural Cooperatives → Selling Position n.2
- Outlet n.3: Farm-Based Association → Selling Position n.2
- Outlet n.4: Government Agencies → Selling Position n.3
- Outlet n.5: Political Leader → Selling Position n.3
- Outlet n.6: Private Trader in Local Market → Selling Position n.4
- Outlet n.7: Local Merchant/Grocery → Selling Position n.4

- Outlet n.8: Local Market
- Outlet n.9: Mobile Market

Selling Position n.5

- Outlet n.10: Private Trader in Main Market
- Outlet n.11: Main Market

Selling Position n.6

- Outlet n.12: Private Company
- Outlet n.13: Auction Market

Selling Position n.7

Roadside selling is often not considered either as a "market outlet" or as an upstream choice due to its direct interaction with consumers. However, the evidence provided by Reardon et al. (2012), Barrett and Swallow (2006), and Minten and Kyle (1999) supports the inclusion of roadside selling as part of the market chain. It serves as a direct link connecting farmers to modern retail markets, offering small-scale farmers an avenue to access broader markets and contributing to rural livelihoods and income diversification. Furthermore, selling roadside is positioned at the beginning of the market chain due to its close proximity to the source of agricultural production. Reardon et al. (2012) particularly argue that roadside selling serves as the initial point of contact between farmers and potential buyers, making fresh and unprocessed produce immediately available after harvest.

The proposed value chain structure should be contextualized within developing contexts, considering that more upstream selling options such as roadside selling are often influenced by specific regulations and conditions. In developing countries, where formal market institutions and infrastructure may be limited, upstream market outlets serve as a crucial avenue for small-scale farmers to connect with buyers and access markets. Also, a final note must be made for selling locations, whose score scale of 3 is defined, due to limited observations, as follows:

- Selling Location n.1: Selling within the village or near the village
- Selling Location n.2: Selling near the town or near the district
- Selling Location n.3: Selling outside the district or outside the region

It is important to underline again that the inclusion of this measure is crucial for obtaining a comprehensive, complete, and readily applicable indicator of farmers positioning in value chains. A side note is required in the case of farmers locating in main highly concentrated markets like Addis Ababa in Ethiopia; these have no incentive to sell outside the district or region as they already occupy an extremely favorable location for selling purpose (or distance wise). Therefore, the selling location factor is excluded from their positioning measure calculations.

The LSMS-ISA project's original microdata provides a unique opportunity to explore these research issues by exploiting a large household sample in a panel-data country framework. Panel regression is conducted using fixed effects, as random effects conditions are clearly violated in this context. However, the choice of market positioning implies a series of endogeneity features that are difficult to monitor in simple regressions. For this reason, several specifications including district-wave dummies and time-trends are included in the panel regression. As it will be explained in detail in the identification strategy in Section 7, different specifications will be employed, including a more general consumption variable that encompasses food expenditures and total consumption. To determine the sensitivity of the findings, the same empirical strategy proposed for food and total consumption will be implemented on food quantity.

Last, as supporting evidence of the importance of the proposed market-positioning indicator in the relationships outlined (i.e., market positioning–food security and market positioning–total consumption), in the Appendix, a machine-learning classification-tree mechanism is employed for Ethiopia. A classification tree is a purely data-driven predictive technique aimed at maximizing the predictive performance of a given outcome in out-of-sample scenarios. At the core of machine learning lies the firewall principle: none of the data involved in generating the predictive model should be used to evaluate its predictive performance (Mullainathan & Spiess, 2017). The trees are intuitive and composed solely of variables selected by the algorithm as highly correlated with the outcome variable, which is the dummy "Above-the-95th Percentile - Food Consumption/Total Consumption."

6. Data and Descriptive Statistics

This work employs data from the Ethiopia and Nigeria LSMS-ISA dataset collected by the Ethiopian Central Statistics Agency and the National Bureau of Statistics of Nigeria in collaboration with the World Bank. The Ethiopia LSMS-ISA socioeconomic survey was conducted in three successive waves from 2011 to 2016. The first wave ran from 2011 to 2012, the second from 2013 to 2014, and the third from 2015 to 2016. Similarly, in Nigeria, LSMS-

ISA general household surveys were conducted during the same period: between 2010 and 2011 (first wave), between 2012 and 2013 (second wave) and between 2015 and 2016 (third wave). The LSMS-ISA surveys are all representative at a national, urban or rural, and regional level. Possible panel attrition issues were addressed by conducting unconditional ANOVA tests across samples. The final sample of farmers commercializing their crops consists of approximately 1460 observations for Ethiopia and 1178 for Nigeria.

This paper uses two sets of data from the World Bank LSMS-ISA dataset: household-level data and agricultural data. The household-level data includes modules related to the households' characteristics, while the agricultural data includes relevant postharvest information, such as buying outlets and selling locations. In addition, some data related to inputs used in the analysis are retrieved from the post-planting questionnaire. Specifically, in the LSMS-ISA postharvest questionnaire, farmers provide evidence of their main commercial partners by answering the question: "Who/What were the main buyers/outlets for your crop sales?" in the case of Ethiopia or "To whom did you mainly sell the harvest crop?" in the case of Nigeria. Answers to this question rely on a network roster of more than 30 possible actors. Households can indicate two commercial partners in their answer: a first (main) commercial partner and a second (minor) commercial partner. However, no matter how many actors indicated this answer, the question asking on the quantity of crop sold in total relies on a unique answer that does not distinguish across buyers/outlets (if more than one is indicated). For the sake of this analysis, only the first (main) buyer is considered with the total quantity. In addition, in those few cases where households indicated the same quantity, but two different types of crops were sold to the same first (main) buyer, only the quantity of crop most often sold is included in the calculation process.

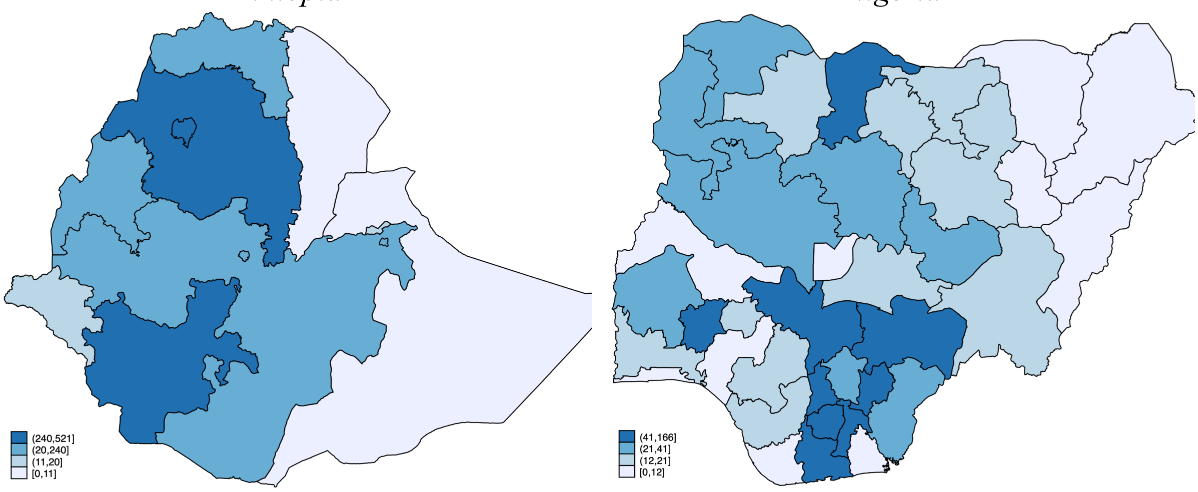
Household variables are defined in Table A.3.1 and their descriptive statistics are reported in Table A.3.2 for Ethiopia and A.3.3 for Nigeria, both in the Appendix. In the sample of Nigeria, household variables, such as adults' education and the age of the household head, as well as harvest crop and land size are omitted due to the presence of several missing observations.

Household heads in the Ethiopian sample are, on average, 46 years old and male. On average, household members have completed more than one year of schooling, and approximately three individuals are part of the labor force. On average, each household owns more than 9,000 square meters of land, from which they harvest approximately 915 kg of crops. Regarding land inputs generally, households receive free seed, although they keep purchasing the remainder of seed needed and use fertilizers. On average, in both samples, each household comprises six individuals, among whom there might be two children and a maximum of one infant. In the Nigerian sample, households use fertilizers, but they generally do not purchase them nor keep leftovers.

Geographically, households tend to be located far from the main market, that is, the capital (see Figure 2). In the Ethiopian sample, none of the households in the considered sample is in Addis Ababa. Specifically, households mainly concentrate in three regions: more than 35% of the population lives in the Southern Nations, Nationalities, and Peoples region; almost 30% in Amhara; and more than 15% in Oromia. In contrast, less than 15 households are located in Afar, Dire Dawa, Gambela, Harari, and Somali regions. The remaining 39 households are located in Benishangul-Gumuz. For the Nigerian sample, the Federal Capital City hosts only 11 households, while states like Ebonyi and Imo more than 10% of the total sample.

Figure 2: Household Density per Region/State

Ethiopia *Nigeria*



Source: Author's elaboration.

Regarding selling preferences, most households tend to sell a large part of their agricultural production to buyers or outlets outside the market, such as relatives, friends, and neighbors (Table 3).

Table 3: Quantity of Crop Sold (in Kilos) per Selling Outlet Across the Years

	Ethiopia			Nigeria		
	2011	**2013**	**2015**	**2011**	**2013**	**2015**
Relative	97.85	200	23.23	4771.4	272.1	1254.6
	(110.3)	(224)	(35.06)	(7813.1)	(252.1)	(2040.6)
Friend/Neighbor	55.44	590.80	22.21	738.3	815.1	743.1
	(60.42)	(1049.90)	(30.68)	(1041.0)	(1986.1)	(1790.5)
VDC Member	-	1.50	-	-	-	-
	-	(.)	-	-	-	-
Village Headman	37.28	100	-	-	1168.0	300
	(27.88)	(.)	-	-	(1081.8)	(.)
Main Farm	-	-	-	3916.7	75	1964.7
	-	-	-	(4710.1)	(63.64)	(2111.5)
Roadside	-	106.50	23.09	1092.9	2163.1	522.3
	-	(81.89)	(27.84)	(1554.5)	(3065.2)	(338.7)
Mobile Market	34.33	65.12	20.04	299.5	2450	3115.2
	(13.65)	(47.76)	(26.11)	(175.4)	(2757.7)	(9804.1)
Local Market (LM)	87.74	100.50	28.76	924.0	126821.1	860.5
	(147.5)	(154.80)	(57.82)	(2773.5)	(550475.6)	(2765.7)
Priv. Trader in LM	287.1	357.30	35.71	865.4	1024.2	677.2
	(928.6)	(856.90)	(90.25)	(2280.7)	(2454.9)	(1063.9)
Local Merchant	274.30	214.50	11.28	2202.2	2703.3	347.0
	(224.40)	(174.20)	(17.92)	(4001.2)	(11149.1)	(330.3)
Main Market (MM)	87.62	144	29.01	4786.3	717.4	1071.4
	(95.76)	(320.10)	(67.54)	(21614.3)	(1220.0)	(2135.2)
Priv. Trader in MM	131.10	423.20	47.23	638.6	1084.6	1560.2
	(189)	(2278.80)	(94.43)	(936.1)	(1937.5)	(1838.5)
Government Agency	15	-	-	-	1936.3	85.78
	(14.14)	-	-	-	(4379.8)	(.)
Auction Market	30	-	-	-	-	85.78
	(.)	-	-	-	-	(.)
Private Company				6173.3	2885.6	461.3
				(7666.0)	(4503.9)	(57.07)
Employer				-	-	400
				-	-	(.)
Sav. & Credit Coop.	2.60	1733.30	2.09	-	-	-
	(.)	(1527.50)	(1.36)	-	-	-
Agricultural Coop.	703	70	81.89	-	-	-
	(1623.20)	(.)	(170.10)	-	-	-
Farm. Association	53.75	56.60	162	350	-	-
	(34.49)	(40.51)	(198.30)	(.)	-	-
NGO	-	8	-	112.5	-	-
	-	(.)	-	(123.7)	-	-
Parastatal Org.				-	320	-
				-	(.)	-
Other	40	77.50	3.96	-	2375	593.1
	(41.43)	(65.51)	(3.58)	-	(3005.2)	(419.4)
Average	129.10	211.5	32.32	1539.6	4015.5	948.9
Observations	554	1074	923	396	861	591

Regarding Ethiopia, in 2013, following the floods in late 2011, the number of crops sold to friends or neighbors was almost three times the average quantity sold to any other outlet, and the number sold to savings and credit cooperatives was more than eight times higher than the average. This tendency decreased in 2015, when percentages of crops sold to buyers outside the markets returned to the levels of 2011 (e.g., the percentage of total crops sold to relatives is equal to five in both 2011 and 2015, while for friends/neighbors is equal to three in 2011 and four in 2015). Similar patterns are seen in the sample for Nigeria. The quantities of crop sold to private companies and main markets sharply decrease after 2011. In 2012, large crop quantities are sold locally through local markets. While in 2015, there is an increase in the quantities of crop sold through the mobile markets or via the private traders in the main market.

Following the statistics of Table 3, Table 4 groups the data by position and Table 5 by selling location as defined in Section 5.

Table 4: Quantity of Crop Sold (in Kilos) per Position

	Ethiopia			Nigeria		
	2011	**2013**	**2015**	**2011**	**2013**	**2015**
Position n.1	-	106.50	23.09	1092.9	2450	522.3
(selling roadside)	-	(81.89)	(27.84)	(1554.5)	(2757.7)	(338.7)
Position n.2	443.30	59.95	108.60	191.7	-	-
(selling to agricultural coop. or associations)	(1255.60)	(33.74)	(171.80)	(162.7)	-	-
Position n.3	15	-	-	-	-	85.78
(selling to government agents or political leaders)	(14.14)	-	-	-	-	(.)
Position n.4	285.30	346.20	32.41	1199.6	2260.0	652.8
(selling to a priv. trader in LM or merchant in LM)	(865.10)	(825)	(84.54)	(2805.0)	(9865.0)	(1029.7)
Position n.5	86.99	100.10	28.69	908.6	5922.1	969.5
(selling via mobile market or to LM directly)	(146.60)	(154)	(57.61)	(2740.8)	(108624.1)	(3447.0)
Position n.6	103.10	224.70	35.72	3988.6	1281.6	1127.6
(selling to a priv. trader in MM or to MM directly)	(137.40)	(1257.50)	(78.89)	(19453.9)	(2710.2)	(2101.6)
Position n.7	30	-		6173.3	2885.6	367.4
(selling to a private comp. or to the auction market)	(.)	-		(7666.0)	(4503.9)	(193.5)
Average	133	197.40	33.04	1488.9	4435.8	954.2
Observations	522	1027	884	347	758	515

In the sample for Ethiopia, farmers selling to formal outlets position upstream in the market chain by largely selling to agricultural cooperatives and farm-based associations (Table 4) in the village or near the town or district (Table 5). Specifically, households that sell their crops to the most upstream positions (n.1 and n.2) were 47% in 2011, 20% in 2013, and 58% in 2015.

At the same time, the percentages of those downstream positions n.5 and n.6 decreased in the years following the floods, precisely 36% in 2011, 27% in 2013, and 4% in 2015. Similarly, the quantity of crops sold outside the district/region significantly decrease after 2011.

Contrarywise to Ethiopia, in the Nigerian sample, farming households sell predominately in downstream positions (Position 6 and 7), but large quantities of crop are still sold through local markets. In terms of selling location, patterns similar to those in the sample for Ethiopia are observed with most quantities sold within the village. Nevertheless, before 2012, 38% of the crop was sold outside the region.

Table 5: Ethiopia – Quantity of Crop Sold (in Kilos) per Selling Location

	Ethiopia			**Nigeria**		
	2011	**2013**	**2015**	**2011**	**2013**	**2015**
Selling Location n.1 *(selling within the village or near the village)*	158.30 (557.30)	168 (245.70)	26.89 (62.94)	678.3 (1716.5)	5784.1 (105928.9)	909.0 (2916.6)
Selling Location n.2 *(selling in/near the town or in/near the district)*	105.50 (180.90)	229.70 (1248.20)	40.43 (83.95)	3329.9 (16322.8)	1061.3 (2505.9)	1152.9 (3482.3)
Selling Location n.3 *(selling outside the district or outside the region)*	110 (106)	28.60 (25)	12.90 (23.38)	2450.7 (5128.5)	2116.1 (3255.7)	843.8 (1152.3)
Average	132.80	197.60	33.07	1488.9	4439.4	954.2
Observations	521	1026	883	347	757	515

Finally, Table 6 reports the descriptive statistics for the main outcome variables (food consumption and total consumption) and the statistics used for the sensitivity analysis (food quantity) for both samples.

Consumption values are expressed in per capita terms and are deflated in real/constant local currency values for the year 2010, using the Consumer Price Index (CPI) computed by the World Bank.[3] On average, Ethiopian and Nigerian households' food consumption represents more than 70% of their total consumption expenditure. Farmers are generally poor, with distribution highly skewed towards the minimum value (mean consumption equals less than 7% of the maximum value). The same kind of skewness is present in food consumption and quantity, where the mean quantity is not even 1% of the maximum value.

[3] Available at http://data.worldbank.org/indicator/FP.CPI.TOTL.

Table 6: Dependent Variables Summary Statistics

			N. of Obs.	Mean	St. Dev.	Min. Value	Max. Value
Ethiopia		**Food Consumption** ***(decimals, ETB)***	1,394	1,666.08	1891.68	156.24	41,616.74
		Total Consumption[4] ***(decimals, ETB)***	1,394	2,021.67	1986.22	188.59	42,073.02
	Sens. Testing	Food Quantity *(decimals, Kg)*	1,459	7.15	37.77	0.07	1,004.4
Nigeria		**Food Consumption** ***(decimals, NGN)***	1,178	56,075.51	74,259.26	4,751.17	1,672,537
		Total Consumption[5] ***(decimals, NGN))***	1,178	78,349.05	88,541.40	9,334.46	1,699,927
	Sens. Testing	Food Quantity *(decimals, Kg)*	1,175	32.9454	156.10	0.04	3268.39

7. Identification Strategy, Results, and Sensitivity

This section is articulated as follows: first, it outlines the identification strategy of this work and then reports the results, discussion, and policy implications of the analysis. The identification strategy outlined in Subsection 7.1 establishes the framework for reporting various types of results: an analysis comparing the performance of alternative positioning indicators (Subsection 7.2) and presents the primary results for the amended positioning indicator, along with sensitivity and robustness checks (see Subsections 7.3, 7.4, and 7.5, respectively). The comprehensive discussion of the results and an examination of the role of market intermediaries are presented in Subsection 7.6.

7.1 Identification Strategy

The proposed identification strategy establishes the empirical approach for evaluating the performance and effects of the amended positioning indicator. Based on the literature considering farmers' consumption in any period as a semi-logarithmic econometric

[4] Following the LSMS-ISA documentation on the Ethiopia Socioeconomic Survey, consumption total expenditures include three sources: food, non-food and education expenses for each household.
[5] As specified in the "Basic Information Document" for the LSMS-ISA Nigeria General Household Survey, total consumption is calculated as the sum of all food, education, non-food, and imputed rent expenditures.

specification, the identification strategy of this work tests whether there is a statistically significant relationship between the proposed value-chain positioning indicator for the natural log of food and total consumption.[6]

Based on empirical literature, a set of observable household characteristics is used as a proxy for several factors including households' preferences, expectations, and composition (Dercon, 2004; Chaudhuri, 2003), while the set of product characteristics such as such as fertilizer use, the receiving of free seed, the purchase of any seed, the seed type, the crop type, the land available for cropping and the quantity of crop harvested, controls for heterogeneity in production characteristics among farmers (Montalbano et al., 2018).

To examine the impact of farmers' market chain positioning on their consumption levels, the following specification is utilized:

$$C_{h,t} = \alpha_h + \beta_t + \phi_1 Down_{h,t} + \delta X_{h,t} + \varepsilon_{h,t}; \quad [5]$$

where $C_{h,t}$ is alternatively the natural log of household per adult equivalent of food consumption and total consumption, $Down_{h,t}$ represents the value of the proposed downstreamness indicator, and $X_{h,t}$, is the vector of control variables for household heterogeneity and includes observable household and production characteristic. In Equation [5], ϕ_1 represents the impact of downstream positioning on consumption. In this case, rejecting $H_{(0)}$: ϕ_1=0 implies that *changes* in the proposed market positioning indicator are empirically associated to *changes* in household food/total consumption. $X_{h,t}$, is the vector of controls for household heterogeneity and includes observable household and production characteristics. The results should be interpreted as changes in the value chain positioning indicator within households over time, thanks to the inclusion of household fixed effects. In the considered sample, there is indeed

[6] LSMS-ISA household surveys for Nigeria do not provide per adult equivalencies in consumption aggregates. Considering the current debate around the likelihood of incurring in mistakes when self-calculating equivalencies (see, Deaton & Margaret, 1998) and to make estimates across the two samples comparable, the consumption levels for Ethiopia are reported in terms of per capita in line with those for Nigeria.

within-variation among those interviewed for more than one surveying wave, which allows for the preservation of the same positioning score across time.[7]

Thanks to the panel specification above, this empirical strategy also controls for unobserved heterogeneity in the data by inserting a set of α_h controls to account for household fixed effects in the regression, village/district/region dummies, and a set of β_t time/wave fixed effects. Moreover, to avoid additional sources of unobserved heterogeneity, this analysis proposes two additional specifications: (i) the addition of a full set of village/district/region-wave dummies (that this paper simply refers to as 'district-wave' dummies) to control time-variant unobserved covariate characteristics at the village/district/region level; (ii) the further addition of household linear and squared wave/time-trends to control time-varying unobserved confounders. The resulting value for the market chain positioning of each farming household is calculated as the average of the positioning scores in each individual crop selling chain. Additionally, when possible within the considered sample, crop fixed effects are always included as control variables in regression analysis.

Although a three-wave panel is unable to capture a real trend, the latter specification allows for controlling additional predictable unobservable components which may not be captured by the existing controls, thus further reducing the role of the stochastic components. Possible reverse causality between food/total consumption and market positioning is not expected to impact the estimates because proxies for food consumption and commercialization are measured in different time periods. The consumption questions typically refer to the last seven days before the interview, while the selling decisions are typically made at the end of the harvest season. To account for seasonality, an extra dummy is added to the analysis, one considering the month of the interview.

The proposed identification strategy considers only households participating in value chains, these constitute less than 7% of the observations in the considered sample. Given the modest portion of farmers not selling theirs crop in value chains, all the reported estimates consider only farmers selling in value chains. Aware of the possible selection biases caused by this

[7] In the sample for Ethiopia, among the 299 households who were interviewed for more than one surveying wave, none of these resulted in no variation in the positioning indicator value; the same applies in the sample for Nigeria to those 179 households interviewed for more than one surveying year.

choice, in the robustness checks, main results from Equation [5] are repeated using the so-called "Heckman correction."

Moreover, another possible source of bias in the estimates is detected, that of self-selection. Self-selection, or the ability of farmers to self-select themselves in the group of those with the highest improvements in consumptions and positioning, is questioned in the robustness checks through the implementation of the control function method proposed by Wooldridge in 2015. Summary statistics describing the differences across surveying years between "position changers" (or "movers") and "position static" (or "non-movers") are reported the Appendix.

The downstreamness indicator in the main analysis is the proposed amended indicator in Equation [4], whose performance in regression analysis is first tested in comparison to the simpler "à la Antràs and Chor" (AC) indicator adaptation in Equation [3] and the other alternative proxies of market positioning, like distance to the main market and a dummy variable equal to one when selling to downstream buyers (i.e., Selling Position n.6 and Selling Position n.7). Given the absence of more sophisticated empirical methods, the indicator performance is interpreted in relation to the results of the adjusted R-squared, the AIC and BIC coefficients within the proposed regression framework. Using the same LSMS-ISA survey data from Ethiopia and Nigeria, Equation [5] is applied to examine the relationship between the proposed downstreamness indicator's association with food quantity as an alternative outcome variable. This replication of the empirical strategy serves the purpose of sensitivity analysis. Additionally, robustness checks are conducted by replicating the main analysis with population sampling weights. These checks aim to test the robustness of the downstreamness indicator's association with the main outcome variables, namely food and total consumption.

7.2 Indicator Results

Table 7 presents a comparative analysis for the considered proxies of value chains positioning.

Table 7: Downstreamness Indicators Comparison – Main Results for Ethiopia

	Food Consumption					Total Consumption				
	Adjusted Down.	**À Ant. & Ch. Down.**	**(ln) Crop Share**	**(ln) Distance to Market**	**Down. as Dummy**	**Adjusted Down.**	**Down. À la Ant. & Ch.**	**(ln) Crop Share**	**(ln) Distance to Market**	**Down. as Dummy**
Positioning	42.01***	3.569***	0.104*	-0.196	0.0567	35.96***	3.053***	0.0782	-0.0554	0.0410
	(12.91)	(1.226)	(0.0619)	(1.638)	(0.100)	(11.01)	(1.044)	(0.0528)	(1.442)	(0.0862)
Fem. Head	0.195	0.0421	-0.0329	-0.132	-0.104	0.0233	-0.108	-0.176	-0.214	-0.229
	(0.679)	(0.739)	(0.794)	(0.821)	(0.825)	(0.589)	(0.641)	(0.690)	(0.722)	(0.713)
Age Head	0.0179**	0.0181**	0.0198***	0.0122	0.0192***	0.0169***	0.0171***	0.0185***	0.0113+	0.0181***
	(0.00748)	(0.00750)	(0.00748)	(0.00856)	(0.00731)	(0.00650)	(0.00650)	(0.00649)	(0.00768)	(0.00639)
HH Labor	0.0187	0.0167	0.0155	0.0535	0.0198	0.0387	0.0370	0.0361	0.0707+	0.0393
	(0.0506)	(0.0511)	(0.0510)	(0.0513)	(0.0507)	(0.0456)	(0.0458)	(0.0459)	(0.0461)	(0.0456)
Hous. Size	-0.268***	-0.268***	-0.277***	-0.284***	-0.275***	-0.226***	-0.226***	-0.234***	-0.247***	-0.232***
	(0.0552)	(0.0552)	(0.0557)	(0.0559)	(0.0552)	(0.0510)	(0.0510)	(0.0513)	(0.0533)	(0.0511)
Educ. Ad.	1.485	1.166	1.025	0.308	0.540	1.609+	1.336	1.154	0.668	0.786
	(1.250)	(1.233)	(1.269)	(1.166)	(1.269)	(1.075)	(1.063)	(1.100)	(0.971)	(1.096)
N. of Inf.	0.144**	0.140**	0.136*	0.0482	0.129*	0.0959+	0.0922+	0.0873+	0.0269	0.0819
	(0.0696)	(0.0693)	(0.0701)	(0.0727)	(0.0712)	(0.0599)	(0.0596)	(0.0602)	(0.0613)	(0.0603)
N. of Child	0.0533	0.0603	0.0803*	0.102**	0.0920**	0.0459	0.0519	0.0706*	0.0854**	0.0794*
	(0.0479)	(0.0478)	(0.0474)	(0.0462)	(0.0457)	(0.0421)	(0.0421)	(0.0418)	(0.0412)	(0.0407)
Av. Educ.	-1.475	-1.160	-1.019	-0.282	-0.531	-1.591+	-1.321	-1.137	-0.635	-0.768
	(1.251)	(1.234)	(1.270)	(1.161)	(1.270)	(1.077)	(1.065)	(1.102)	(0.967)	(1.098)
Harv. Cr.	0.00007	0.00007	0.00006	0.00008	0.00006	0.00006	0.00006	0.00006	0.00007	0.00005
	(0.00007)	(0.00007)	(0.00006)	(0.00005)	(0.00007)	(0.00006)	(0.00006)	(0.00006)	(0.00005)	(0.00006)
Field Size	0.000006	0.000006	0.000005	0.000005	0.000006	0.000008	0.000008	0.000005	0.000006	0.000007
	(0.000007)	(0.000007)	(0.000007)	(0.000007)	(0.000007)	(0.000007)	(0.000007)	(0.000007)	(0.000007)	(0.000007)
Free Seed	0.143	0.107	0.203	0.162	0.183	-0.0907	-0.122	-0.0414	-0.0289	-0.0565
	(0.402)	(0.400)	(0.395)	(0.330)	(0.370)	(0.374)	(0.375)	(0.367)	(0.311)	(0.351)
Seed Purc.	0.118	0.115	0.0819	-0.0175	0.0744	0.0136	0.0107	-0.0180	-0.0958	-0.0235
	(0.175)	(0.173)	(0.174)	(0.169)	(0.177)	(0.159)	(0.157)	(0.158)	(0.153)	(0.161)
Fert. Use	-0.150	-0.172	-0.209+	-0.157	-0.216	-0.119	-0.137	-0.171	-0.110	-0.176
	(0.137)	(0.139)	(0.143)	(0.111)	(0.151)	(0.116)	(0.117)	(0.123)	(0.0965)	(0.129)
Seed FE* Crop FE*	-	-	-	-	-	-	-	-	-	-
Time FE*	-	-	-	-	-	-	-	-	-	-
Dist. FE*	-	-	-	-	-	-	-	-	-	-
HH Trends	-	-	-	-	-	-	-	-	-	-
Constant	6.039***	6.226***	6.730***	9.253	6.277***	6.659***	6.819***	7.200***	8.844+	6.858***
	(0.986)	(0.989)	(1.086)	(6.577)	(1.026)	(0.853)	(0.857)	(0.936)	(5.817)	(0.887)
Obs.	1,387	1,387	1,387	1,381	1,387	1,387	1,387	1,387	1,381	1,387
N. HH_id	1,097	1,097	1,097	1,093	1,097	1,097	1,097	1,097	1,093	1,097
R-sq. Adj.	0.718	0.716	0.708	0.643	0.704	0.727	0.759	0.717	0.687	0.749
AIC	-1316.97	-1306.11	-1266.77	-1013.52	-1251.08	-1697.19	-1686.64	-1644.86	-1371.93	-1633.08
BIC	-615.49	-604.63	-565.29	-375.39	-549.61	-995.71	-985.16	-943.38	-733.80	-931.60

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

To evaluate the performance of the amended indicator, several comparisons were made with alternative proxies of market positioning. Specifically, the simpler "à la Antràs and Chor" (AC) indicator, the unsophisticated crop share of the total quantity sold along the chain, distance to the main market, and the categorical variable "selling to downstream buyers" were examined alongside the amended indicator. The analysis was conducted using the sample data for Ethiopia. The results from Equation [5], which included district dummies and time trends, showed significant downstreamness coefficients only for the adjusted and AC indicators, as indicated in Table 7. This finding challenges the commonly used proxies for marketing factors, orientation, and positioning that have been traditionally employed in empirical studies (e.g., *inter alia*, Montalbano et al., 2018; Migose et al., 2018; Mkuna & Wale, 2022). Furthermore, model comparison using adjusted R-squared, AIC, and BIC coefficients further supported the superior performance of the proposed indicators compared to the non-AC ones, as shown in Table 7. These findings highlight the greater efficiency and effectiveness of the amended indicator in capturing market positioning.

Tables A.3.4 and A.3.5 offer insights into the models based on quintiles and main crops, showing that the amended indicator consistently has the highest significance level, highest adjusted R-squared values, and lowest AIC and BIC criteria. The AC indicators outperform the alternatives in observations up to the 3rd quartiles, especially in maize production. Descriptive statistics for the proposed amended positioning indicator can be found in Table 8.

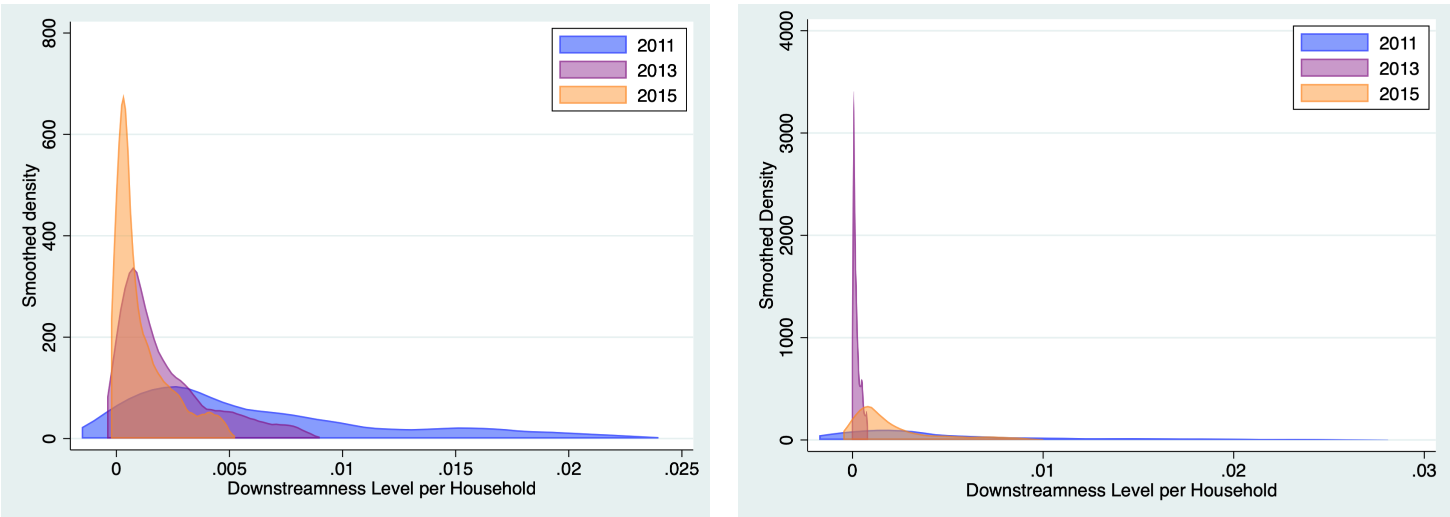
Table 8: Downstreamness Indicator Results

		N. of observations	Mean	Standard Deviation	Minimum Value	Maximum Value
Ethiopia	**Downstreamness in 2011 *(decimals)***	521	0.021757	0.065071	0	0.704935
	Downstreamness in 2013 *(decimals)*	1,026	0.018650	0.072349	0.000019	0.699783
	Downstreamness in 2015 *(decimals)*	883	0.018235	0.066194	0.000012	0.704935
Nigeria	**Downstreamness in 2011 *(decimals)***	346	0.048960	0.118564	0.000005	1
	Downstreamness in 2013 *(decimals)*	757	0.002883	0.027114	0	0.445774
	Downstreamness in 2015 *(decimals)*	515	0.032263	0.088104	0.000014	0.857143

The study findings indicate that in the Ethiopian sample, the positioning indicator for crop-specific value chains ranges from 0 to 0.7, with rural households having an average downstreamness value of approximately 0.02 (Table 8). In Nigeria, there is greater heterogeneity in downstreamness values, with a maximum of 1 in 2011 and a decrease to 0.45 in 2013, deviating from the observed trend in 2011 and 2015 (Table 8). These findings support the transition of food supply chains from local and fragmented to longer and geographically connected ones (IFAD, 2016). Farmers in the market chain predominantly position themselves upstream (Montalbano et al., 2018), and the crops they sell exhibit low price elasticity of demand (see Table A.3.6 and Table A.3.7 in the Appendix). Analyzing the data while excluding outliers reveals micro-trends in market positioning dynamics over the years (Figure 3, Figure A.3.1, and Figure A.3.2)

Figure 3: Household Downstreamness Values - Kernel Density by Year

Ethiopia *Nigeria*



The quasi-bell-shaped kernel density distributions in the Appendix (Figures A.3.3, A.3.4, and A.3.5 for Ethiopia, and Figures A.3.6, A.3.7, and A.3.8 for Nigeria) support the validity of the proposed indicator, excluding outliers to examine the significance of small variations. It is important to note that the indicator results have a range between 0 and 1, with lower elasticities leading to higher downstreamness values and higher elasticities leading to lower downstreamness values.

7.3 Indicator Empirical Testing with Food and Total Consumption

Table 9 presents the estimated coefficients for Equation [5] for food and total consumption in Ethiopia.

Table 9: Main Results for Ethiopia – Panel Fixed Effects Clustered by Household ID

	Food Consumption			Total Consumption		
	Wave Fixed Effects	District-Wave Fixed Effects	Wave Fixed Effect HH Trends	Wave Fixed Effects	District-Wave Fixed Effects	Wave Fixed Effect HH Trends
Downstreamness	31.04**	43.11***	42.01***	27.17*	36.13***	35.96***
	(15.03)	(12.74)	(12.91)	(14.31)	(11.03)	(11.01)
Female Head	0.183	0.180	0.195	0.0319	0.0715	0.0233
	(0.637)	(0.629)	(0.679)	(0.584)	(0.528)	(0.589)
Age Head	0.0195**	0.0181**	0.0179**	0.0177**	0.0171***	0.0169***
	(0.00774)	(0.00743)	(0.00748)	(0.00748)	(0.00652)	(0.00650)
Household Labor	-0.0271	0.0173	0.0187	-0.0136	0.0349	0.0387
	(0.0455)	(0.0516)	(0.0506)	(0.0415)	(0.0468)	(0.0456)
Household Size	-0.161***	-0.273***	-0.268***	-0.145***	-0.229***	-0.226***
	(0.0590)	(0.0556)	(0.0552)	(0.0558)	(0.0515)	(0.0510)
Education Adults	-0.400*	1.571	1.485	-0.462**	1.675+	1.609+
	(0.215)	(1.242)	(1.250)	(0.197)	(1.073)	(1.075)
N. of Infants	0.0983	0.151**	0.144**	0.0828	0.102*	0.0959+
	(0.0790)	(0.0698)	(0.0696)	(0.0700)	(0.0600)	(0.0599)
N. of Child	-0.00503	0.0539	0.0533	-0.0165	0.0478	0.0459
	(0.0494)	(0.0473)	(0.0479)	(0.0444)	(0.0414)	(0.0421)
Average Education	0.454**	-1.556	-1.475	0.526***	-1.654+	-1.591+
	(0.215)	(1.243)	(1.251)	(0.197)	(1.076)	(1.077)
Harvest Crop	0.00006	0.00007	0.00007	0.00003	0.00006	0.00006
	(0.00006)	(0.00007)	(0.00007)	(0.00005)	(0.00006)	(0.00006)
Field Size	0.00001	0.000006	0.000006	0.000009	0.000009	0.000008
	(0.000009)	(0.000008)	(0.000007)	(0.000006)	(0.000007)	(0.000007)
Free Seed	-0.555	0.134	0.143	-0.596*	-0.114	-0.0907
	(0.380)	(0.396)	(0.402)	(0.350)	(0.367)	(0.374)
Seed Purchase	0.182	0.0954	0.118	0.105	-0.00246	0.0136
	(0.152)	(0.176)	(0.175)	(0.131)	(0.160)	(0.159)
Fertilizer Use	-0.0363	-0.144	-0.150	-0.00724	-0.102	-0.119
	(0.103)	(0.135)	(0.137)	(0.0916)	(0.114)	(0.116)
Seed Type Dummy* **Crop Code Dummy***	-	-	-	-	-	-
Year Dummy* Month Dummy*	-	-	-	-	-	-
Region Dummy* Woreda Dummy* Zone Dummy* Town Dummy* Subcity Dummy* Kebele Dummy*		-	-		-	-
HH Trends HH Trends^2			-			-
Constant	7.650***	5.948***	6.039***	7.991***	6.554***	6.659***
	(0.628)	(0.991)	(0.986)	(0.583)	(0.848)	(0.853)
Observations	1,387	1,387	1,387	1,387	1,387	1,387
Number of HH_id	1,097	1,097	1,097	1,097	1,097	1,097
R-squared Adjusted	0.306	0.717	0.718	0.314	0.725	0.727

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

The findings highlight a positive relationship between the proposed positioning indicator values and consumption levels. All estimates were adjusted for household production characteristics to account for additional latent variables that could explain variations in market positioning, effectively reducing potential endogeneity resulting from selectivity bias (Fafchamps & Hill, 2005).

The key result of these estimates is a significant and positive association between market positioning and food and total consumption among farmers, as evidenced across different specifications. By accounting for time- and geography-related factors, it is observed that Ethiopian farmers positioned downstream in the market experience significantly higher per-capita consumption levels compared to farming households with similar characteristics but lower positioning scores. Specifically, on average and holding other factors constant, a marginal increase of 0.01 in the positioning indicator value corresponds to an increase of more than 50% in per-capita food consumption and over 40% in per-capita total consumption. These patterns refute the notion that food consumption patterns are exclusively influenced by changes in food prices relative to non-food expenditure costs. It is important to emphasize that failure to consider household trends and account for household and geographical characteristics in the estimation equation would result in a downward bias in the estimated "market positioning effect" when comparing coefficients across columns. Furthermore, the findings demonstrate similar dynamics for food and total consumption, with lower significance observed in the baseline specification and a general downward bias if district indicators are not included as control variables.

Although the hypothesized change of 0.01 in the positioning indicator score is relatively small compared to the inherent variability captured by the standard deviations of the calculated coefficients for the downstreamness indicator across the different specifications provided, it still represents a shift in the coefficient estimate which is worth to be considered. Within-variation in downstreamness equal to or greater than 0.01 is observed in less than 2% of the cases for Ethiopia. Among these households who experience such a change in overall positioning, despite there are not significant variations in initial levels of downstreamness, the biggest variations in food consumption levels are recorded by those whose change in positioning is driven by a modification in quantities sold and the identity of the crop buyer.

Table 10 presents the main results for Nigeria.

Table 10: Main Results for Nigeria – Panel Fixed Effects Clustered by Household ID

	Food Consumption			Total Consumption		
	Wave Fixed Effects	District-Wave Fixed Effects	Wave Fixed Effect HH Trends	Wave Fixed Effects	District-Wave Fixed Effects	Wave Fixed Effect HH Trends
Downstreamness	31.50***	33.39***	33.85***	26.79**	31.56**	31.46**
	(11.94)	(12.16)	(12.50)	(10.75)	(13.97)	(14.19)
Female Head	0.0206	-0.0463	-0.0345	0.0437	-0.181	-0.145
	(0.194)	(0.170)	(0.181)	(0.180)	(0.173)	(0.187)
Household Labor	-0.137***	-0.0251	-0.0290	-0.113***	-0.0216	-0.0264
	(0.0305)	(0.0371)	(0.0383)	(0.0270)	(0.0354)	(0.0377)
Household Size	0.0279	-0.0144	-0.0132	0.0173	0.0137	0.0136
	(0.0374)	(0.0409)	(0.0399)	(0.0469)	(0.0364)	(0.0354)
N. of Infants	0.00635	-0.0173	-0.0114	-0.0153	-0.0309	-0.0348
	(0.0598)	(0.0757)	(0.0411)	(0.0562)	(0.0772)	(0.0860)
N. of Child	-0.0236	-0.0183	-0.0187	-0.0202	-0.0241	-0.0143
	(0.0418)	(0.0391)	(0.0814)	(0.0353)	(0.0390)	(0.0423)
Fertilizer Use	-0.00118	0.0594	0.0657	-0.0607	-0.0498	-0.0365
	(0.167)	(0.180)	(0.183)	(0.151)	(0.191)	(0.194)
Fertil. Purchase	0.149	0.0378	0.0515	0.154	0.128	0.142
	(0.173)	(0.183)	(0.182)	(0.150)	(0.184)	(0.184)
Leftover Fertil.	0.180	0.195	0.181	0.147	0.150	0.131
	(0.148)	(0.204)	(0.210)	(0.142)	(0.173)	(0.179)
Free Fertilizer	-1.079***	0.0480	-0.204	-0.608***	0.0697	-0.221
	(0.0875)	(0.191)	(0.327)	(0.0827)	(0.215)	(0.380)
Year Dummy*	-	-	-	-	-	-
State Dummy* Local Government Area Dummy*	-	-	-	-	-	-
HH Trends HH Trends^2		-	-		-	-
Constant	10.75***	11.45***	10.93***	11.08***	11.49***	11.03***
	(0.236)	(0.277)	(0.512)	(0.276)	(0.244)	(0.576)
Num. Obs.	1,178	1,178	1,178	1,178	1,178	1,178
Num. HH_id	979	979	979	979	979	979
R-squared Adj.	0.406	0.819	0.821	0.317	0.735	0.738

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Similar to Ethiopia, market outlets for Nigerian farmers include local and district markets, traders, agricultural cooperatives, farmer-based associations, and auction markets. Unlike that of Ethiopia, some farmers in Nigeria register to sell directly to processors (i.e., private companies). The variety of crops sold is similar to that listed for Ethiopia, with the addition of non-food crops such as cotton. Equation [5] of the empirical strategy is applied to the Nigerian panel dataset, with a few differences due to the available data.[8]

The results are nearly identical to those obtained for Ethiopia. In all specifications of the outcome variables, if rural households can increase their positioning indicator value by 0.01, on average and holding other factors constant, they can achieve an approximate 40% increase in per-capita food consumption and around 37% increase in per-capita total consumption.

Hence, controlling factors such as district/village dummies and time trends, Ethiopian farmers who participate and have a better position in the market chain register, on average and *ceteris paribus*, have a per-capita equivalent consumption level higher than those farming households with the same characteristics and who have a lower position-indicator score. The results for both food and total consumption are perfectly aligned.

7.4 Sensitivity Analysis

Table 11 shows the result of the sensitivity analysis for food quantity in both samples. Similar to consumption, food quantity is measured in logarithmic form. Food quantity is positively affected by higher positioning scores for all the specifications provided for both samples.

Results in both countries are very similar. If rural households are able to increase their positioning indicator value by 0.01, on average, and *ceteris paribus*, they are able to more than double their food quantity level both in Ethiopia and Nigeria. Therefore, the impact of increased positioning in value chains on food quantity per household is much greater, in terms of magnitude, than the impact on food and total consumption levels per capita.

[8] The variable "crop code" is not controlled for in the case of Nigeria, given the few changes in labeling across the years that may have altered the panel dataset combined "crop code" variable. Also, interview month is omitted due to several missing observations. Consumption data rely on the postharvest surveying visit. Data on fertilizer use are from the post-planting questionnaire.

Table 11: Sensitivity Testing with Food Quantity

	Food Quantity (Ethiopia)			Food Quantity (Nigeria)		
	Wave Fixed Effects	**District-Wave Fixed Effects**	**Wave Fixed Effect HH Trends**	**Wave Fixed Effects**	**District-Wave Fixed Effects**	**Wave Fixed Effect HH Trends**
Downstreamness	61.86**	70.51*	81.38**	61.07**	82.03***	78.18***
	(26.55)	(36.81)	(36.54)	(25.31)	(26.60)	(28.09)
Female Head	-0.956	-0.939+	-1.125+	-0.629	-0.768**	-0.632+
	(0.945)	(0.620)	(0.732)	(0.523)	(0.382)	(0.407)
Age Head	0.0203	0.0135	0.0127			
	(0.0173)	(0.0136)	(0.0135)			
Household Labor	-0.122	-0.0596	-0.0459	-0.123*	0.103	0.101
	(0.111)	(0.122)	(0.121)	(0.0686)	(0.0870)	(0.0883)
Household Size	0.195*	0.0999	0.0894	0.239***	0.0846	0.0756
	(0.1000)	(0.111)	(0.110)	(0.0687)	(0.0647)	(0.0659)
Education Adults	-1.373**	2.859*	1.802			
	(0.697)	(1.554)	(1.542)			
N. of Infants	-0.0336	0.282*	0.296*	0.163	0.221*	-0.105+
	(0.147)	(0.158)	(0.159)	(0.121)	(0.128)	(0.0961)
N. of Child	-0.0734	-0.0297	-0.0453	-0.152*	-0.118	0.206
	(0.0904)	(0.0959)	(0.0974)	(0.0812)	(0.0936)	(0.127)
Average Education	1.501**	-2.705*	-1.638			
	(0.700)	(1.564)	(1.544)			
Harvest Crop	-0.0000249	-0.000183+	-0.000146			
	(0.0000951)	(0.000117)	(0.000121)			
Field Size	-0.00000320	-0.0000174	-0.0000189+			
	(0.0000113)	(0.0000131)	(0.0000127)			
Free Seed/Fert.	0.0387	-0.350	-0.323	-0.755***	-0.461	-0.498
	(0.310)	(0.690)	(0.673)	(0.0875)	(0.326)	(0.426)
Seed/Fert. Purchase	-0.282	-0.115	-0.139	0.521*	0.662*	0.655*
	(0.356)	(0.352)	(0.338)	(0.313)	(0.344)	(0.350)
Fertilizer Use	-0.218	0.130	0.0860	-0.288	-0.193	-0.155
	(0.216)	(0.275)	(0.264)	(0.267)	(0.301)	(0.304)
Letfover Fert.				0.310	0.736***	0.711***
				(0.397)	(0.220)	(0.223)
Seed Type Dummy* **Crop Code Dummy***	-	-	-			
Year Dummy* Month Dummy*	-	-	-	-	-	-
Reg./State Dummy* Wor./Loc. Gov. Area Dummy*	-	-	-	-	-	-
HH Trends HH Trends^2		-	-		-	-
Constant	-1.086	7.683***	7.756***	2.066***	2.081***	2.885***
	(1.048)	(1.974)	(1.916)	(0.432)	(0.384)	(0.767)
Observations	1,452	1,452	1,452	1,175	1,175	1,175
Number of HH_id	1,121	1,121	1,121	977	977	977
R-squared Adjusted	0.126	0.534	0.544	0.592	0.875	0.876

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

7.5 Robustness Checks

Table 12: Main Results with Population Sampling Weights for Ethiopia

	Food Consumption			Total Consumption		
	Wave Fixed Effects	**District-Wave Fixed Effects**	**Wave Fixed Effect HH Trends**	**Wave Fixed Effects**	**District-Wave Fixed Effects**	**Wave Fixed Effect HH Trends**
Downstreamness	22.68+	21.85+	21.47+	20.08+	21.81*	22.39*
	(15.07)	(14.50)	(14.61)	(13.58)	(13.00)	(12.97)
Female Head	0.0796	-0.734+	-0.872*	-0.0425	-0.659*	-0.839**
	(0.678)	(0.461)	(0.503)	(0.622)	(0.374)	(0.419)
Age Head	0.0192**	0.0212***	0.0206***	0.0172**	0.0192***	0.0187***
	(0.00845)	(0.00746)	(0.00745)	(0.00814)	(0.00670)	(0.00663)
Household Labor	0.0155	0.0244	0.0223	0.0101	0.0464	0.0459
	(0.0454)	(0.0534)	(0.0518)	(0.0419)	(0.0510)	(0.0493)
Household Size	-0.175***	-0.291***	-0.279***	-0.136**	-0.242***	-0.232***
	(0.0589)	(0.0616)	(0.0608)	(0.0585)	(0.0595)	(0.0583)
Education Adults	-0.497***	1.638	1.754	-0.542***	1.791	1.911+
	(0.174)	(1.414)	(1.414)	(0.143)	(1.245)	(1.232)
N. of Infants	0.132*	0.196***	0.195***	0.107	0.136**	0.135**
	(0.0768)	(0.0699)	(0.0701)	(0.0680)	(0.0639)	(0.0645)
N. of Child	-0.0321	0.0365	0.0263	-0.0446	0.0281	0.0162
	(0.0514)	(0.0481)	(0.0494)	(0.0467)	(0.0461)	(0.0469)
Average Education	0.540***	-1.636	-1.759	0.591***	-1.789	-1.912+
	(0.176)	(1.419)	(1.418)	(0.145)	(1.251)	(1.237)
Harvest Crop	0.00005	0.000122*	0.000129**	0.00001	0.000105*	0.000114*
	(0.00006)	(0.00006)	(0.00006)	(0.00005)	(0.00006)	(0.00006)
Field Size	0.000009	-0.000002	-0.000003	0.000007	0.0000009	-0.0000006
	(0.000007)	(0.000007)	(0.000007)	(0.000006)	(0.000007)	(0.000007)
Free Seed	-0.289	0.210	0.228	-0.382	-0.0498	-0.0233
	(0.356)	(0.367)	(0.373)	(0.326)	(0.340)	(0.348)
Seed Purchase	0.167	0.227	0.245	0.0768	0.106	0.122
	(0.171)	(0.162)	(0.160)	(0.139)	(0.152)	(0.150)
Fertilizer Use	-0.00348	-0.203*	-0.232**	0.0293	-0.109	-0.142
	(0.104)	(0.116)	(0.117)	(0.0859)	(0.109)	(0.110)
Seed Type Dummy* **Crop Code Dummy***	-	-	-	-	-	-
Year Dummy* Month Dummy*	-	-	-	-	-	-
Region Dummy* Woreda Dummy* Zone Dummy* Town Dummy* Subcity Dummy* Kebele Dummy*	-	-	-	-	-	-
HH Trends HH Trends^2		-	-		-	-
Constant	7.236***	6.906***	7.045***	7.605***	7.562***	7.679***
	(0.618)	(1.231)	(1.216)	(0.581)	(1.069)	(1.054)
Observations	1,387	1,387	1,387	1,387	1,387	1,387
Number of HH_id	1,097	1,097	1,097	1,097	1,097	1,097
R-squared Adjusted	0.333	0.722	0.726	0.338	0.704	0.709

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Robustness checks are reported in Table 12 for Ethiopia and Table 13 for Nigeria. Table 12 shows the results of Table 9 replicated with population sampling weights[9]. Results are robust and consistent with what was previously obtained. As in Table 9, results for both food and total consumption show the same dynamics: lower significance for the baseline specification and a downward bias if district dummies are not in the control group but only the wave dummies are considered.

Table 13: Main Results with Population Sampling Weights for Nigeria

	Food Consumption			**Total Consumption**		
	Wave Fixed Effects	**District-Wave Fixed Effects**	**Wave Fixed Effect HH Trends**	**Wave Fixed Effects**	**District-Wave Fixed Effects**	**Wave Fixed Effect HH Trends**
Downstreamness	15.96	20.52*	21.58**	11.98	18.26	18.56+
	(12.26)	(10.46)	(10.79)	(10.89)	(13.01)	(13.02)
Female Head	0.148	0.0108	-0.0111	0.129	-0.155	-0.157
	(0.217)	(0.139)	(0.145)	(0.191)	(0.128)	(0.137)
Household Labor	-0.135***	-0.0629*	-0.0623+	-0.107***	-0.0496	-0.0506
	(0.0336)	(0.0374)	(0.0395)	(0.0285)	(0.0349)	(0.0381)
Household Size	0.00595	0.0156	0.0177	-0.0120	0.0394	0.0403
	(0.0422)	(0.0335)	(0.0323)	(0.0666)	(0.0340)	(0.0326)
N. of Infants	0.00354	-0.0707	-0.00433	-0.00757	-0.0789	-0.0726
	(0.0700)	(0.0674)	(0.0358)	(0.0708)	(0.0690)	(0.0772)
N. of Child	-0.00415	-0.00797	-0.0644	-0.0171	-0.0212	-0.0150
	(0.0393)	(0.0340)	(0.0725)	(0.0355)	(0.0357)	(0.0389)
Fertilizer Use	-0.00430	-0.00221	0.00907	-0.0220	-0.0575	-0.0387
	(0.168)	(0.168)	(0.171)	(0.158)	(0.179)	(0.180)
Fertil. Purchase	0.161	-0.0302	-0.0102	0.131	0.0330	0.0541
	(0.157)	(0.157)	(0.158)	(0.144)	(0.158)	(0.160)
Leftover Fertil.	0.205	0.0763	0.0853	0.169	0.140	0.144
	(0.147)	(0.171)	(0.174)	(0.143)	(0.175)	(0.179)
Free Fertilizer	-1.112***	0.173	-0.248	-0.651***	0.143	-0.323
	(0.0852)	(0.173)	(0.321)	(0.0844)	(0.202)	(0.405)
Year Dummy*	-	-	-	-	-	-
State Dummy* Local Government Area Dummy*	-	-	-	-	-	-
HH Trends HH Trends²		-	-		-	-
Constant	10.90***	11.27***	10.38***	11.29***	11.38***	10.52***
	(0.265)	(0.232)	(0.506)	(0.382)	(0.229)	(0.645)
Num. Obs.	1,172	1,172	1,172	1,172	1,172	1,172
Num. HH_id	973	973	973	973	973	973
R-squared Adj.	0.326	0.827	0.834	0.227	0.756	0.765

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

[9] Conversely to Nigeria, combined population weights are not reported in the LSMS-ISA Ethiopia Rural Socioeconomic Surveys. To avoid mistakenly corrections, population weights were adjusted across the years by attaching the latest weight to the household's highest surveying wave.

Similarly, in Table 13 above, the results for Nigeria (shown in Table 9) are replicated with the provided population sampling weights.

Controlling for factors such as district/village dummies, Ethiopian and Nigerian households who participate and have a better position in the market chain register, on average and *ceteris paribus*, have a per-capita equivalent food and total consumption level around 20% times higher than those farming households with the same characteristics and who have a position-indicator score lower than 0.01 unit. Coefficient estimates for the proposed amended positioning indicator in Table 12 and 13 are significant for almost all the specifications provided in both samples.

In addition, in Table A.3.8. in the Appendix, main results for Ethiopia are replicated considering consumption levels normalized per adult equivalent instead of household size. Estimates are entirely in line with those reported in Table 9. When assessing the relationship between market positioning and consumption levels, selection issues may arise. Farming households may choose to participate in markets and position in value chains because of characteristics influencing their consumption levels and their market position.

Possible selection bias coming from the exclusion from the main sample of around 100 households commercializing their crop but not in value chains, is controlled via *xtheckmanfe* a Stata module introduced by Rios-Avila in 2021 able to estimate fixed effects panel models in the presence of endogeneity and sample selection using the estimator proposed in Wooldridge (1995) and Semykina and Wooldridge (2010). *Xtheckmanfe* delivers standard errors using a bootstrap procedure. Results controlling for time fixed effected and adjusted with the Heckman correction are reported in Table A.3.9 in the Appendix. It is important to note that *xtheckmanfe* computational algorithms do not converge when including control variables like "household average education level" and "crop code" with several zeros or missing values. For this reason, in order to show the robustness of the panel fixed-effects estimates, even with such minor changes in the regression model, Heckman-panel-fixed-effects estimates are reported next to those resulting from the first specification of Equation [5] excluding those cited control variables. Heckman results are consistent and in line with the main ones. Bootstrap replications are set to 250.

Moreover, another possible source of bias is taken into consideration: the one coming from "movers" versus "non-movers" (i.e., farmers changing market positioning across the years and those that do not). Regarding this matter, Table A.3.10 in the Appendix provides descriptive statistics for two groups of farmers: "movers" who changed their market positioning or had only one market observation in two surveying waves, and "non-movers" who maintained a stable market position or had no recorded commercialization data in two consecutive surveying waves.

When assessing the relationship between market positioning and consumption levels, selection issues may arise. Farming households may choose to participate in markets and position in value chains because of characteristics influencing their consumption levels and their market position. To tackle this issue more incisively, a control function (CF) approach is implemented to cope with possible self-selection bias. This means including in the main regression the estimated residual of a first stage equation (see Table A.3.11 in the Appendix) where the usual controls are used as exclusion restrictions in the linear model having as dependent variable the binary variable "Positioning Downstreamness" equal to 1 when Position is equal to 6 or 7. This residual (denoted as ρ in Table A.3.12 in the Appendix) is by definition uncorrelated with the endogenous variable and can help to derive unbiased estimators in the main equation, thus softening possible self-selection in the obtained estimates (Wooldridge, 2015). Following Wooldrige (2015), in first stage, an Ordinary Least Squares (OLS) regression is implemented. In the OLS regressions (Table A.3.11 in the Appendix) most of the variables related included as exclusion restrictions are not significantly associated with the probability of positioning downstream. The residuals from the OLS regressions in Table A.3.11 in the Appendix are included in Equation [5] to control for selection. Table A.3.12 in the Appendix reports the results, showing very consistent outcomes with the previous regressions. The lack of significance of the OLS residual (ρ) highlights the absence of a sampling error in the first stage equation.

7.6 Discussion and Policy Implications

To summarize, the empirical outcomes indicated that changes in market positioning significantly and consistently matters to increasing the consumption levels of Ethiopian farmers selling crops in the market chain. From this perspective, the findings of Montalbano et al. (2018) extend to Ethiopia regarding the positive role of farmers' market participation in Uganda. However, the results contradict the conclusion of Montalbano et al. (2018), arguing instead for the non-significance of market intermediaries. The access to markets offered by local traders can be comparable to what farmers would receive at the nearest wholesale or retail market if certain conditions apply, such as better selling location and higher quantity sold.

Table 14 reports the outcomes of estimates of Equation [5] considering as independent variables crop share instead of the downstreamness level and as additional control the position number as defined in Section 5. This analysis checks on the role of market intermediaries by regressing consumptions levels on the share of crop sold in the market chain, and by controlling for the usual household characteristics as well as market position.

Table 14: Testing the Significance of Market Outlets for Ethiopia

	Food Consumption			Total Consumption		
	Wave Fixed Effects	District-Wave Fixed Effects	Wave Fixed Effect HH Trends	Wave Fixed Effects	District-Wave Fixed Effects	Wave Fixed Effect HH Trends
Quantity Share	0.105**	0.123**	0.107*	0.102**	0.0880*	0.0800+
	(0.0499)	(0.0578)	(0.0608)	(0.0449)	(0.0491)	(0.0512)
Female Head	0.0466	-0.616	-0.679	-0.0761	-0.703	-0.821*
	(0.684)	(0.605)	(0.631)	(0.626)	(0.454)	(0.493)
Age Head	0.0197**	0.0217***	0.0212***	0.0178**	0.0201***	0.0197***
	(0.00778)	(0.00695)	(0.00695)	(0.00748)	(0.00606)	(0.00601)
Household Labor	-0.0168	0.0270	0.0328	-0.00567	0.0443	0.0520
	(0.0444)	(0.0515)	(0.0508)	(0.0404)	(0.0468)	(0.0458)
Household Size	-0.170***	-0.300***	-0.293***	-0.152***	-0.254***	-0.249***
	(0.0584)	(0.0550)	(0.0541)	(0.0545)	(0.0503)	(0.0495)
Education Adults	-0.342+	1.641	1.266	-0.398*	1.475	1.148
	(0.236)	(1.314)	(1.337)	(0.217)	(1.145)	(1.167)
N. of Infants	0.0996	0.155**	0.145**	0.0864	0.106*	0.0969
	(0.0807)	(0.0735)	(0.0735)	(0.0713)	(0.0612)	(0.0615)
N. of Child	0.0103	0.0628	0.0594	-0.00428	0.0547	0.0497
	(0.0495)	(0.0464)	(0.0469)	(0.0439)	(0.0407)	(0.0411)
Average Education	0.403*	-1.623	-1.255	0.466**	-1.450	-1.128
	(0.236)	(1.316)	(1.337)	(0.218)	(1.148)	(1.168)
Harvest Crop	0.00006	0.000127*	0.000137*	0.00004	0.000112*	0.000127**
	(0.00006)	(0.00007)	(0.00007)	(0.00005)	(0.00006)	(0.00006)
Field Size	0.00001*	0.000005	0.000005	0.00001*	0.000008	0.000007
	(0.000007)	(0.000008)	(0.000008)	(0.000006)	(0.000007)	(0.000007)
Free Seed	-0.522	0.187	0.203	-0.559*	-0.0620	-0.0287
	(0.365)	(0.377)	(0.379)	(0.335)	(0.350)	(0.355)
Seed Purchase	0.156	0.0651	0.0998	0.0811	-0.0302	-0.00159
	(0.153)	(0.167)	(0.165)	(0.131)	(0.154)	(0.151)
Fertilizer Use	-0.0366	-0.221	-0.227	-0.0127	-0.175	-0.192
	(0.110)	(0.142)	(0.145)	(0.0991)	(0.121)	(0.123)
Seed Type Dummy* **Crop Code Dummy***	-	-	-	-	-	-
Position Dummy*	-	-	-	-	-	-
Year Dummy* Month Dummy*	-	-	-	-	-	-
Region Dummy* Woreda Dummy* Zone Dummy* Town Dummy* Subcity Dummy* Kebele Dummy*		-	-		-	-
HH Trends HH Trends^2			-			-
Constant	7.868***	6.122***	5.958***	8.122***	6.372***	6.273***
	(0.671)	(1.116)	(1.121)	(0.613)	(0.948)	(0.957)
Observations	1,387	1,387	1,387	1,387	1,387	1,387
Number of HH_id	1,097	1,097	1,097	1,097	1,097	1,097
R-squared Adjusted	0.316	0.720	0.724	0.326	0.731	0.735

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

A shown in Table 14, the share of crop quantity sold in the chain positively affects food and total consumption when controlling for positioning in value chains, expressed as in Montalbano et al. (2018) as a dummy for the identity of market intermediaries. Across the different specifications, the significance of quantity share coefficients is below the 15th percentile, contrary to the conclusions of Montalbano et al. (2018). These results are of paramount importance in terms of policy implications: enabling the access to intermediaries positioned downstream in the market chain lifts the positive effects of crop shares sold along the chain on farmers' consumption levels.

As ancillary evidence of the relevance in the sample data of the market positioning indicator for consumption levels, Figures A.3.9 and A.3.10 in the Appendix show the classification tree for food consumption and total consumption, respectively. In both cases, market positioning is among the variables selected and interacts with other household characteristics depending on whether the value of each variable is below or above the reported thresholds (95th percentile). The tree classifies each observation in the dataset as either above or below the threshold value of "Food Consumption" or "Total Consumption." It must be noted that although the relationships depict signal correlation rather than causation, they are in harmony with the results from the panel-regression analysis. In addition, as explained in Section 3, a key metric of stage-positioning in agricultural market chain relies on the identity of intermediaries.

Finally, a concern should be sounded concerning the external validity of these findings. Since the focus is on investigating market positioning, the overwhelming majority of farmers who produce crops only for home consumption are excluded from the analysis. This gap hampers the ability of the analysis to derive consistent estimates for the entire population of a crop producer.

Nevertheless, results of the parallel test conducted for Nigeria are highly reassuring regarding the proposed amended indicator's external validity. In particular, the reproduction of the proposed indicator for Nigerian farmers' crop value chains leads to results very similar to those obtained for Ethiopia. When controlling for outliers, Nigerian farming households present downstreamness value ranging from 0 to 0.30; the distribution is particularly skewed towards the zero in year 2013 (see Figures A.3.7 in the Appendix). Nevertheless, the effects of market positioning on consumption levels are approximately equal to those obtained for Ethiopia.

8. Conclusions

Crop commercialization is among the main drivers of economic development today. Agricultural trade increases incomes and improves nutrition, yet this effect depends on a series of factors such as positioning in the market chain. Researchers have long debated the role of commercialization and market participation but have yet to develop a method to assess the effect of positioning, especially at the level of small farmers, involving relevant features such as transaction costs, contract enforcement and market shocks.

Although the study of farmers' market decisions dates back to the 1990s (Fafchamps, 1992; von Braun, 1995; Key et al., 2000), a systematic approach to how the market is structured at the farmer level still needs to be addressed. The motivation behind this work lies on the idea that farmers selling to wholesalers/producers are better off than farmers that sell to the most proximate markets. A robust theoretical approach to positioning smallholder farmers in value chains would provide a foundation for modern rural-development literature. This work adjusts Antràs and Chor's downstreamness indicator to farming households' selling locations and buyer-market chains. It contributes to the literature by creating a conceptual framework for farmers' market positioning and a replicable setting for assessing the effects of market positioning on both food security and welfare levels.

Using a national, representative household survey in Ethiopia and in Nigeria, the paper explores whether changes in market positioning scores correlate with higher consumption levels. The results demonstrate that farmers who can sell more downstream in the value chain benefit in terms of food consumption and total consumption. Micro-variations in market positioning largely affect rural development. The proposed analysis also shows that the amended indicator à la Antras and Chor performs better than the most viable alternatives in assessing the welfare implications of market positioning. These results are robust for the different specifications of the empirical strategy, and sensitivity testing is provided that confirms this work's research question by using food quantity. In addition, robustness checks confirm the strength of the obtained results.

The result of this work leaves important implications on the functioning degree of local market structures as well as the ability of intermediaries to exploit farmers unable to reach final markets. The proposed market positioning indicator and its empirical testing pave the way to future research in micro-analyses. Given the relevance of market-chain analysis at the micro-level, new and better data will better structure the links between local value chains and GVCs. In particular, although a network roster for inputs acquisition is provided in the currently available datasets, it often presents several missing observations making it difficult for comparison across countries. It would be useful to move from an analysis centered on farmers to data collection of trade flows for all the actors that contribute to the agricultural chain; this will allow to describe the value added that is generated along a farmer's selling line. In this respect, international organizations will likely present additional features related to farmers' market practices in the near future.

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Appendix

A.1 Antràs and Chor's Measurement of Upstreamness and Downstreamness (2018)

Considering a classic WIOT table, a simple measure of GVC positioning is the ratio $\frac{F_i^r}{Y_i^r}$, which is the share of gross output in sector *r* in country *i* that is sold to consumers. This simple measure does not capture variation in the upstreamness of country-industry pairs beyond the extent to which their output is directly for final consumption.

To move beyond this simple measure, one needs to consider also intermediate output. In particular, if one defines the dollar amount of sector *r*'s output from country *i* needed to produce one dollar's worth of industry *s*'s output in country j as $a_{ij}^{rs} = \frac{Z_{ij}^{rs}}{Y_j^s}$, gross output Y_i^r can be conceived as

$$Y_i^r = \sum_{s=1}^{S} \sum_{j=1}^{J} a_{ij}^{rs} Y_j^s + F_i^r, \qquad \text{[A.1.1]}$$

that iterating becomes:

$$Y_i^r = F_i^r + \sum_{s=1}^{S} \sum_{j=1}^{J} a_{ij}^{rs} F_j^s + \sum_{s=1}^{S} \sum_{j=1}^{J} \sum_{t=1}^{S} \sum_{k=1}^{J} a_{ij}^{rs} a_{jk}^{st} F_k^t + \cdots. \qquad \text{[A.1.2]}$$

Building on this, Antràs and Chor (2013) suggest computing the (weighted) average position of a country-industry's output in GVCs by multiplying each of the terms by its respective production-staging distance from final use plus one and dividing by Y_i^r:

$$U_i^r = 1 \times \frac{F_i^r}{Y_i^r} + 2 \times \frac{\sum_{s=1}^{S} \sum_{j=1}^{J} a_{ij}^{rs} F_j^s}{Y_i^r} + 3 \times \frac{\sum_{s=1}^{S} \sum_{j=1}^{J} \sum_{t=1}^{S} \sum_{k=1}^{J} a_{ij}^{rs} a_{jk}^{st} F_k^t}{Y_i^r} + \cdots. \qquad \text{[A.1.3]}$$

It is clear that $U_i^r \geq 1$, and larger values are associated with relatively higher levels of upstreamness of the output originating from sector *r* in country *i*.

In 2012, Fally proposed a measure of upstreamness (or "distance from final use") based on the theory that industries selling a disproportionate share of their output to relatively upstream industries should be relatively upstream in the chain. In particular, he argues that

$$\widetilde{U}_i^r = 1 + \sum_{s=1}^{S} \sum_{j=1}^{J} b_{ij}^{rs} \widetilde{U}_j^s, \qquad \text{[A.1.4]}$$

where $b_{ij}^{rs} = \frac{Z_{ij}^{rs}}{Y_i^r} = a_{ij}^{rs} \frac{Y_j^s}{Y_i^r}$ is the share of total output of sector *r* in country *i* that is purchased by industry s in country *j*.

If the same procedure is replicated for measuring downstreamness while embedding the share of sector *r*'s output in country *i* that is used in industry s in country *j* with $b_{ij}^{rw} = \frac{Z_{ij}^{rs}}{Y_i^r}$, it may be shown that

$$Y_j^s = \sum_{s=1}^{S} \sum_{j=1}^{J} b_{ij}^{rs} Y_j^r + VA_i^s, \qquad [A.1.5]$$

that iterating becomes:

$$Y_j^s = VA_i^s + \sum_{s=1}^{S} \sum_{j=1}^{J} b_{ij}^{rs} VA_j^r + \sum_{s=1}^{S} \sum_{j=1}^{J} \sum_{t=1}^{S} \sum_{k=1}^{J} b_{ki}^{tr} b_{ij}^{rs} VA_k^t + \cdots. \qquad [A.1.6]$$

Building on Antràs and Chor (2013), Miller and Temurshoev (2017) propose that downstreamness ($D_j^s \geq 1$) is equal to Equation [A.1.6] multiplying each factor with the production stage order and dividing by Y_j^s, i.e.,

$$D_j^s = 1 \times \frac{VA_j^s}{Y_j^s} + 2 \times \frac{\sum_{s=1}^{S} \sum_{j=1}^{J} b_{ij}^{rs} VA_i^r}{Y_j^s} + 3 \times \frac{\sum_{s=1}^{S} \sum_{j=1}^{J} \sum_{t=1}^{S} \sum_{k=1}^{J} b_{ki}^{tr} b_{ij}^{rs} VA_k^t}{Y_j^s} + \cdots. \qquad [A.1.7]$$

As in the case of upstreamness, Fally suggests that

$$\widetilde{D}_j^s = 1 + \sum_{s=1}^{S} \sum_{j=1}^{J} a_{ij}^{rs} \widetilde{D}_i^r; \qquad [A.1.8]$$

where $a_{ij}^{rs} = \frac{z_{ij}^{rs}}{Y_i^r} = b_{ij}^{rs} \frac{Y_j^s}{Y_i^r}$. Fally's equation and Miller and Temurshoev's equation are mathematically equivalent.

A.2 Antràs and Chor's GVC Structuring (2013)

In 2013, Antràs and Chor developed a model of business behavior based on that outlined by Acemoglu et al. (2007). The model was extended, incorporating a deterministic sequencing of production stages. In their benchmark model, the authors tackle the organizational problem of a business creating a final product.

<u>Assumptions</u>

1. *Production is sequential.*

   Under this first assumption, the quality-adjusted volume of final goods production is equal to

   $$q = \theta \left(\int_0^1 x(j)^\alpha I(j) dj \right)^{1/\alpha} \quad ; \qquad \text{[A.2.1]}$$

   where θ is a productivity parameter, $\alpha \in (0,1)$ is a degree-of-substitutability marker, and $I(j)$ is an indicator function equal to 1 if input j is produced after all inputs have been produced or 0 otherwise.

   The marginal increase in output $q'(m)$ contributed by the supplier at stage m is equal to a Cobb-Douglas function, as follows:

   $$q'(m) = \frac{1}{\alpha} \theta^\alpha x(m)^\alpha q(m)^{1-\alpha} I(m); \qquad \text{[A.2.2]}$$

   where $x(m)$ represents the supplier's compatible input production, $q(m)$ is the volume of production generated up to that stage, and $I(m)$ makes the production technology inherently sequential (i.e., downstream stages are useless without the inputs from upstream stages).

2. *There are suppliers engaged in input production.*

   Each intermediate input is produced by a different supplier with whom the firm needs to contract.

3. *Consumers have preferences regarding the final good.*

   Consumers' preferences feature a constant elasticity of substitution across the varieties of goods. In particular, the firm's revenue function is concave in quality-adjusted output with constant elasticity ρ. The revenues obtained by the final-good production are equal to

$$r = A^{1-\rho}\theta^{\rho}\left(\int_0^1 x(j)^{\alpha} I(j)dj\right)^{\rho/\alpha};$$ [A.2.3]

where A > 0 is an exogenous, industry-wide demand-shifter and $\rho \in (0,1)$ is a constant elasticity (i.e., price elasticity is constant and equal to $1/(1-\rho)$).

4. *Contracts are incomplete.*

   The supplier at stage m is paid only after the input has been produced and the firm has inspected it. This negotiation is assumed to be independent from all other negotiations taking place at other stages. The intermediate input is assumed to be compatible only with the firm's output, so the supplier has no outside options. As a result, $I(j) = 1$ for all $j < m$, and the value of final-goods production at stage *m* is equal to the following:

$$r(m) = A^{1-\rho}\theta^{\rho}\left[\int_0^m x(j)^{\alpha}dj\right]^{\rho/\alpha}.$$ [A.2.4]

   Hence, the incremental contribution of the supplier at stage m is given by the application of Leibniz's integral rule to Equation [4]:

$$r'(m) = \frac{\partial r(m)}{\partial m} = \frac{\rho}{\alpha}\left(A^{1-\rho}\theta^{\rho}\right)^{\frac{\alpha}{\rho}} r(m)^{\frac{\rho-\alpha}{\rho}} x(m)^{\alpha}.$$ [A.2.5]

   The authors assume that the firm obtains a share $\beta(m)$ equal to β_v of this incremental contribution when the suppliers are integrated and $\beta_0 < \beta_v$ when the supplier is a stand-alone entity (i.e., production is outsourced).

In conclusion, under Antràs and Chor (2013)'s assumptions, the firms and the supplier play the following game:

- at each stage j of the production process, the firm posts a contract for a supplier;
- suppliers apply for the contract and only one is selected by the firm;
- production takes place sequentially; and
- the final product is realized once all stages are completed.

<u>Equilibrium</u>

The game-perfect equilibrium is given by subgame resolution at each level.

1. *Supplier's Investment in Stage* m

At stage m, the supplier receives $1 - \beta(m)$ shares of $r'(m)$ and chooses an investment level $x(m)$ to maximize profits, as follows:

$$max\pi_S(m) = \left(1 - \beta(m)\right)\frac{\rho}{\alpha}(A^{1-\rho}\theta^{\rho})^{\frac{\alpha}{\rho}}r(m)^{\frac{\rho-\alpha}{\rho}}x(m)^{\alpha} - cx(m), \quad \text{[A.2.6]}$$

leading to

$$x(m) = [(1 - \beta(m)) - \frac{\rho\left(A^{1-\rho}\theta^{\rho}\right)^{\alpha/\rho}}{c}]^{\frac{1}{1-\alpha}}r(m)^{\frac{\rho-\alpha}{\rho(1-\alpha)}}. \quad \text{[A.2.7]}$$

Hence, the investment made by the supplier at stage m increases with demand level A, firm productivity θ, and the supplier's bargaining share $1 - \beta(m)$. It decreases with a higher investment marginal cost c. If $\rho > \alpha$, investment choices are sequential complements; in the opposite situation, investment choices are sequential substitutes.

2. *Suppliers' Investments Along the Value Chain*

To obtain the equilibrium investment levels of all suppliers along the value chain, first, Equation $[A.2.7]$ must be entered into Equation $[A.2.5]$, obtaining

$$r'(m) = \frac{\rho}{\alpha}\left(\frac{\left(1-\beta(m)\right)\rho\theta}{c}\right)^{\frac{\alpha}{1-\alpha}}A^{\frac{1-\rho}{\rho(1-\alpha)}}r(m)^{\frac{\rho-\alpha}{\rho(1-\alpha)}} \quad \text{[A.2.8]}$$

whose differential equation, separable in $r(m)$ and $\beta(m)$, is

$$r(m) = A\left(\frac{1-\rho}{1-\alpha}\right)^{\rho(1-\alpha)/(\alpha(1-\rho))}\left(\frac{\rho\theta}{c}\right)^{\rho/(1-\rho)} \times \left[\int_0^m \left(1-\beta(m)\right)^{\alpha/(1-\alpha)}dj\right]^{\rho(1-\alpha)/(\alpha(1-\rho))} \quad \text{[A.2.9]}$$

Second, the resulting equation is entered into Equation $[A.2.7]$, yielding

$$x(m) = A\left(\frac{1-\rho}{1-\alpha}\right)^{(\rho-\alpha)/(\alpha(1-\rho))}\left(\frac{\rho}{c}\right)^{1/(1-\rho)}\theta^{\rho/(1-\rho)}\left(1-\beta(m)\right)^{1/(1-\alpha)} \times \left[\int_0^m \left(1-\beta(m)\right)^{\alpha/(1-\alpha)}dj\right]^{(\rho-\alpha)/(\alpha(1-\rho))} \quad \text{[A.2.10]}$$

3. *Optimal Organizational Structure*

A firm maximizes its profits by maximizing revenues from final sales (i.e., $\pi_F = \int_0^1 \beta(j)r'(j)dj$). Substituting π_F into the expressions from $[A.2.8]$ and $[A.2.9]$ produces the following:

$$\pi_F = \frac{\rho}{\alpha} A \left(\frac{1-\rho}{1-\alpha}\right)^{(\rho-\alpha)/(\alpha(1-\rho))} \left(\frac{\rho}{c}\right)^{1/(1-\rho)} \int_0^1 \beta(j)\left(1-\beta(m)\right)^{\alpha/(1-\alpha)} \times \left[\int_0^j \left(1-\beta(k)\right)^{\alpha/(1-\alpha)} dk\right]^{(\rho-\alpha)/(\alpha(1-\rho))} dj \qquad \text{[A.2.11]}$$

To determine if integration or outsourcing is optimal at a given stage, it is necessary to consider the real-value functions $v(j) \equiv \int_0^j \left(1-\beta(k)\right)^{\alpha/(1-\alpha)} dk$ $[A.2.12]$ from which the firm chooses its share of the supplier's incremental contribution $\beta(m)$. To derive the function $\beta(m)$, the firm maximizes the function

$$\pi_F(v) = \kappa \int_0^1 (1 - v'(j))^{(1-\alpha)/\alpha} v'(j) v(j)^{(\rho-\alpha)/(\alpha(1-\rho))} dj \qquad \text{[A.2.13]}$$

where κ is a positive constant. The profit-maximizing function v must satisfy the Euler-Lagrange condition that, as specified in Equation $[A.2.13]$, is given by

$$v^{(\rho-\alpha)/(\alpha(1-\rho))}(v')^{(1-\alpha)/\alpha-1}\left[v' + \frac{\rho-\alpha}{1-\rho}\frac{(v')^2}{v}\right] = 0 \qquad \text{[A.2.14]}$$

Imposing the initial condition $v(0) = 0$ and the transversality condition $v'(j)^{(1-\alpha)/\alpha} = \alpha$ and using Equation $[12]$, reveals that the optimal division of surplus at stage m is given by $\beta^*(m) = 1 - am^{(\alpha-\rho)/\alpha}$ $[A.2.15]$.

The following propositions result:

PROPOSITION 1: The optimal bargaining share $\beta^*(m)$ *is an increasing function of* m *in the case of complements and a decreasing function in the case of substitutes.*

PROPOSITION 2: In the complements case, there exists a unique m_c^* *such that all production stages are outsourced* $m \in [0, m_c^*)$ *and all stages* $m \in [m_c^*, 1]$ *are integrated within the firm's boundaries. The same applies to substitutes.*

PROPOSITION 3: Whenever integration and outsourcing are both present, a decrease in ρ *will expand the range of stages that are vertically integrated.*

In their benchmark model, Antràs and Chor (2013) consider both production and bargaining as sequential. However, in their supplementary materials, the authors discuss two extensions of their main paper.

1. *A Spider with Snake Legs*

   When production resembles a spider, the final good entangles a continuum measure 1 of modules or parts indexed by n. These are put together simultaneously by a symmetric technology featuring a constant elasticity of substitution, $\frac{1}{1-\zeta} >= 1$ across the different modules. Each of the modules is produced by a sequential combination of intermediate inputs. Preferences about the final good are still given by Equation $[A.2.2]$, while revenues for the final-good producer are equal to the following:

$$r = A^{1-\rho}\left[\int_0^1 X(n)^{\zeta} dn\right]^{\rho/\zeta} \qquad [A.2.16]$$

where $X(n)$ represents the production technology for each module $n \in [0,1]$ that involves a continuum measure 1 of stages, indexed by j. In particular,

$$X(n) = \theta\left(\int_0^1 x_n(j)^{\alpha}\, I(j) dj\right)^{1/\alpha}; \qquad [A.2.17]$$

which is analogous to Equation $[A.2.1]$ in the benchmark model. A module producer decides which of its module-specific inputs to integrate, as in the case with stages involving the final-good producer in the main model. Assumptions for contract and bargaining between each module producer and the module-specific suppliers are the same as in the benchmark model. However, the revenue captured by the module producer n are determined by the share of final-good revenue $[A.2.16]$, not demand. Given the final-good revenue $[A.2.16]$, the authors derive that the payoff for each module producer is given by

$$r_n = \left(\frac{\rho}{\rho+\zeta}\right) A^{1-\rho} X(n)^{\zeta} X(-n)^{\rho-\zeta}; \qquad [A.2.18]$$

where $X(-n)$ is the symmetric level of module services of all modules other than $n.$ In equilibrium, $X(n) = X(-n)$, and each module producer ends up with a share $\frac{\rho}{\rho+\zeta}$ of final goods revenue. Unlike in the benchmark model, the concavity of the revenue is determined by the degree of substitution across module ζ rather than by the elasticity of demand α for the final good (similar to ρ in the main model). In conclusion, if $\zeta > \alpha$, then module inputs are sequential complements; otherwise, they are substitutes.

2. *A Snake with Spider Legs*

Conversely, there may be a snake-like sequential production structure with each stage input j composed of a unit-measure of distinct components produced simultaneously by different suppliers. The firm bargains with a continuum of suppliers at each stage m rather than with only one supplier. The payoff for a supplier n in stage m is given by

$$P_{Sm}(n) = (1-\beta(m))\frac{\rho}{\alpha}(A^{1-\rho}\theta^{\rho})^{\alpha/\rho}r(m)^{(\rho-\alpha)/\rho}x_m(n)^{\xi}x_m(-n)^{\alpha-\xi}; \quad [A.2.19]$$

where $x(-n)$ is the symmetric investment level chosen by all suppliers other than n. Equation $[A.2.19]$ is analogous to Equation $[A.2.6]$, except that the concavity of the payoff is led by ξ rather than α. Thus, regardless of the value of ξ, the incentive to integrate decreases or increases along the value chain depending on the relative magnitudes of ρ and α.

A.3. Figures and Tables

Table A.3.1: Variable Definitions and Other Basic Information

Variable name	**Definition**	**Time period**	**Source**
Gender of the Household Head	Gender of the household head *(binary, 1=female)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Age of the Household Head *(decimals)*	Age years of the household head *(decimals)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Number of Household Members in the Labor Force *(decimals)*	Number of household members (*binary, 1=female)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Household Size *(decimals)*	Number of people in the household *(decimals)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Average Years of Education for Household Adults *(decimals, years of schooling)*	Average education level attained by the household adult members *(values from 0 to 8)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Average Years of Education for Household Head *(decimals, years of schooling)*	Average education level attained by the household head *(values from 0 to 8)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Number of Household Infants *(decimals)*	Number of household members in the infant age range *(decimals)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Number of Household Children *(decimals)*	Number of household members in the children age range *(decimals)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Household Years of Education *(decimals, years of schooling)*	Average education level attained by all household members *(values from 0 to 8)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Harvest Crop *(decimals, Kg)*	Quantity of crop harvest in the surveying period *(decimals, Kg)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Field Size *(decimals, Ha)*	Average field size in the surveying period *(decimals, Ha)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Free Seed	Event of receiving free seed ***(binary, 1=no and 2=yes)***	2011-2015	World Bank LSMS-ISA Ethiopia only
Seed Purchase	Necessity of purchasing seed ***(binary, 1=no and 2=yes)***	2011-2015	World Bank LSMS-ISA Ethiopia only
Fertilizer Use	Use of fertilizers ***(binary, 1=no and 2=yes)***	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Fertilizer Purchase	Purchase of fertilizers ***(binary, 0=no and 1=yes)***	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Leftover Fertilizer	Presence of leftover fertilizers ***(binary, 0=no and 1=yes)***	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Free Fertilizer	Event of receiving free fertilizers ***(binary, 0=no and 1=yes)***	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria

Table A.3.2: Households Summary Statistics for Ethiopia

	N. of observations	Mean	Standard Deviation	Minimum Value	Maximum Value
Gender of the Household Head ***(binary, 1=female)***	1,460	0.18	0.39	0	1
Age of the Household Head ***(decimals)***	1,460	45.72	14.21	18	97
Number of Household Members in the Labor Force ***(decimals)***	1,460	2.69	1.38	0	10
Household Size ***(decimals)***	1,460	5.77	2.19	1	14
Average Years of Education for Household Adults ***(decimals, years of schooling)***	1,460	1.70	1.83	0	8
Number of Household Infants ***(decimals)***	1,460	0.58	0.80	0	5
Number of Household Children ***(decimals)***	1,460	2.39	1.68	0	10
Household Years of Education ***(decimals, years of schooling)***	1,460	1.70	1.83	0	8
Harvest Crop ***(decimals, Kg)***	1,460	914.13	752.98	0	3,249.61
Field Size ***(decimals, m^2)***	1,460	9,030.31	9,370.73	0	38,917.46
Free Seed ***(binary, 2=yes)***	1,459	1.99	0.12	1	2
Seed Purchase ***(binary, 2=yes)***	1,462	1.94	0.24	1	2
Fertilizer Use ***(binary, 2=yes)***	1,462	1.81	0.40	1	2

Table A.3.3: Households Summary Statistics for Nigeria

	N. of observations	Mean	Standard Deviation	Minimum Value	Maximum Value
Gender of the Household Head ***(binary, 1=female)***	1,178	0.20	0.40	0	1
Number of Household Members in the Labor Force ***(decimals)***	1,178	2.48	2.13	0	13
Household Size ***(decimals)***	1,178	6.41	3.27	1	28
Number of Household Infants ***(decimals)***	1,178	0.55	0.92	0	6
Number of Household Children ***(decimals)***	1,178	1.90	2.22	0	14
Fertilizer Purchase ***(binary, 1=yes))***	1,178	0.33	0.47	0	1
Letfover Fertilizer ***(binary, 1=yes)***	1,178	0.03	0.17	0	1
Free Fertilizer ***(binary, 1=yes)***	1,178	0.01	0.10	0	1
Fertilizer Use ***(binary, 1=organic)***	1,178	1.69	0.46	1	2

Table A.3.4: Downstreamness Indicators Comparison by Quintile for Ethiopia

	Food Consumption					Total Consumption				
	Adjusted Down.	Down. À la Ant. & Ch.	(ln) Crop Share	Distance to Market	Down. as Dummy	Adjusted Down.	Down. À la Ant. & Ch.	(ln) Crop Share	Distance to Market	Down. as Dummy
Up to 1st Q.										
Positioning	-232.9***	-25.91***	-1.277***	-0.721***	-5.424***	-51.15***	-5.142***	-0.0388***	81.58***	0.101***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0. 000)	(0.000)	(0.000)	(0.000)
Observations	292	292	292	289	292	289	289	289	284	289
R-sq. Adj.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
AIC	-	-	-	-	-	-	-	-	-	-
BIC	-	-	-	-	-	-	-	-	-	-
Up to 2nd Q.										
Positioning	9.724***	1.349***	0.0522***	-5.119***	-0.0715***	42.40***	5.958***	0.147***	-6.207***	-0.370***
	(0.000)	(0.000)	(0.000)	(1.008)	(0.000)	(0.000)	(0. 000)	(0.000)	(1.128)	(0.000)
Observations	570	570	570	564	570	578	578	578	573	578
R-sq. Adj.	1.00	1.00	1.00	0.995	1.00	1.00	1.00	1.00	0.998	1.00
AIC	-	-	-	-3416.40	-	-	-	-	-4156.29	-
BIC	-	-	-	-3329.70	-	-	-	-	-4051.87	-
Up to 3rd Q.										
Positioning	55.40**	6.617***	0.233***	0.579	0.000652	76.13***	5.932***	0.127**	-0.553	0.224*
	(23.89)	(2.024)	(0.0698)	(1.576)	(0.137)	(13.70)	(1.535)	(0.0535)	(1.373)	(0.099)
Observations	855	855	8.55	849	855	864	864	864	859	864
R-sq. Adj.	0.938	0.941	0.942	0.910	0.932	0.960	0.956	0.948	0.926	0.945
AIC	-2854.72	-2893.27	-2915.32	-2509.49	-2776.86	-3473.32	-3374.20	-3237.60	-2909.87	-3197.50
BIC	-2645.67	-2668.97	-2701.524	-2310.23	-2563.06	-3263.81	-3164.69	-3028.09	-2714.89	-2987.99
Up to 4th Q.										
Positioning	28.05+	2.641+	0.103	1.694	-0.0403	25.07+	2.297+	0.102*	0.926	-0.0395
	(19.07)	(1.714)	(0.0771)	(1.539)	(0.137)	(15.32)	(1.435)	(0.0554)	(1.579)	(0.110)
Observations	1,131	1,131	1,131	1,125	1,131	1,144	1,144	1,144	1,138	1,144
R-sq. Adj.	0.838	0.839	0.837	0.787	0.834	0.868	0.869	0.868	0.833	0.864
AIC	-2412.49	-2415.12	-2403.59	-2106.72	-2380.28	-2783.76	-2787.40	-2779.93	-2522.46	-2745.19
BIC	-1924.50	-1922.12	-1910.57	-1664.47	-1892.29	-2234.16	-2237.79	-2230.32	-2023.79	-2195.58
Up to 5th Q.										
Positioning	42.01***	3.569***	0.104*	-0.196	0.0567	35.96***	3.053***	0.0782+	-0.0554	0.0410
	(12.91)	(1.226)	(0.0619)	(1.638)	(0.100)	(11.01)	(1.044)	(0.0528)	(1.442)	(0.0862)
Observations	1,387	1,387	1,387	1,381	1,387	1,387	1,387	1,387	1,381	1,387
R-sq. Adj.	0.718	0.716	0.708	0.643	0.704	0.727	0.759	0.717	0.687	0.749
AIC	-1316.97	-1306.11	-1266.77	-1013.52	-1251.08	-1697.19	-1686.64	-1644.86	-1371.93	-1633.08
BIC	-615.49	-604.63	-565.29	-375.39	-549.61	-995.71	-985.16	-943.38	-733.80	-931.60

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1.
All estimates with a number of decimals above 6 are rounded to the third decimal unit.
Regression controls and intercepts are not reported.

Table A.3.5: Downstreamness Indicators Comparison by Main Crop for Ethiopia

	Food Consumption					Total Consumption				
	Adjusted Down.	**Down. À la Ant. & Ch.**	**(ln) Crop Share**	**Distance to Market**	**Down. as Dummy**	**Adjusted Down.**	**Down. À la Ant. & Ch.**	**(ln) Crop Share**	**Distance to Market**	**Down. as Dummy**
Teff										
Positioning	*-60.14*	*-3.362*	*-0.178*	*310.5****	*-1.550****	*-98.18***	*-7.674**	*-0.305***	*324.9****	*-1.412****
	(47.69)	*(4.590)*	*(0.167)*	*(67.03)*	*(0.0263)*	*(39.42)*	*(3.948)*	*(0.136)*	*(49.59)*	*(0.0325)*
Observations	368	368	368	366	368	368	368	368	366	368
R-sq. Adj.	0.947	0.944	0.946	0.970	1.00	0.953	0.954	0.951	0.981	0.999
AIC	-1114.85	-1095.84	-1109.40	-1333.25	-2874.13	-1245.94	-1204.47	-1233.37	-1534.53	-2611.82
BIC	-1024.97	-1005.95	-1019.52	-1247.91	-2784.24	-1156.05	-1114.59	-1143.48	-1444.77	-2521.93
Maize										
Positioning	*87.95****	*7.722****	*0.102*	*-1.425*	*-0.453*	*49.93****	*4.282****	*0.0561*	*-2.023*	*-0.136*
	(21.30)	*(1.586)*	*(0.165)*	*(3.006)*	*(0.502)*	*(8.154)*	*(0.619)*	*(0.0892)*	*(1.838)*	*(0.282)*
Observations	272	272	272	272	272	272	272	272	272	272
R-sq. Adj.	0.994	0.996	0.990	0.991	0.991	0.998	0.998	0.996	0.997	0.996
AIC	-1471.13	-1506.15	-1301.95	-1297.27	-1293.71	-1818.29	-1842.19	-162.80	-1646.24	-1621.40
BIC	-1413.44	-1448.46	-1244.26	-1239.58	-1236.02	-1760.60	-1784.50	-1572.10	-1588.55	-1563.71
Sorghum										
Positioning	*131.7****	*8.149****	*0.473****	*-68.21*	*3.008****	*225.2****	*13.94****	*0.809****	*-116.6*	*4.305****
	(0.0029)	*(0.0001)*	*(0.000)*	*(.)*	*(0.000)*	*(0.004)*	*(0.0001)*	*(0.000)*	*(.)*	*(0.000)*
Observations	167	167	167	167	167	167	167	167	167	167
R-sq. Adj.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
AIC	-	-	-	-	-	-	-	-	-	-
BIC	-	-	-	-	-	-	-	-	-	-
Wheat										
Positioning	*457.1*	*50.89*	*5.547****	*-420.7****	*-1.742****	456.8	50.86	5.543***	-332.5***	-1.741***
	(.)	*(.)*	*(0.000)*	*(0.744)*	*(.)*	(.)	(.)	(0.000)	(0.643)	(.)
Observations	150	150	150	148	150	150	150	150	148	150
R-sq. Adj.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
AIC	-	-	-	-	-	-	-	-	-	-
BIC	-	-	-	-	-	-	-	-	-	-
Sorghum or Wheat										
Positioning	*8.936*	*-0.0532*	*-0.150**	*-97.12****	*-0.208*	*70.32****	*5.2878****	*0.222***	*-114.5****	*-0.132*
	(22.12)	*(1.679)*	*(0.0771)*	*(13.84)*	*(0.192)*	*(15.06)*	*(1.153)*	*(0.0899)*	*(7.745)*	*(0.171)*
Observations	317	317	317	317	317	317	317	317	317	317
R-sq. Adj.	0.981	0.981	0.982	0.994	0.984	0.989	0.987	0.980	0.998	0.981
AIC	-1177.82	-1175.60	-1191.27	-1533.66	-1189.90	-1385.28	-1321.33	-1228.85	-1901.08	-1197.30
BIC	-1076.33	-1074.11	-1089.78	-1439.84	-1088.41	-1283.79	-1219.84	-11127.36	-1807.26	-1095.80

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1.
All estimates with a number of decimals above 6 are rounded to the third decimal unit.
Regression controls and intercepts are not reported.

Table A.3.6: Commercialized Crops Price Elasticity of Demand for Ethiopia

Crop type	Elasticity
Barley	-0.948
Maize	-0.746
Millet	-1.074
Sorghum	-0.656
Teff	-0.888
Wheat	-0.981
Mung Bean	-0.952
Haricot Beans	-0.952
Horse Beans	-0.952
Lentils	-0.952
Field Peas	-0.952
Soya Beans	-0.952
Red Kideny Beans	-0.952
Lineseed	-0.999
Ground Nuts	-0.983
Nueg	-0.999
Rape Seed	-0.999
Sesame	-0.999
Fenugreek	-0.976

Source: Adapted from Tafere et al. (2010).

Table A.3.7: Commercialized Crops Price Elasticity of Demand for Nigeria

Crop type	Elasticity
Barley	-0.948
Maize	-0.44
Plantain	-0.3228
Oil Palm Tree	-0.3228
Melon	0.7017
Okro	-0.3228
Pepper	-0.3228
Cocoyam	-0.3228
Yam	-0.21
Rice	0.14
Beans/Cowpea	-0.7
Guinea Courn/Sorghum	-0.8
Cassava Old	-0.0667
Banana	-0.3858
Ground Nut/Peanuts	-0.535
Soya BeANS	-0.5035
Onion	-0.3228
Pumpkin Seed	-0.3228
Potato	-0.3228
Shelled Maize (Grain)	-0.44
White Yam	-0.21
Water Yam	-0.21
Cocoa	-0.333
Cotton	-0.74
Cashew	0.7017
Kolanut	-0.5035

Source: Adapted from World Bank Group (1982), Akinleye & Rahji (2007), Pan et al (2009), Ashagidigbi (2019), Obayelu et al. (2019), Adeniji (2019).

Figure A.3.1: Ethiopia Household Downstreamness Values - Density by Year

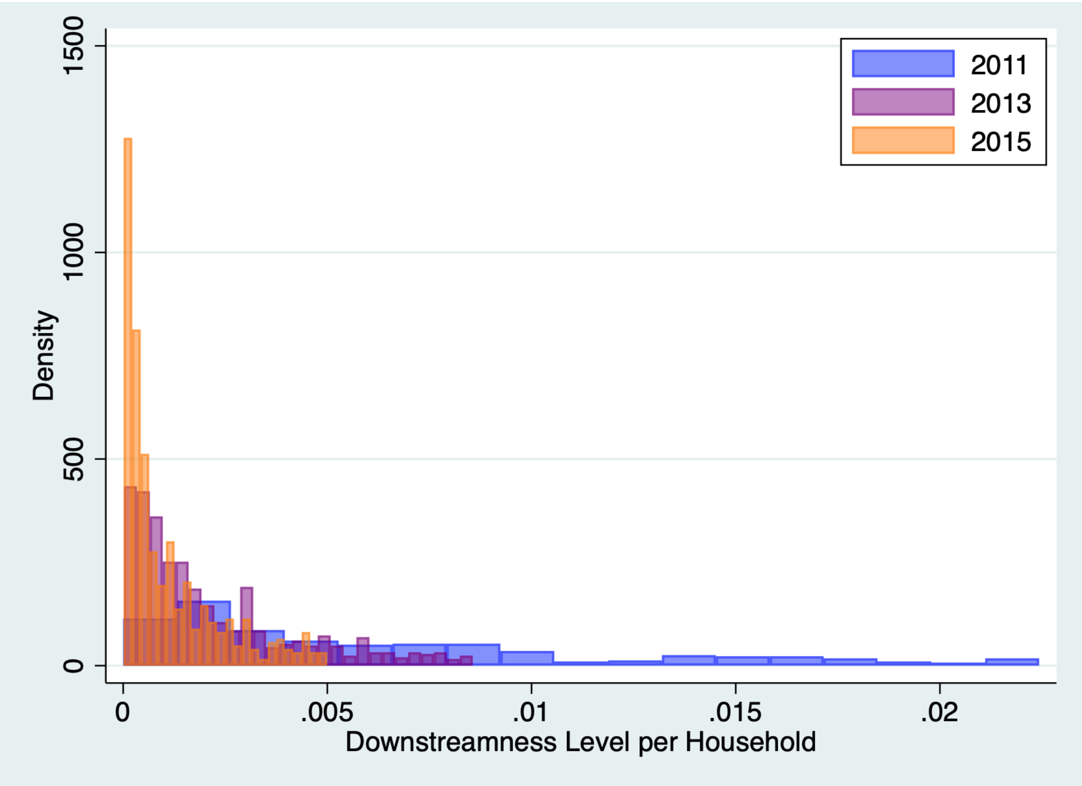


Figure A.3.2: Nigeria Household Downstreamness Values - Density by Year

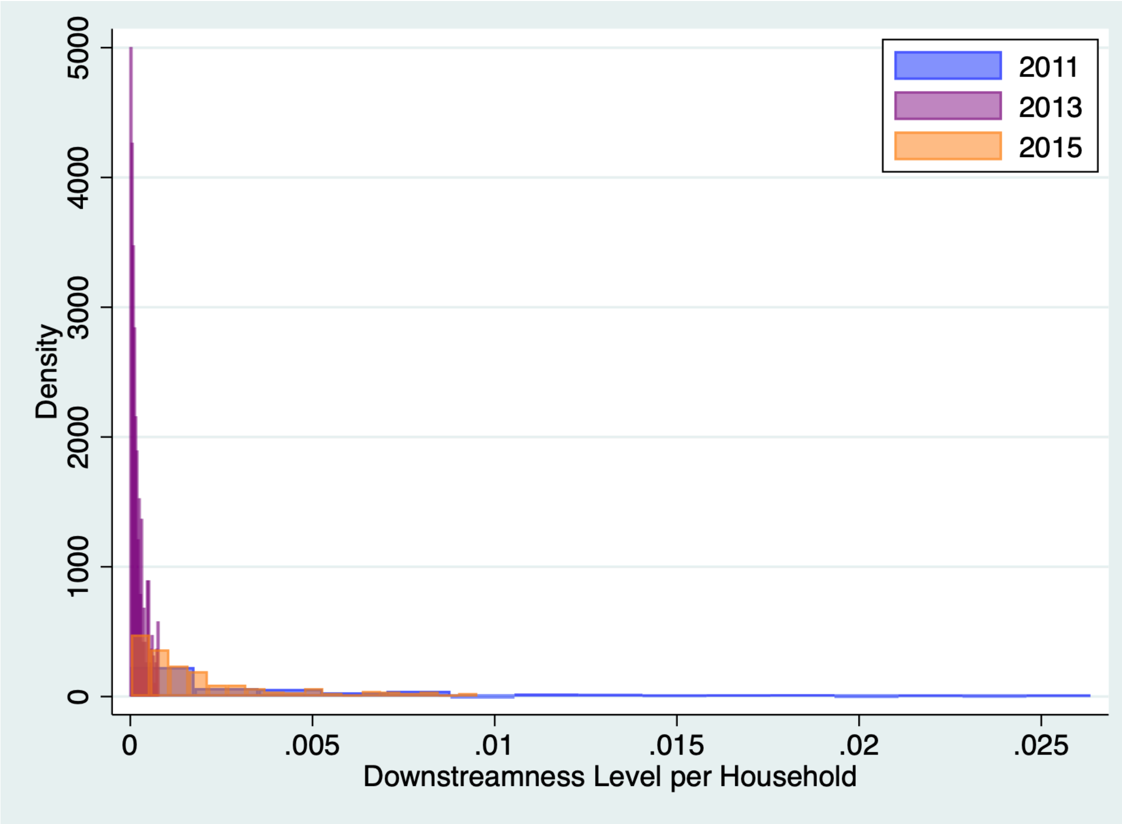


Figure A.3.3: Kernel Density Downstreamness Positioning Indicator Ethiopia 2011

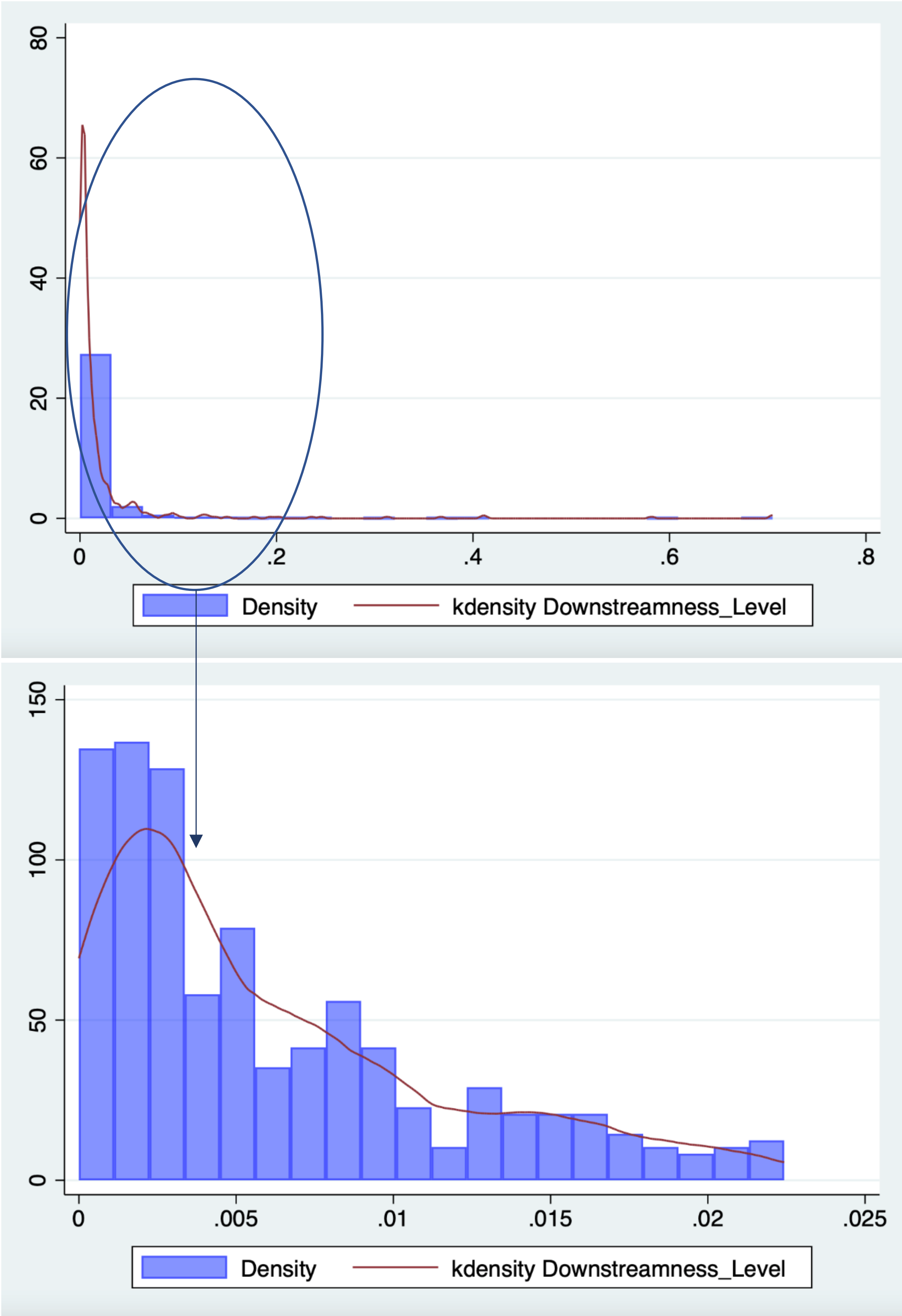


Figure A.3.4: Kernel Density Downstreamness Positioning Indicator Ethiopia 2013

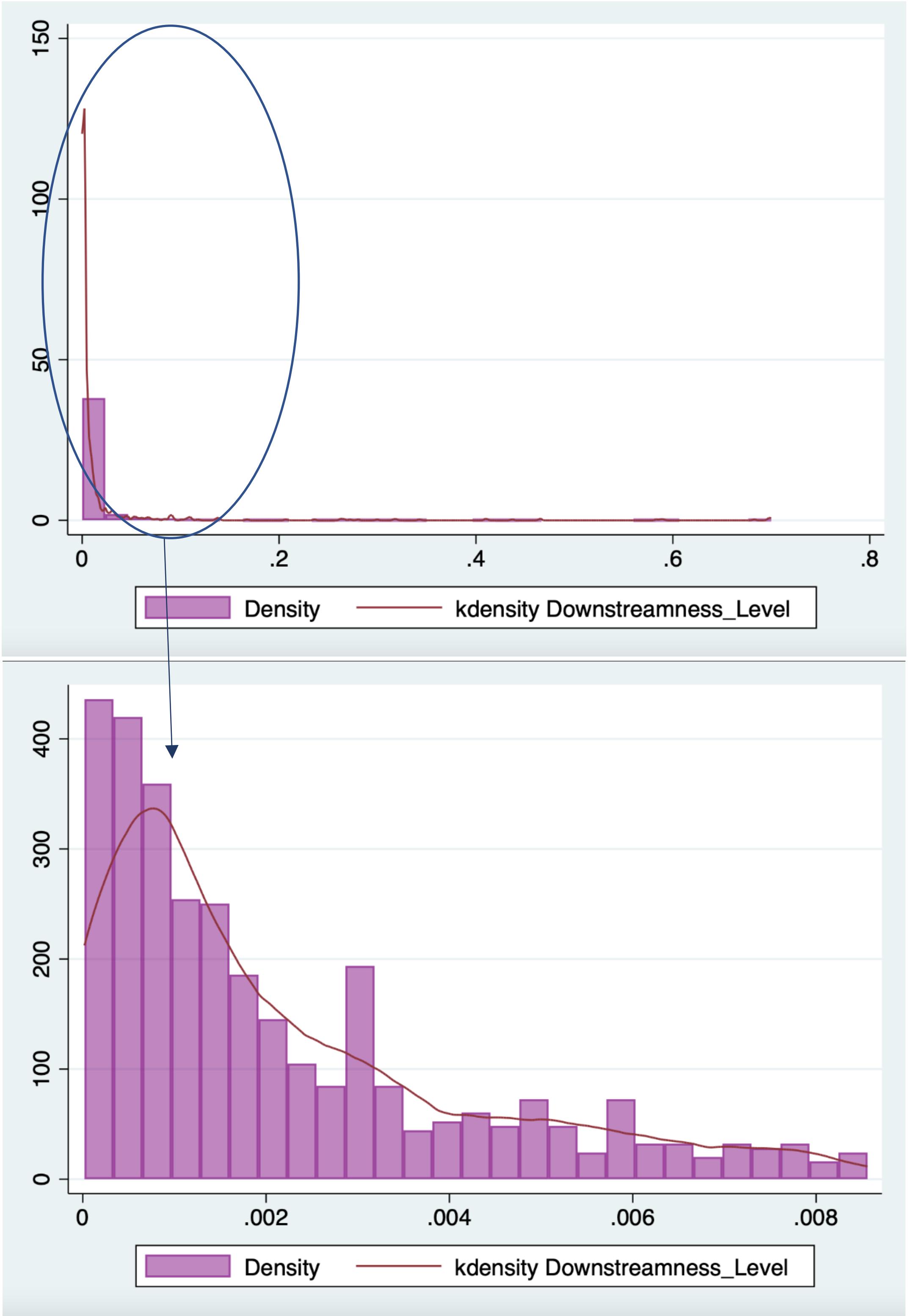


Figure A.3.5: Kernel Density Downstreamness Positioning Indicator Ethiopia 2015

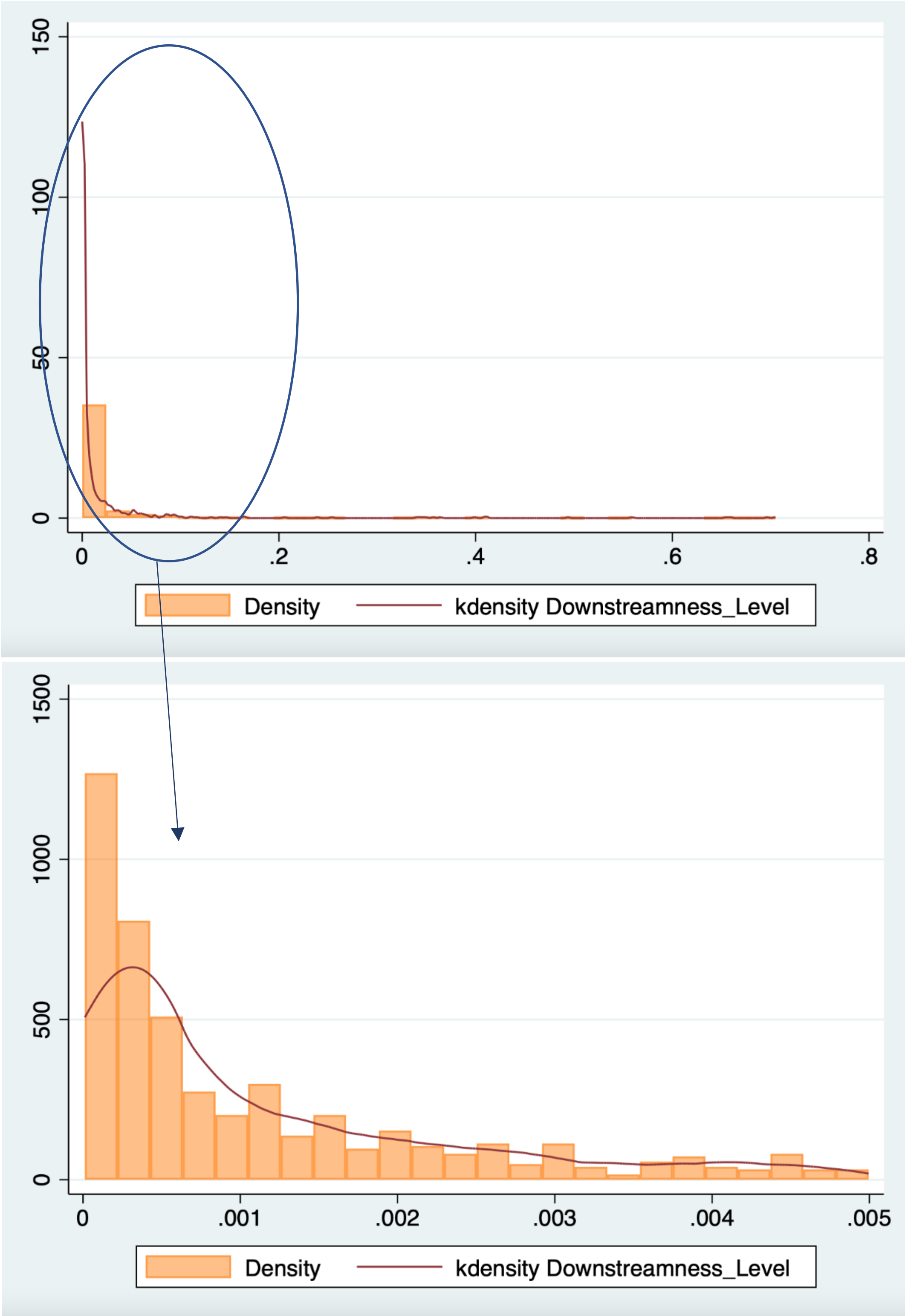


Figure A.3.6: Kernel Density Downstreamness Positioning Indicator Nigeria 2011

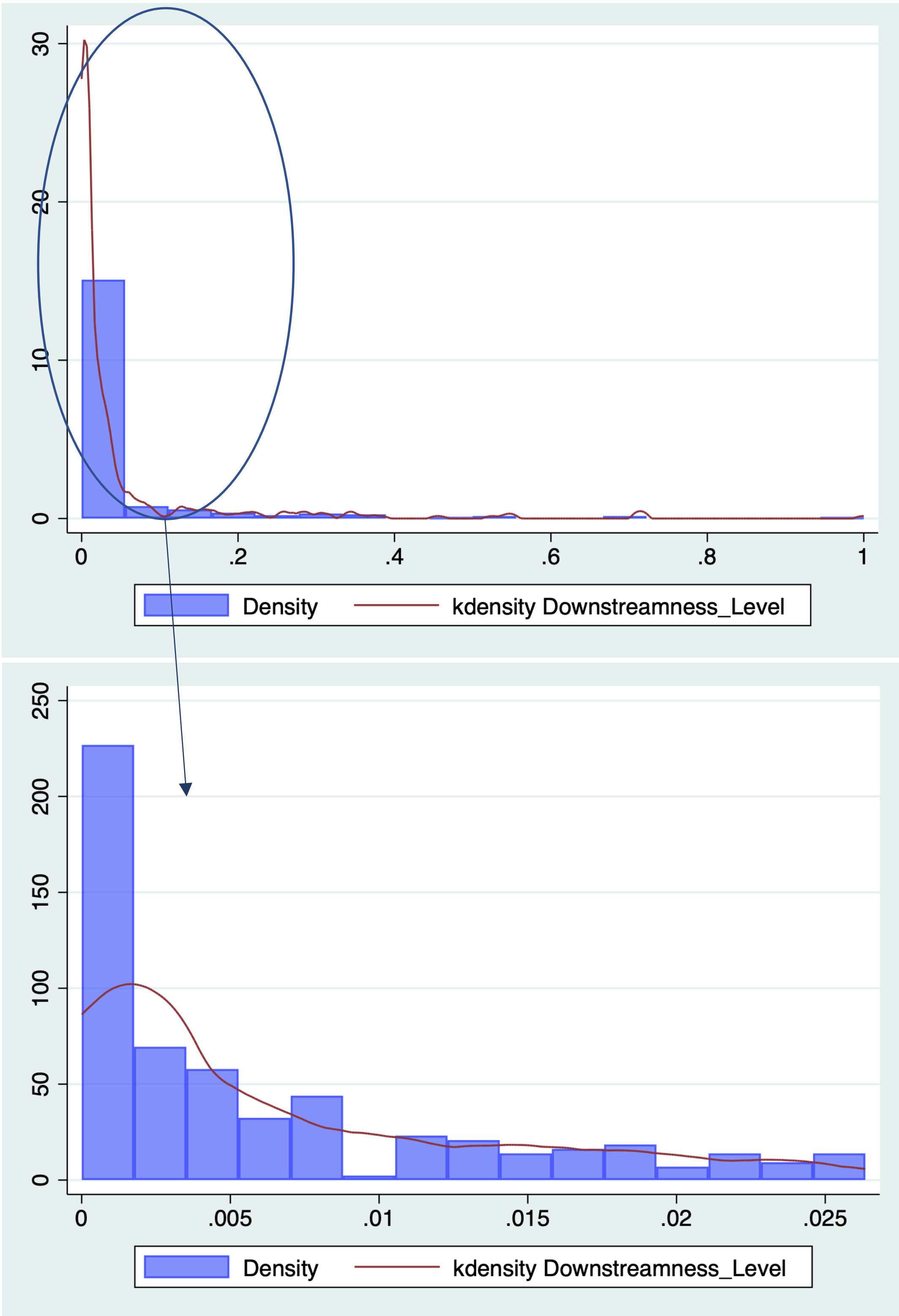


Figure A.3.7: Kernel Density Downstreamness Positioning Indicator Nigeria 2013

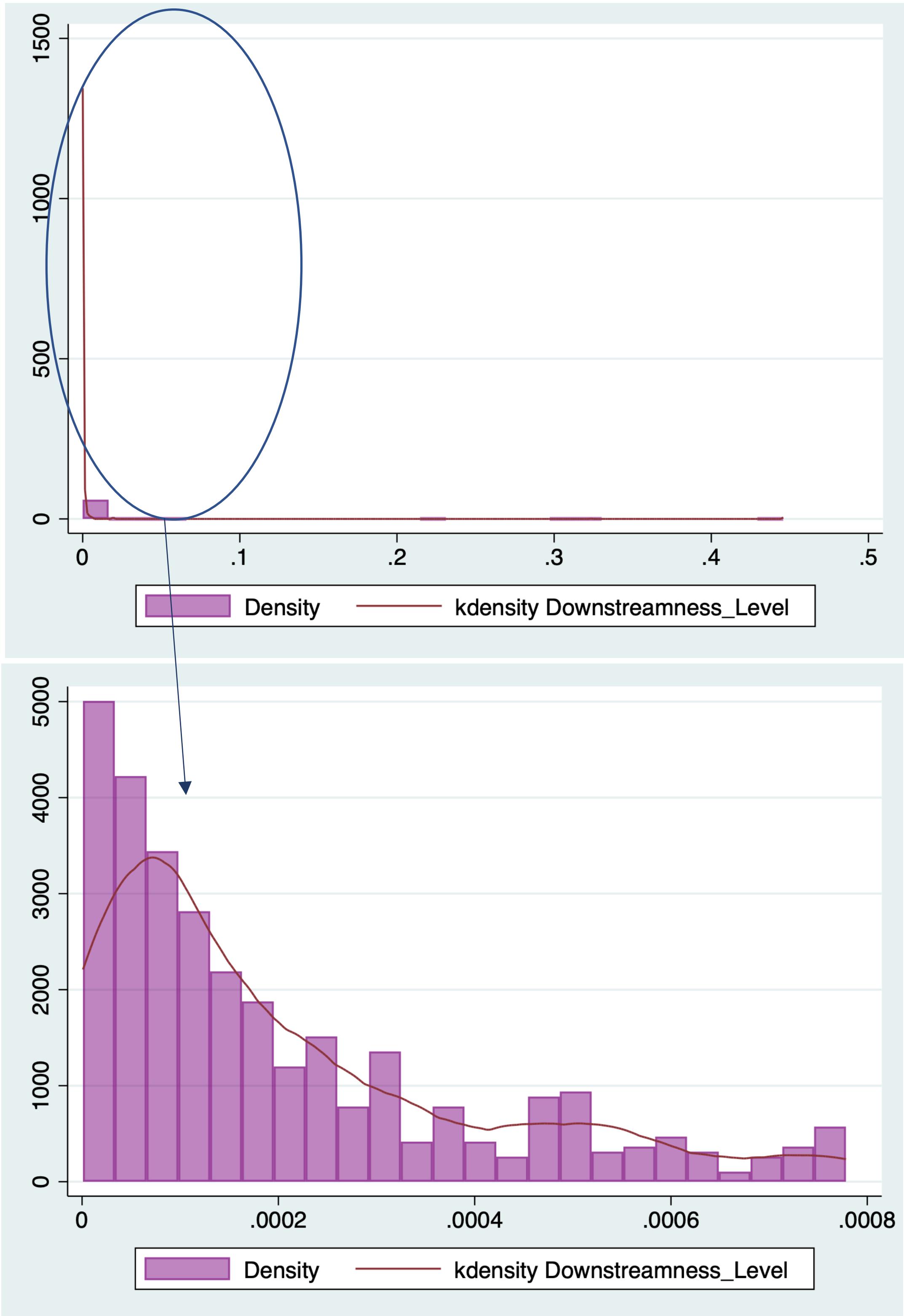


Figure A.3.8: Kernel Density Downstreamness Positioning Indicator Nigeria 2015

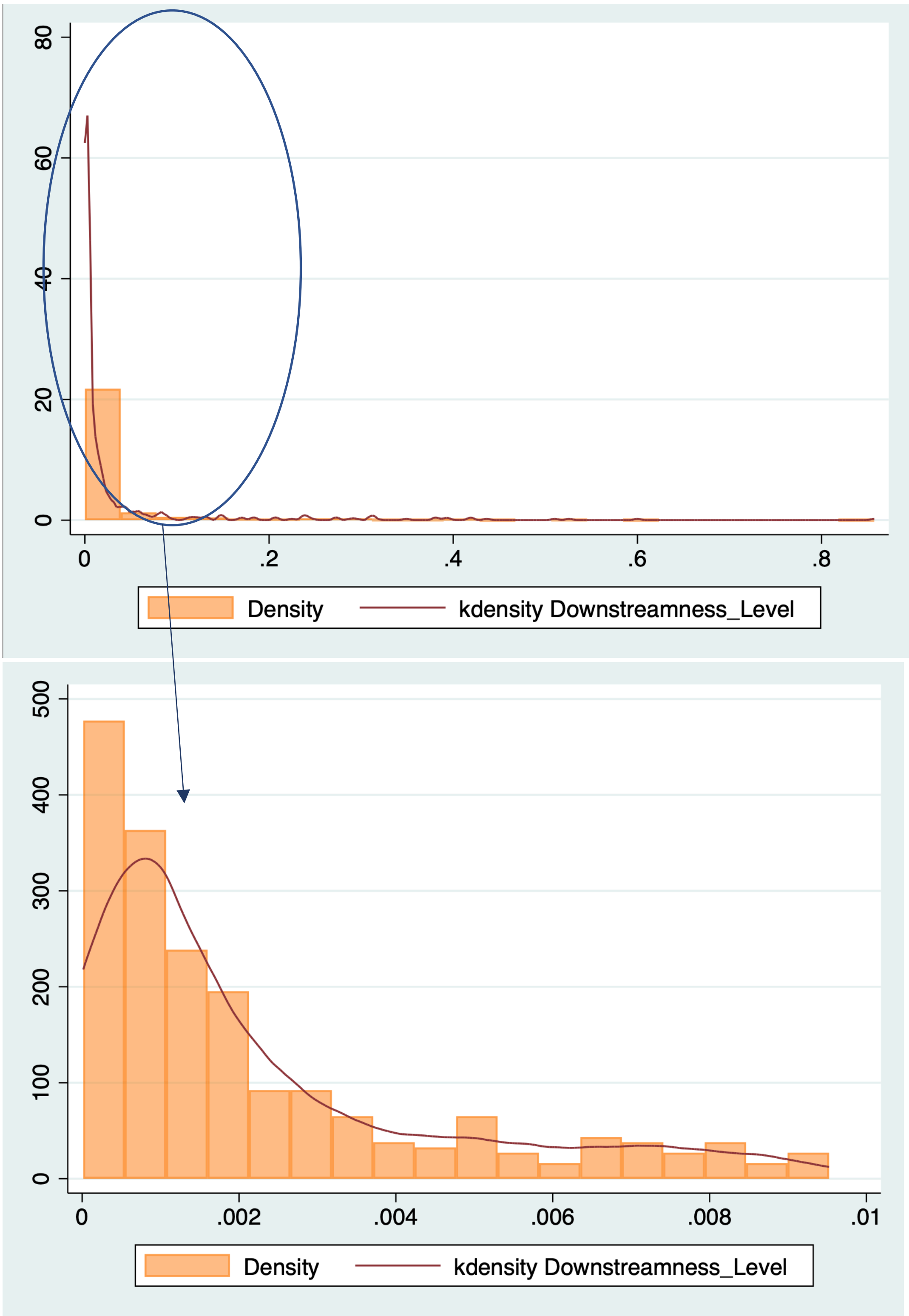


Table A.3.8: Ethiopia Main Results with Consumption per Adult Equivalent

	Food Consumption			Total Consumption		
	Wave Fixed Effects	**District-Wave Fixed Effects**	**Wave Fixed Effect HH Trends**	**Wave Fixed Effects**	**District-Wave Fixed Effects**	**Wave Fixed Effect HH Trends**
Downstreamness	28.10*	38.38***	38.03***	24.23+	31.40***	31.99***
	(15.48)	(12.29)	(12.41)	(14.77)	(10.77)	(10.65)
Female Head	0.190	0.192	0.185	0.0385	0.0836	0.0134
	(0.655)	(0.692)	(0.723)	(0.601)	(0.594)	(0.635)
Age Head	0.0151+	0.0131+	0.0130+	0.0132	0.0121+	0.0121+
	(0.00939)	(0.00895)	(0.00898)	(0.00919)	(0.00806)	(0.00800)
Household Labor	-0.162***	-0.113**	-0.112**	-0.148***	-0.0955*	-0.0917*
	(0.0513)	(0.0540)	(0.0534)	(0.0474)	(0.0494)	(0.0486)
Household Size	0.00290	-0.108*	-0.106*	0.0197	-0.0644	-0.0642
	(0.0648)	(0.0581)	(0.0578)	(0.0627)	(0.0545)	(0.0540)
Education Adults	-0.429**	1.690	1.650	-0.491***	1.793+	1.774+
	(0.195)	(1.276)	(1.289)	(0.176)	(1.092)	(1.101)
N. of Infants	0.149*	0.187***	0.184**	0.133*	0.138**	0.135**
	(0.0806)	(0.0713)	(0.0718)	(0.0719)	(0.0629)	(0.0630)
N. of Child	-0.125**	-0.0935*	-0.0942*	-0.137***	-0.0997**	-0.102**
	(0.0517)	(0.0493)	(0.0499)	(0.0478)	(0.0443)	(0.0448)
Average Education	0.474**	-1.694	-1.656	0.546***	-1.791+	-1.772+
	(0.196)	(1.279)	(1.291)	(0.176)	(1.096)	(1.104)
Harvest Crop	0.00006	0.00008	0.00009	0.00003	0.00007	0.00008+
	(0.00006)	(0.00006)	(0.00006)	(0.00005)	(0.00005)	(0.00005)
Field Size	0.00001	0.000005	0.000005	0.000008	0.000007	0.000006
	(0.000007)	(0.000007)	(0.000007)	(0.000006)	(0.000007)	(0.000007)
Free Seed	-0.673	0.255	0.263	-0.713*	0.00653	0.0291
	(0.424)	(0.400)	(0.405)	(0.396)	(0.376)	(0.382)
Seed Purchase	0.160	0.176	0.187	0.0829	0.0786	0.0822
	(0.142)	(0.174)	(0.175)	(0.120)	(0.154)	(0.155)
Fertilizer Use	-0.0568	-0.167	-0.173	-0.0277	-0.125	-0.142
	(0.103)	(0.135)	(0.138)	(0.0919)	(0.114)	(0.116)
Seed Type Dummy* **Crop Code Dummy***	-	-	-	-	-	-
Year Dummy* Month Dummy*	-	-	-	-	-	-
Region Dummy* Woreda Dummy* Zone Dummy* Town Dummy* Subcity Dummy* Kebele Dummy*		-	-		-	-
HH Trends HH Trends^2			-			-
Constant	7.816***	6.793***	6.844***	8.157***	7.399***	7.463***
	(0.707)	(0.970)	(0.974)	(0.666)	(0.838)	(0.849)
Observations	1,387	1,387	1,387	1,387	1,387	1,387
Number of HH_id	1,097	1,097	1,097	1,097	1,097	1,097
R-squared Adjusted	0.222	0.698	0.698	0.224	0.703	0.704

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1.

Table A.3.9: Sample Bias – Panel FE with the Heckman Correction

	Food Consumption		Total Consumption	
	Heckman	FE	Heckman	FE
	Wave Fixed Effects	Wave Fixed Effects	Wave Fixed Effects	Wave Fixed Effects
Downstreamness	49.91*	29.54**	47.51*	25.86**
	(25.83)	(12.17)	(25.18)	(11.55)
Female Head	0.126	0.187	-0.152	0.0174
	(0.874)	(0.653)	(0.795)	(0.586)
Age Head	0.00647	0.0145*	-0.00179	0.0123+
	(0.0292)	(0.00863)	(0.0270)	(0.00850)
Household Labor	-0.0212	0.0181	0.0221	0.0331
	(0.0981)	(0.0450)	(0.0898)	(0.0417)
Household Size	-0.325***	-0.200***	-0.294***	-0.197***
	(0.110)	(0.0641)	(0.104)	(0.0601)
Education Adults	0.0340	0.0585**	0.0399	0.0630***
	(0.0513)	(0.0275)	(0.0452)	(0.0240)
N. of Infants	0.0892	0.0859	0.0641	0.0792
	(0.149)	(0.0753)	(0.133)	(0.0675)
N. of Child	0.0193	0.00579	0.0229	0.00198
	(0.105)	(0.0472)	(0.0948)	(0.0427)
Harvest Crop	0.00006	0.00007	0.00008	0.00005
	(0.000115)	(0.00005)	(0.000102)	(0.00005)
Field Size	0.00001	0.00001*	0.00001	0.000009+
	(0.00001)	(0.000006)	(0.00001)	(0.00005)
Free Seed	-0.0297	-0.450	-0.112	-0.481
	(0.575)	(0.358)	(0.522)	(0.327)
Seed Purchase	0.232	0.114	0.123	0.0389
	(0.265)	(0.148)	(0.220)	(0.130)
Fertilizer Use	-0.0269	-0.0498	-0.0584	-0.0138
	(0.190)	(0.0955)	(0.173)	(0.0833)
Seed Type Dummy*	-	-	-	0.123
Time FE*		-	-	-
Constant	7.594***	7.786***	7.656***	8.145***
	(0.335)	(0.607)	(0.300)	(0.565)
Observations	1,455	1,387	1,455	1,387
Boostrap Replications	232		232	
Number of HH_id		1,097		1,097
R-squared Adjusted		0.257	0.235	0.250

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1.

Note: Control variables “household average education level” and “crop code” are excluded as their inclusion in the regression models does not allow convergence in the Heckman Fixed Effect computational tools.

Table A.3.10: Summary Statistics Non-Movers vs Movers

		N. of observations		**Mean**		**Standard Deviation**		Minimum Value		Maximum Value	
		M	NM	M	NM	M	NM	M	NM	M	NM
Between Wave 1 and Wave 2	**Gender Hous. Head** ***(binary)***	970	492	0.18	0.19	0.38	0.39	0	0	1	1
	Age Hous. Head ***(decimals)***	970	492	45.32	46.50	14.36	1.89	10	21	97	85
	Hous. Labor Force ***(decimals)***	970	492	2.71	2.64	1.37	1.39	0	0	10	8
	Household Size ***(decimals)***	970	492	5.66	5.98	2.20	2.16	1	1	14	13
	Av. Educ. Adults ***(decimals)***	969	491	1.63	1.85	1.80	1.88	0	0	8	8
	Household Infants ***(decimals)***	970	492	0.54	0.65	0.82	0.79	0	0	4	5
	Hous. Children ***(decimals)***	970	492	2.35	2.48	1.68	1.67	0	0	10	8
	Hous. Education ***(decimals)***	969	492	1.63	1.85	1.79	1.88	0	0	8	8
	Harvest Crop ***(decimals, Kg)***	970	492	817.53	1106.91	718.27	781.06	0	0	3249.61	3230
	Field Size ***(decimals, m^2)***	970	492	9522.82	8066.65	9444.17	9144.86	0	0	38917.5	38050.83
	Free Seed ***(binary, 2=yes)***	967	492	0.98	1.00	0.14	0.06	0	0	1	1
	Seed Purchase ***(binary, 2=yes)***	970	492	0.95	0.92	0.23	0.27	0	0	1	1
	Fertilizer Use ***(binary, 2=yes)***	970	492	0.84	0.74	0.37	0.44	0	0	1	1
Between Wave 2 and Wave 3	**Gender Hous. Head (binary)**	1183	279	0.19	0.14	0.39	0.34	0	0	1	1
	Age Hous. Head ***(decimals)***	1183	279	46.23	43.58	14.05	14.71	18	18	87	97
	Hous. Labor Force ***(decimals)***	1183	279	2.73	2.52	1.42	1.17	0	0	10	6
	Household Size ***(decimals)***	1183	279	5.89	5.27	2.19	2.11	1	1	14	11
	Av. Educ. Adults ***(decimals)***	1181	279	1.75	1.52	1.85	1.74	0	0	8	7
	Household Infants ***(decimals)***	1183	279	0.72	0	0.84	0	0	0	5	0
	Hous. Children ***(decimals)***	1183	279	2.55	1.72	1.71	1.35	0	0	10	5
	Hous. Education ***(decimals)***	1181	279	1.75	1.51	1.85	1.73	0	0	8	7
	Harvest Crop ***(decimals, Kg)***	1183	279	940.63	805.85	72.94	647.37	0	0	3249.61	3122
	Field Size ***(decimals, m^2)***	1183	277	8935.27	9446.25	9236.24	9895.60	0	0	38858.3	38917.46
	Free Seed ***(binary, 2=yes)***	1182	279	1.00	0.95	0.06	0.23	0	0	1	1
	Seed Purchase ***(binary, 2=yes)***	1183	279	0.93	0.96	0.26	0.19	0	0	1	1
	Fertilizer Use (binary, 2=yes)	1183	279	0.79	0.87	0.41	0.33	0	0	1	1

Legend: “M” stands for “Position-Movers,” while “NM” stands for “Non-Position-Movers”.

Table A.3.11: Self-Selection Bias – OLS for Residuals Calculation

	Positioning Downstream in the Chain		
	Wave Fixed effects	**District-Wave Fixed Effects**	**Wave Fixed Effect HH Trends**
Female Head	-0.0106	-0.0121	-0.0113
	(0.0362)	(0.0341)	(0.0342)
Age Head	-0.000187	-0.000768	-0.000779
	(0.00108)	(0.000974)	(0.000973)
Household Labor	0.00388	-0.00380	-0.00398
	(0.0171)	(0.0161)	(0.0161)
Household Size	0.00210	0.00488	0.00502
	(0.0156)	(0.0144)	(0.0144)
Education Adults	-0.370***	-0.408**	-0.408**
	(0.0699)	(0.197)	(0.197)
N. of Infants	-0.00550	-0.00270	-0.00271
	(0.0234)	(0.0228)	(0.0227)
N. of Child	0.00337	0.00283	0.00282
	(0.0170)	(0.0161)	(0.0161)
Average Education	0.379***	0.418**	0.418**
	(0.0710)	(0.197)	(0.198)
Harvest Crop	0.00003	0.000006	0.000006
	(0.00002)	(0.000002)	(0.000002)
Field Size	-0.000002	-0.000001	-0.000001
	(0.000001)	(0.000002)	(0.000002)
Free Seed	-0.0679	0.0253	0.0259
	(0.121)	(0.0917)	(0.0919)
Seed Purchase	0.0756	0.0328	0.0331
	(0.0533)	(0.0542)	(0.0543)
Fertilizer Use	-0.0132	0.0165	0.0161
	(0.0352)	(0.0378)	(0.0378)
Seed Type Dummy* Crop Code Dummy*	-	-	-
Position Dummy*	-	-	-
Year Dummy* Month Dummy*	-	-	-
Region Dummy* Woreda Dummy* Zone Dummy* Town Dummy* Subcity Dummy* Kebele Dummy*		-	-
HH Trends HH Trends^2			-
Constant	0.690**	0.506	0.553
	(0.331)	(0.564)	(0.577)
Observations	1,455	1,455	1,455
R-squared Adjusted	0.035	0.299	0.4298

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1.

Table A.3.12: Self-Selection Bias – Control Function Method

	Food Consumption			Total Consumption		
	Wave Fixed Effects	District-Wave Fixed Effects	Wave Fixed Effect HH Trends	Wave Fixed Effects	District-Wave Fixed Effects	Wave Fixed Effect HH Trends
Downstreamness	27.23*	43.03***	41.03***	24.28+	36.23***	35.86***
	(15.71)	(13.04)	(13.07)	(14.97)	(11.23)	(11.20)
Female Head	0.109	0.177	0.108	-0.0243	0.0757	0.0191
	(0.628)	(0.632)	(0.686)	(0.579)	(0.531)	(0.592)
Age Head	0.0188**	0.0181**	0.0198***	0.0171**	0.0171***	0.0169***
	(0.00799)	(0.00743)	(0.00658)	(0.00767)	(0.00652)	(0.00650)
Household Labor	-0.0197	0.0175	0.0107	-0.00807	0.0346	0.0390
	(0.0460)	(0.0518)	(0.0496)	(0.0421)	(0.0469)	(0.0456)
Household Size	-0.162***	-0.273***	0.00665	-0.145***	-0.229***	-0.226***
	(0.0590)	(0.0555)	(0.0562)	(0.0557)	(0.0515)	(0.0510)
Education Adults	-0.473**	1.578	1.024	-0.517**	1.666	1.617
	(0.223)	(1.254)	(1.286)	(0.205)	(1.085)	(1.084)
N. of Infants	0.0937	0.152**	0.131*	0.0793	0.102*	0.0963
	(0.0791)	(0.0694)	(0.0707)	(0.0701)	(0.0596)	(0.0596)
N. of Child	-0.00396	0.0538	0.0295	-0.0157	0.0480	0.0456
	(0.0493)	(0.0471)	(0.0488)	(0.0443)	(0.0414)	(0.0421)
Average Education	0.534**	-1.563	-1.010	0.587***	-1.645	-1.599+
	(0.224)	(1.256)	(1.288)	(0.206)	(1.088)	(1.086)
Harvest Crop	0.00005	0.00007	0.00009	0.00003	0.00006	0.00007
	(0.00006)	(0.00007)	(0.00007)	(0.00005)	(0.00006)	(0.00006)
Field Size	0.00001+	0.000006	0.000009	0.000009	0.000009	0.000008
	(0.000007)	(0.000008)	(0.000008)	(0.000006)	(0.000007)	(0.000007)
Free Seed	-0.570	0.135	0.352	-0.607*	-0.114	-0.0903
	(0.377)	(0.396)	(0.349)	(0.349)	(0.367)	(0.374)
Seed Purchase	0.194	0.0953	0.0921	0.114	-0.00234	0.0136
	(0.153)	(0.176)	(0.191)	(0.132)	(0.160)	(0.159)
Fertilizer Use	-0.0136	-0.143	-0.162	0.0100	-0.102	-0.118
	(0.106)	(0.136)	(0.137)	(0.0950)	(0.115)	(0.117)
Seed Type Dummy* **Crop Code Dummy***	-	-	-	-	-	-
Position Dummy*	-	-	-	-	-	-
Time Dummy**	-	-	-	-	-	-
Region Dummy* Woreda Dummy* Zone Dummy* Town Dummy* Subcity Dummy* Kebele Dummy*		-	-		-	-
HH Trends			-			-
ρ	7.973***	6.238***	6.256***	8.306***	-0.00707	0.00676
	(0.632)	(0.987)	(0.976)	(0.586)	(0.0869)	(0.0871)
Constant	7.973***	6.238***	6.256***	8.306***	6.837***	6.950***
	(0.632)	(0.987)	(0.976)	(0.586)	(0.848)	(0.855)
Observations	1,387	1,387	1,387	1,387	1,387	1,387
Number of HH_id	1,097	1,097	1,097	1,097	1,097	1,097
R-squared Adjusted	0.193	0.667	0.643	0.213	0.683	0.685

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1.

Figure A.3.9: Ethiopia - Classification Tree for Food Consumption above 95 Percentile

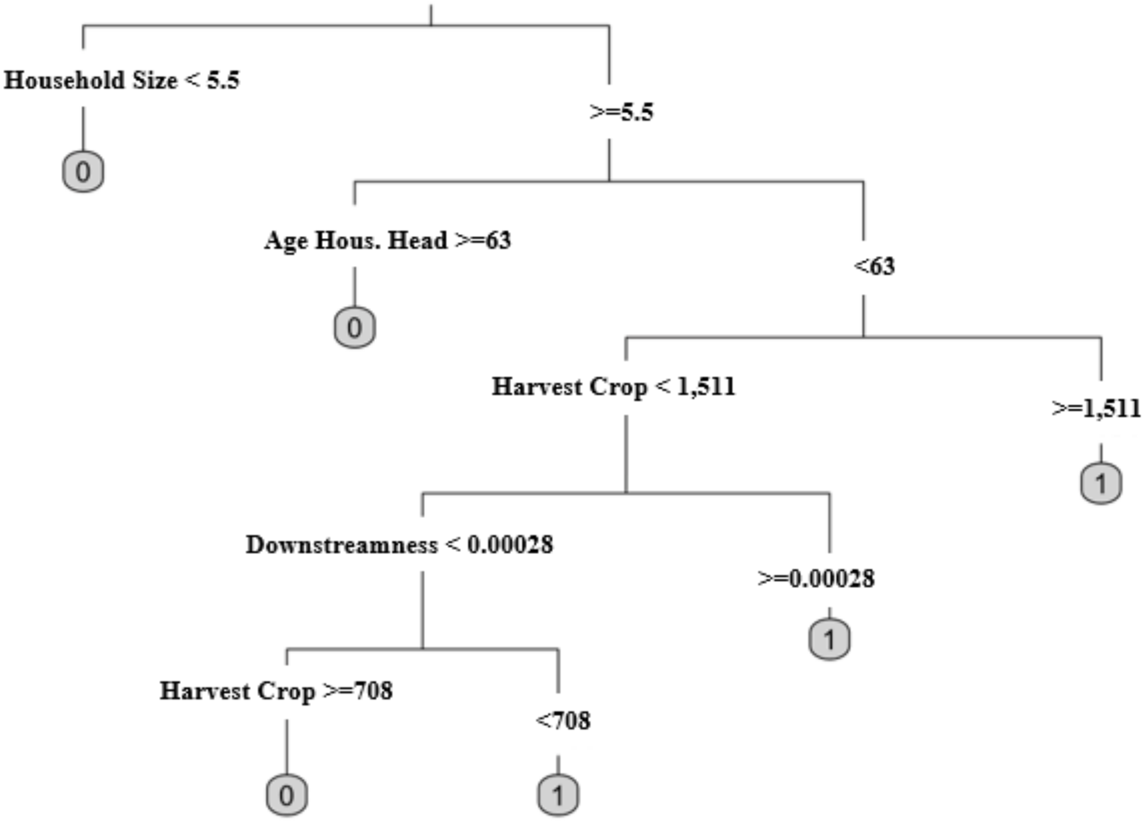
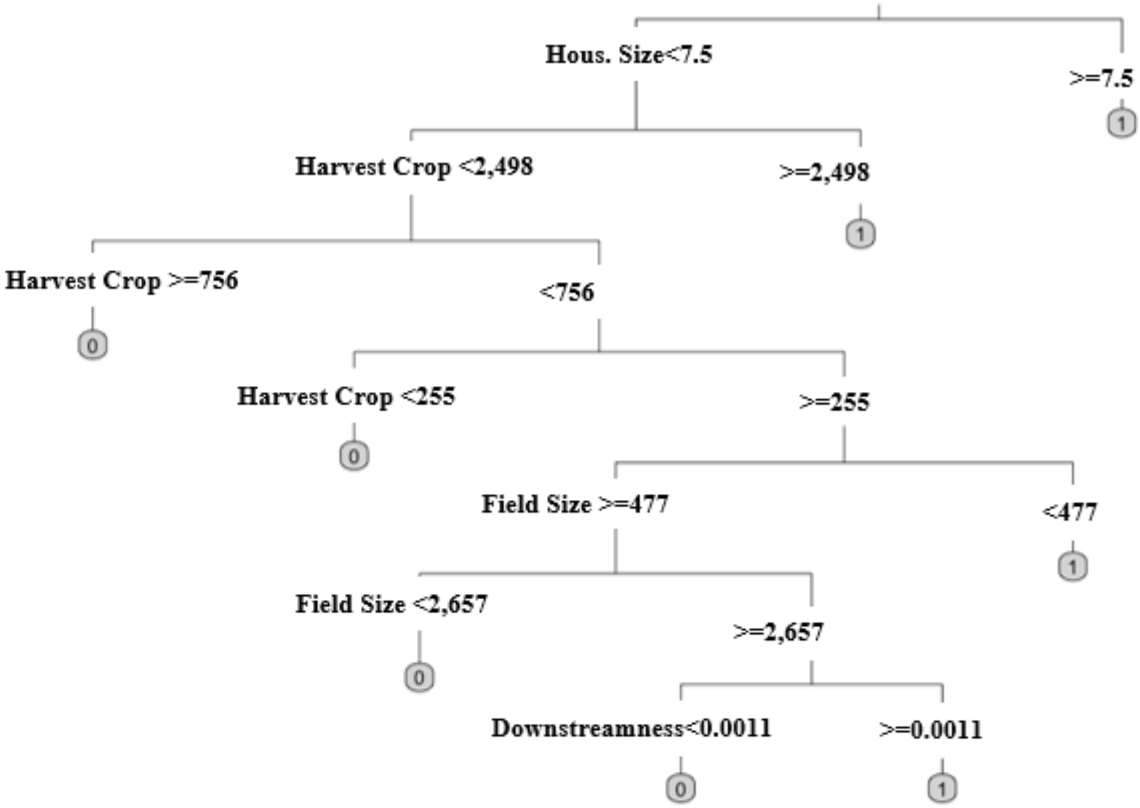


Figure A.3.10: Ethiopia - Classification Tree for Total Consumption above 95 Percentile



Essay 2

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Market Proximity, Resilience and Food Security: A Cross-Country Empirical Examination[+]

Abstract

Scholars advocate that proximity to final markets increases food security, but empirical evidence is scarce. This works sheds light on this issue by applying a hybrid empirical approach – which combines machine learning algorithms, vulnerability models and mediation analysis – to a new cross-country household dataset made available by the International Fund for Agricultural Development in 2017-2018. Specifically, this paper finds positive and statistically significant associations among proximity to market chains, resilience and food security. In particular, it tests the plausibility of the exclusion restriction that proximity to agri-food value chains does not affect food security fluctuations other than through its impact on resilience capacity by implementing an instrumental variable approach and a mediation analysis. The latter method reveals that market chain proximity accounts for a significant share of the positive correlation between household resilience and the variations of food security outcomes. The dampening role played by proximity to agri-food markets in decreasing welfare fluctuations is also confirmed when replacing food security outcomes with income ones. Overall, these findings suggest that policymakers should prioritize interventions to improve infrastructure and access to markets as a means to boost household resilience and, in turn, decrease welfare fluctuations and vulnerability to food insecurity.

Keywords: rural development, market chain, vulnerability, resilience, food security

JEL-Codes: Q12; O12; C31, C3

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Introduction

The integration of smallholder farmers into traditional markets is expected to yield strongly pro-poor outcomes, due to a virtuous cycle of efficiency, leading to increased household income, consumption, food security, and nutritional outcomes (Montalbano et al., 2018). Nevertheless, participation in the market chain may be less beneficial to the food security levels of the poorest and most vulnerable groups, who often fail to benefit from increased market participation (Bouis & Haddad, 1990; von Braun et al., 1991; Abbi et al., 1991; Kennedy & Cogill, 1987; Popkin, 1980). The ways through which proximity to market chains, especially in agri-food sectors, affects food security levels is indeed unsolved: when confronted to market forces, especially global linkages, makes farmers vulnerable for specific reasons, such as being averse to price changes and negotiating power (Bellemare et al., 2013).

Yet factors like market power, marketing costs and asymmetric information constrain efficient transmission of prices to farmers, both spatially and vertically (Meyer & Cramon-Taubadel, 2004). Several agricultural markets are oligopsonistic in nature, with a large number of farmers and very few processors and private and/or public traders alike. Furthermore, the geographic dispersion of smallholder farmers enables traders to exploit their market power, significantly impacting market structure and decreasing farmers' welfare (Sexton, 2013; Swinnen & Vandeplas, 2012; Swinnen & Vandeplas, 2014; Kikuchi et al., 2016; Fałkowski, 2010; Osborne, 2005).

The literature agrees the guiding principles of 'buy low' and 'sell high', central to the competitive storage model, are unattainable for farmers who rely on grain sales for liquidity (Stephens & Barrett, 2011; Burke et al., 2019). The reason is that the decisions of farmers to sell or store grain are constrained by liquidity and varying price expectations. Unlike traders, smallholder farmers often face constraints related to information and physical storage constraints that limiting their ability to adjust their behavior based on weather forecasts (Letta et al., 2021). Lastly, market participation is restricted to lower-value activities in developing contexts, constraining farmers' positioning to backward stages in the market value chain (African Development Bank et al., 2014).

To further complicate matters, in the presence of incomplete or missing markets (as is most often the case in developing regions), farming households perceive food self-sufficiency as a source of protection against price risks in food markets (Fafchamps, 1992; de Janvry &

Sadoulet, 2006). In this respect, food production takes on an insurance value, in addition to its regular contribution to income. The supposed benefits of agriculture commercialization on food security may be offset by transaction costs, risk aversion and low resilience capacity (Montalbano et al., 2018). On the other hand, taking the market option, prices for small producers depend on their positioning within the farmer-producing class. As such, small farmers tend to rush post-harvest production to sell their crop to the market when market price volatility goes down the value chain, pushing small producers into a vicious cycle of low productivity, low quality and low prices (Purcell, 2018).

Therefore, the empirical association between farmers' food security and agri-food value chain positioning is not straightforward. Most scholars have carried out quantitative assessments based on single-country studies, and context-specific frameworks focused on the effects of market participation. Broader empirical assessments are hampered by difficulties in terms of both data and methodology: the market choice hinges on several factors influencing both households' decision-making process and their food security (Key et al., 2000), whereas alternative commercialization options have mixed impacts on food security (Swinnen & Vandeplas, 2014; Wohlgenant, 2001; Weldegebriel, 2004; McCorriston et al., 2001; Wang et al., 2006). As Bellemare and Bloem (2018) stress, the literature is still lacking in cross-country, multi-area and multi-year studies disentangling the endogeneity affecting contract farming decisions. Although access to competitive agricultural markets shows a positive correlation with food security (Maggio and Sitko; 2019), a thorough investigation of the specific role of key mediation factors capable of increasing the resilience of smallholder farmers is still lacking. Evidence of the welfare effects of farmers' better resilience via market chain proximity is even scarcer.

This article seeks to fill this gap by assessing the presence of a significant association between farmers' market proximity (which it is here used as a proxy for positioning in agri-food value chains), their resilience to shocks and stressors, and, in turn, their vulnerability to food insecurity. In competitive systems spatial arbitrage should lower the price differences across markets to the level of transaction costs, farmers should naturally sell at the farm gate, and shocks could hit all the market chain's nodes via standard transmission channels (Fafchamps, 1992). However, this is often not the case in developing contexts where distance to final markets drives farmers' vulnerability to market shocks. In such a scenario, farmers' resilience to shocks is correlated with their distance from the market. Through a hybrid empirical approach -

combining traditional econometric methodologies, theory-based empirical models, machine learning routines and mediation analysis – this paper shows how farmers' market proximity is significantly and negatively associated with vulnerability to food insecurity. According to standard theory - under full certainty and efficient markets - there are no reasons to register heterogeneity in food security induced by market proximity. However, this study demonstrates that there is indeed heterogeneity in a cross-country sample, suggesting that households' resilience to food insecurity is influenced by their proximity to markets, which is here assumed to be independent of their own preferences, as it is typically the case in developing contexts.

The main argument backing this research is that this happens because market proximity and access to markets influence households' resilience capacity in various ways: it can reduce farmers' exposure to traders' exploitation, mitigates risk exposure by allowing the sharing of information about final markets among farmers, generates positive spillovers for the actors involved and might stimulate farmers to sell higher quantities and, in turn, earn more.

These findings have relevant and actionable policy implications, as they help to prioritize interventions, not only to improve market participation but also focus on access to markets and market positioning as a crucial means to boost household resilience and in turn decrease households' vulnerability. They also suggest that exposure to risk is a key driver capable of reconciling the absence of welfare effects of positioning highlighted by theoretical literature with the empirical evidence of the significant welfare-enhancing effects of proximity to final markets. This work provides three main contributions: i) unlike previous literature, it assesses how resilience impacts vulnerability to food insecurity via market proximity; ii) from a methodological point of view, it introduces machine learning algorithms into the estimation of a multidimensional vulnerability model; iii) as for empirics, it applies an IFAD original dataset of household surveys available for eight countries with different development settings coming from three diverse continents, thus improving the external validity of outcomes compared to previous single-country works. Note that this work employs subjective measures taken from these survey data to capture the multidimensional natura of both food security and resilience, in line with the increasing use in scientific literature of people's perceptions and self-reported experiences as measures of food security and resilience that can compete with, or at least complement, objective measurements, especially in data-scarce environments (Cafiero et al., 2018). Nevertheless, a sensitivity analysis replacing the subjective food security outcome with total gross income is provided to show robustness to objective measures of welfare deprivation.

The rest of the paper is arranged as follows: Sections 2 and 3 describe the relevant literature and the conceptual framework. Section 4 presents the empirical approach and identification strategies. Section 5 illustrates the data and reports some preliminary descriptive statistics. The results are presented and discussed in Section 6. Section 7 wraps up and concludes.

2. Literature Review

The analysis of the costs and benefits of market channels is yet to be fully undertaken, and its many underlying assumptions lack sufficient empirical support. Accessing the market requires different choices, depending on factors like access costs and risk preferences (de Janvry & Sadoulet, 2006; Key et al., 2000; Jensen, 2010; Svensson & Yanagizawa, 2009). Also, as debated in several empirical studies on nutrition and commercialization (DeWalt, 1993; von Braun, 1995; Carletto et al., 2017), household income growth may not represent the only way to food security and higher welfare levels. There are a number of reasons for this. First, cash income may be less likely to be converted in increased food intake while fostering substitution mechanisms towards non-food consumption or less nutritious foods (Bouis & Haddad, 1990; von Braun et al., 1991). Second, profits from commercialization may lead to different investment opportunities and increase the opportunity cost of current consumption, negatively impacting food costs (Abbi et al., 1991; Kennedy & Cogill, 1987; Popkin, 1980).

The literature traditionally views subsistence agriculture (i.e., crops sold to friends/neighbors or for own consumption) as the last-resort option driven by high transaction costs and missing markets or high risk-aversion (Timmer, 1997). In this respect, both fixed and proportional transaction costs significantly affect household behavior. Specifically, costs are more relevant in selling than buying choices (Key et al., 2000). Many empirical studies, such as Renkow et al. (2004), Osborne (2005), and Barret (2005), confirm the strong association between high transaction costs and subsistence agriculture by showing how traders foster households' predisposition towards subsistence agriculture in remote regions. Moreover, most farmers in developing areas view market interaction as dangerous and challenging, making them opt wholly for self-subsistence (Fackler & Goodwin, 2001; Fafchamps & Hill, 2004). Still, selling one's own crop can turn in-kind income into cash income (Kennedy & von Braun, 1995), which can be potentially used to buy goods, improving, in turn, food security (Kennedy & von Braun, 1995; Pingali, 1997; Romer, 1994; Timmer, 1997). Bellemare & Novak (2017) argue for instance that farmers involved in contract farming experience a reduction in their "hungry" season.

However, once farmers enter the market, they position differently according to their primary buyers. The latter might act through different intermediaries, trading firms or State or parastatal organizations managing assembly markets, etc. (Montalbano et al., 2018). In competitive systems, spatial arbitrage should indeed lower price differences across markets to the level of transaction costs (Fafchamps, 1992). Thus, selling at the farm gate should be the natural choice, as farmers do not have to bear the costs of bringing the produced crop to the nearest market. However, Fafchamps and Hill (2004), using original survey data for coffee producers in Uganda, found that the likelihood of selling to the market increases with both the quantity sold and proximity to the market. Mulbah et al. (2021) confirmed that high transaction costs tend to force farmers to sell at low farm-gate prices, reducing their income and increasing the risk of triggering the vicious cycle of poverty. The common wisdom is that high margins for market intermediaries tend to reduce producer margins while augmenting food prices (Coulter & Pouton, 2001). Sexton (2013) and Swinnen and Vandeplas (2014) argue that the geographic dispersion characterizing small farmers determines price margins, given the insurgence of local oligopsony imposing higher transaction costs. Physical distance to the primary market may represent a barrier to participation, and being closer to city centers may translate into being closer to the final buyer in the chain. Other scholars point to large margins for traders by considering the reduced effects of global price increases on producers (McMillan et al., 2002; Fafchamps & Hill, 2008). In this setting, participation in the market and downward positioning in the chain is associated with increased employment, better jobs, resources, governance and food security (Minten et al., 2009; Cattaneo & Miroudot, 2013; Swinnen, 2014; Swinnen & Vandeplas, 2014).

By contrast, Montalbano et al. (2018) found that Ugandan net producers of maize able to sell their periodic surpluses in the local village, district and national markets are better off in terms of food security irrespective of decisions regarding the specific selling point. Other studies highlight the positive effects of contract schemes (Barrett et al., 2012; Bellemare, 2010; Bellemare & Novak, 2017) and the value export chain for smallholder farmers (see, *inter alia*, Minten et al., 2009; Subervie & Vagneron, 2013; Handschuch et al., 2013 and Asfaw et al., 2010). According to this strand, price transmission asymmetries do not vary with market power but with vertical coordination, returns to scale, degree of processing and farmers' risk behavior (Swinnen & Vandeplas, 2014; Wohlgenant, 2001; Weldegebriel, 2004; McCorriston et al., 2001; Wang et al., 2006).

For local actors, territorial sales outlets may perform better than markets, especially when their ability to recover from shocks is low. In Dar es Salaam (Tanzania) for example the raw milk system operates in a broader symbiotic local food system and delivers more fresh milk than any other supplier. Incorporating such a system into a market chain would represent to local farmers a threat to their food security and welfare (Wegerif & Martucci, 2019). Indeed, a shock in staple food prices is more perceived by households with a food-insecure dietary regime than by those at the bottom of the caloric intake distribution pyramid (D'Souza & Jolliffe, 2014), resulting in more vulnerability to market fluctuations. A vicious circle between market participation, resilience to shock, and welfare vulnerability seems to exist, and farmers' risk aversion and resilience capacity represent critical features affecting market positioning.

3. Vulnerability, Resilience and Food Security

Along with the increased relevance of risk analysis in development economics, scholars and practitioners are increasingly interested in developing forward-looking welfare measures. As a result, many approaches to food security, resilience and vulnerability have been proposed in recent years. However, they have progressed on parallel tracks, and less attention has been devoted to investigating the subtle links across the various notions and concepts. While one strand of the literature examines resilience as the endogenous component of vulnerability, others underline the crucial role of its time dimension to disentangle the potential long-lasting adverse effects of shocks on welfare (Montalbano & Romano, 2023). On the other hand, the stability aspect of the most common definition of food security points to food security having a risk dimension: the food security of households certainly decreases when they cannot mitigate downside risks. Unfortunately, the current literature has largely overlooked this forward-looking approach apart from a few isolated cases (e.g. Haddad & Frankenberger, 2003; Løvendal & Knowles, 2006).

The identification strategy of this work evaluates the vulnerability to food security of investigated farmers by looking at the relationship between the resilience-enhancing role of market proximity and the volatility of the stochastic components of food security. Specifically, this work first tests whether households closer to destination markets are less food-insecure, and then provide evidence about an existing association between market proximity and resilience. Resilience is a complex concept that includes a multidisciplinary explanation of the interrelated dynamics of risk exposure, human living standards and ecological and social processes (Barrett et al., 2021). Although the definition of resilience is derived from other sciences, especially ecology, scholars in development economics recently started to integrate this notion in the international development sphere (d'Errico et al., 2019; d'Errico et al., 2020; Barrett et al., 2021).

In development literature resilience is often defined as the capacity to ensure that shocks and stressors do not have long-lasting adverse consequences on development (Constas et al., 2014). When framed behind capacity, resilience entails a latent variable capturing the effects of a combination of observable and unobservable attributes limiting ex-ante risk exposure and the long-term consequences of shocks (Barrett et al., 2021). Hence, resilience is conceived as a set of multiple capacities. Due to data constraints, this paper adopts a subjective measure of resilience, developed and collected by IFAD, based on the self-perceived capacity to recover from shocks (Garbero & Letta, 2022). The metric used for resilience is the Ability to Recover from Shocks (ATR), which measures households' capacity to recover from shocks happening in the year prior to the survey. ATR included different types of shocks like droughts, floods and crop diseases. According to the background paper for the IFAD9 Impact Assessment Initiative,[10] the ATR index equals the mean value of responses across all of the shocks experienced by each household.

Food insecurity exists when households lack the physical, social and economic access to food matching their dietary needs and preferences for a good, healthy and active life. According to Cafiero et al. (2018), households' diverse ability to achieve food security also calls into question the effectiveness of objective measurements. For such reasons, it would be preferable to consider subjective measures rather than objective ones when dealing with biased household *status quos* of food insecurity and resilience. Also, as claimed by Ibok et al. (2019), traditional measures of food insecurity vulnerability, such as food consumption or per capita intake, can be misrepresentative, as they do not account for the multidimensional aspects of food security. Under the project Voices of the Hungry, the United Nations Food and Agriculture Organization (FAO) developed a survey-based experiential measure of food security, called the Food Insecurity Experience Scale (FIES). Starting from 2014, international organizations like FAO

[10] Available at https://www.ifad.org/documents/38714170/39318582/Measuring+IFAD%E2%80%99s+impact.pdf/36c251f1-854e-42de-8990-773728abe1f7?t=1540911311000.

and IFAD started including FIES in their household surveys (Cafiero et al., 2018; Wambogo et al., 2018). The FIES variable measures food insecurity based on direct experiences, and is comprised of eight questions centring on the severity of food insecurity (Smith et al., 2017; Cafiero et al., 2018). Some recent studies (Smith et al., 2017; Coates, 2013) have shown that FIES is more accurate than many model-based objective measures. In the raw FIES score, respondents answer eight yes/no questions (shown in Table A.3 in the Appendix), each capturing a different aspect of food insecurity. Responses are then combined into an overall raw indicator of household food security, the sum of affirmative responses, 0 to 8, constituting the raw FIES score (Kansiime et al., 2021). This raw score is comparable across countries only if one checks for country-level fixed effects. According to Adjognon et al. (2021), households can fall into three categories: 1) mild food insecure, with an aggregate score of between 0 and 2; 2) moderately food insecure, with an aggregate score of between 3 and 6; and 3) severely food insecure, with aggregate scores equal to or higher than 7.

4. Empirical Framework

This empirical analysis utilizes a vulnerability measure similar to that proposed by Chaudhuri (2001 and 2003); the proposed vulnerability measure is then applied to food insecurity rather consumption levels. The use of Chaudhuri's measure is motivated by its ability, in the available cross-sectional setting (see the data section), to deal with heteroscedasticity in farmers' response to market shocks, net of the individual socio-economic determinants. In this respect, vulnerability should not be viewed as a stand-alone concept, but needs to be framed in the household reality, where heteroscedasticity in residuals proxy different household coping strategies. For example, in Kenya and Tanzania, vulnerable small-scale farmers apply different coping strategies: a primary coping strategy that provides food and income through activities substituting farming, and a complementary coping strategy providing some food and income with auxiliary, non-self-sufficient activities (Eriksen et al., 2005).

One of the main privileges of the proposed method is that it allows to consider cross-sectional dataset including countries at very different development stages. Hence, contrary to standard OLS, the variance of the error term is not equal across households and clearly reflects the impact of shocks on households' consumption (Günther and Harttgen; 2009). This paper also withdrew the standard target variable for vulnerability, i.e., consumption, and substitute it with FIES, a non-monetary, subjective variable marking food insecurity leves. In this regard, this work follows the recent contribution by Adjognon et al. (2021), who use a *standardized* raw FIES score as their main outcome variable and standardize the raw FIES score to a scale having mean zero and standard deviation one. For sensitivity purposes, the analysis is replicated with total gross income as an alternative outcome variable in order to derive households' welfare fluctuations. The additional use of income figures, i.e., of an objective and monetary measure of household welfare, ensures that the key results are not driven solely by the use of a subjective, non-monetary welfare measure such as self-reported food security.[11]

Inspired by the conceptual framework of household vulnerability as expected poverty (VEP) (Chaudhuri, 2001 and 2003), the empirical strategy consists of three main steps:

i. it first obtains a volatility measure by filtering the outcome variable (food security or, alternatively, income) through a machine learning-enriched Feasible Generalized Least Squares (FGLS) approach in order to obtain household-specific residuals;
ii. it then computes the measure of vulnerability using an FGLS model;
iii. finally, it tests for resilience-driven heterogeneity in the association between volatility/vulnerability and market proximity (our proxy for market positioning and access to markets) by exploiting first an instrumental variable analysis and then a mediation analysis approach based on structural equation modeling.

In step one the outcome variable (standardized raw FIES score for the main analysis, total gross income for the sensitivity analysis) is regressed on a set of household characteristics, selected via a machine-learning algorithm to obtain residuals representing pure stochastic measures of food security or income volatility.[12] As standard in this setting, each household's ex-ante distribution necessary to calculate its probability of food insecurity is obtained from a flexible heteroskedastic regression specification, which allows us to predict the ex-ante mean and variance for each household, based on its current socio-economic characteristics (Christiaensen & Boisvert., 2000). In this setting, unexplained variance captures the impact of unobservable

[11] It is well known that income is a worse proxy for welfare than consumption, as variations in aggregate consumption are much smaller than those in aggregate income (Campbell & Deaton, 1989). I am aware of this limitation, but, unfortunately, consumption figures are not available in the IFAD dataset.

[12] I am aware that as the raw FIES score is a discrete outcome variable, an ordered probit model could be employed to estimate the simple conditional probability of being food insecure. However, since I am interested in computing more complex measures of volatility and vulnerability to food insecurity, I apply the well-established FGLS procedure developed by Chaudhuri (2001, 2003) and, following the recent paper by Adjognon (2021), use the standardized raw FIES score as the outcome variable in multivariate linear regression models. In any case, note that the results are robust to the use of a continuous outcome variable, namely total gross income.

idiosyncratic and covariate shocks for each household, net of the available risk mitigating and coping mechanisms. The central assumption here is that variance of the error term across households mimics the inter-temporal variance by households. This assumption requires that the stationarity assumption holds up (i.e., households have the same distribution for the outcome variables). As mentioned, the main assumption of this conceptual framework is that the unexplained variance of outcomes in the cross-sectional regression is not equal across households. In other words, the assumption of homoscedasticity is relaxed. As a result, to compute the robust mean and variance of the target variables, this work adopts a three-step FGLS model. To this end, first machine learning algorithms are used to select among all possible combinations of household characteristics only the most predictive ones, to obtain pure stochastic residuals, as follows:

$$y_{ht} = X_h\beta + e_{ht} \; ; \qquad [1]$$

where y_{ht} represents the outcome variable, standardized raw FIES score or, alternatively, total gross income, proxying out the latent welfare variable, X_h is a bundle of observed household characteristics, β a vector of parameters, and e_{ht} the stochastic components. The ability to filter out these pure stochastic components from the deterministic part of the target variables is key in this kind of exercise. To this end, the analysis exploits the predictive power of Least Absolute Shrinkage and Selection Operator (LASSO), a supervised machine learning routine based on regularized regression (Hastie et al., 2009). LASSO enables the selection of the most predictive control variables from a larger set of features, and the use of machine learning routines in residual filtering can enhance the accuracy of outcome prediction and related residuals in the initial FGLS step. Following LASSO, the standardized raw FIES scores are regressed on country fixed effects to address country-specific heterogeneity and ensure comparability across countries in all subsequent specifications.

In the second step of the FGLS procedure, the filtered residuals from the first stage [1] are used to obtain an estimate of the variance:

$$\hat{e}^2{}_{ols,h} = X_h\theta + \eta_h \; . \qquad [2]$$

It is worth noting here that X_h now includes only the combination of household characteristics not dropped by the LASSO procedure in step [1].

The predictions from [2] lead to a robust OLS estimate of the FGLS β coefficient simply by calculating:

$$\frac{y_{ht}}{\hat{\sigma}_{e,h}} = \left(\frac{X_h}{\hat{\sigma}_{e,h}}\right)\beta + \left(\frac{e_h}{\hat{\sigma}_{e,h}}\right); \qquad [3]$$

where $\hat{\sigma}_{e,h}$, which is equal to $\sqrt{X_h\widehat{\theta_{FGLS}}}$, is a consistent estimate of the volatility of the household outcome variable. This study then constructs a volatility dummy considering as "volatile" only households lying above the median of the obtained volatility distribution.

Finally, the forward-looking vulnerability measure is estimated, i.e., the probability that a household *h* with *X* characteristics will be food insecure (or poor, in the case of income) in the near future, using the predicted standardized raw FIES scores through a proxy of the intertemporal distribution of standardized raw FIES scores, whose mean and variance are computed as follows:

$$\widehat{E}[\ y_h\,|X_h] = X_h\hat{\beta}_{FGLS}\ ; \qquad [4]$$

and

$$\widehat{V}[y_h|X_h] = \hat{\sigma}_{e,h} = \sqrt{X_h\hat{\theta}_{FGLS}}. \qquad [5]$$

Thus, the final adjusted vulnerability measure will be equal to:

$$\widehat{V_h} = \Pr[y_h >\ z\,|\,X_h] =\ \phi\left(\frac{X_h\hat{\beta} - z}{\sqrt{X_h\hat{\theta}}}\right); \qquad [6]$$

where z represents the food insecurity (poverty, for income) line and $\phi(.)$ the cumulative density of the standard normal. In order to test the robustness of results in light of farmers' heterogeneity (i.e., the poorer might be in a weaker position to benefit from market access), the FIES vulnerability measure V_h is derived considering two alternative food insecurity lines: one equal to the standardized raw FIES score median and another equal to Adjognon et al. (2021) mild food insecurity line threshold of the raw FIES score equal to 3. Note that, for the two alternative outcomes, food insecurity and income, the construction and interpretation of the threshold line are reversed: food-insecure households are those who move *above* the food insecurity line, whereas in the case of income households fall into deprivation if they move *below* the poverty line.

Once d $\widehat{V_h}$, is obtained, i.e., an estimated measure of the probability of moving above (below) the food insecurity line (the poverty line) in the near future, a vulnerability dummy is constructed which, in the case of food insecurity, is equal to 1 when this probability $\widehat{V_h}$ is above 50% for the first food insecurity line and equal to 25% for the alternative line[13] and, in the case of income, is equal to the median of the income distribution.

After constructing these measures of interest, one is finally able to investigate the associations between market proximity, resilience and volatility/vulnerability. As mentioned earlier, the employed resilience variable (the ability to recover) is an overall subjective metric of the capacity of reaction to various shocks and stressors. Under the hypothesis of complete and efficient markets, proximity to final markets should be uncorrelated with welfare and food security fluctuations and their vulnerability. In this setting, market proximity (as a classic measure for market positioning) is used as an instrument or restriction capable of influencing food security *fluctuations* only via resilience.

A note of caution needs to be mentioned here: although one is aware that market proximity may affect food security *levels* in many ways (e.g., changes in prices, input access and availability of financial services) our argument is that market proximity serves as the primary channel for the adaptive and transformative capacity of resilience (Montalbano and Romano, 2023) when assessing its relationship with food security *fluctuations* rather than levels (exclusion restriction). This is in addition to the other resilience pillars this work simultaneously controls for, via the main households' individual characteristics. In this case, market proximity becomes a key determinant of heterogeneous coping strategies through mechanisms such as spillover effects and information sharing, assuming that proximity is independent of farmers' preferences, as it is always the case in developing contexts, especially for the poorest farmers. The literature consistently shows that proximity to final markets, which serves as a reliable indicator of market participation and positioning in the market chain, is associated with various positive outcomes such as increased employment, better job opportunities, access to resources, improved governance, and higher levels of food security (Minten et al., 2009; Cattaneo & Miroudot, 2013; Swinnen, 2014; Swinnen & Vandeplas, 2014). Nevertheless, it can be argued that food security fluctuations caused by shocks primarily depend on farmers' resilience

[13] Two different thresholds are used as cutoffs for the V_h distribution, since higher levels of raw FIES score imply an increased skewness in the V_h distribution and, in turn, a lower share of vulnerable households as one moves along the distribution.

capacity, which nevertheless affects food security beyond its initial absolute levels.

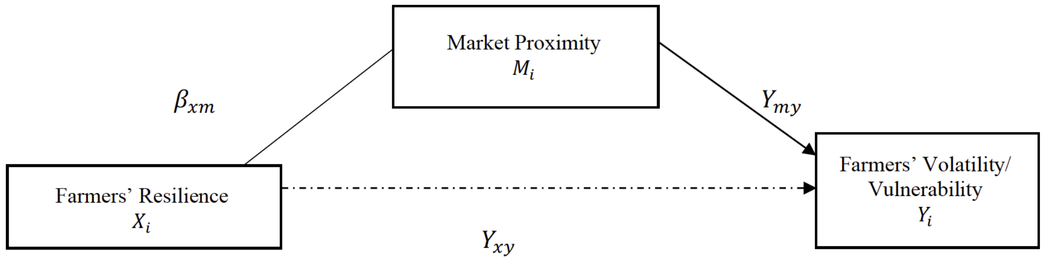
Therefore, to address the endogeneity of resilience with respect to the outcome measures, this work implements first an instrumental variable approach in which market proximity is used as the instrument for household resilience. It is later assumed that it is uncorrelated with the error term but strongly related to resilience, and the exclusion restriction holds, as already mentioned, that market proximity does not affect food security *fluctuations* other than through its impact on resilience capacity. As there are not explicit measures of market positioning in the original IFAD dataset, following extensive literature using distances from cities or major population centers as measures of market access and participation (Amarasinghe et al., 2005; Azzarri & Signorelli, 2020; Muto & Yamano, 2009; Xu et al., 2009).[14] I adopt here a workable solution: market positioning is proxied by proximity to markets, which is calculated as each farmer's distance from the nearest urban center,

After testing the instrumental variable model (i.e., market proximity → resilience → volatility/vulnerability), this work delves further into the investigation of detected associations between resilience and vulnerability by using market proximity no longer as an instrument but as a *mediator*. A way to see how the impact of resilience on farmers' welfare fluctuations and vulnerability is mediated by market proximity is to apply a mediation analysis via Structural Equation Modeling (SEM). SEM is a multivariate technique implementing a system of linked regression-based equations to fathom the complex relationship behind a set of observed and unobserved variables (Gunzler et al., 2013) whose foundation has solid structuring in the literature (e.g., *inter alia*, Baron & Kenny, 1986; Imai et al., 2010; Hicks & Tingley, 2011).[15] As Gunzler et al. (2019) argue, one of the main advantages of applying such a mediation model is that its conceptual nexus can be easily understood via a simple visual representation like the one in Figure 1 below.

[14] Note that since most of the IFAD data mainly focus on farmers, I am primarily focusing on a specific segment of the value chain, with no information on other upstream segments (i.e., buyers, intermediaries, etc.).

[15] Baron and Kenny (1986) developed an SEM approach estimating causal mediation effects by decomposing the total treatment effect into indirect and direct effects. The indirect effect resulted in explaining how the treatment works through the considered mediator, and the direct effect represents all the other factors affecting the dependent variable.

Figure 1: The SEM Conceptual Nexus



Source: Authors' elaboration.

In this case, market proximity - proxied by the inverse of the distance from the nearest urban center - represents the mediator variable, whereas farmer resilience is the treatment variable, and farmers' volatility/vulnerability the final outcome. In particular, it is assumed that resilience influences both volatility and vulnerability, but this relation is mainly happening because of its effects on market proximity that indirectly drives the relationship between resilience and vulnerability. It is important to note that in this second setting the measurement of market proximity, which is captured by the distance to urban markets and incorporated into the instrumental variable model, remains exogenous in relation to fluctuations in food security levels. This allows for a stronger link between higher levels of farmer resilience and lower volatility and vulnerability in food security. Consequently, when examining the relations between resilience and food security volatility and vulnerability using a structural equation modeling (SEM) analysis, the best instrument in the instrumental variable model becomes the ideal candidate as a mediator. While instrumental variable estimation suggests complete mediation through the proposed instrument, indicating that market proximity does not directly impact food security fluctuations but operates through resilience, modern mediation analysis raises important considerations regarding the statistical significance of the indirect effect of the mediator, which was previously regarded as an instrument in the relationship under investigation The SEM approach is operationalized in the following system of equations:

$$M_i = \beta_0 + \beta_{xm} X_i + \epsilon_{mi}; \quad [7]$$

$$y_i = y_0 + y_{my} z_i + y_{xy} x_i + \epsilon_{yi}; \quad [8]$$

where y_{xy} represents the direct effect of resilience on volatility/vulnerability and $\beta_{xm} * y_{my}$ the indirect effect on volatility/vulnerability via market proximity. The additional use of income figures, i.e., of an objective and monetary measure of household welfare, ensures that the key results are not driven by the use of a subjective, non-monetary welfare measure such as self-reported food security.

5. Data and Descriptive Statistics

The considered database is formed by a pool of cross-sectional farmer households' data from a set of standardized surveys carried out by IFAD for its impact evaluations and assessments (the 'IFAD10' database). There are currently only two studies exploiting this novel data source to investigate, respectively, whether agricultural interventions could improve food security and nutrition (Garbero & Jäckering, 2021), and whether machine learning routines could predict household resilience for policy targeting purposes (Garbero & Letta, 2022). The subsample of the original IFAD10 database, that this paper uses, which contains data for all key variables, including a proxy for household resilience, incorporates a total of more than 15,000 initial observations across eight countries (Bangladesh, Brazil, Chad, Indonesia, Mexico, Nepal, Sao Tomé & Principe, and Senegal) collected between 2017 and 2018 (see Figure 2 below).

Figure 2: Map of Countries in the Considered Sample

Source: Authors' elaboration.

Descriptive statistics for a set of common basic demographic and socio-economic characteristics of households in the sample are reported in Tables A.1 and A.2 in the Appendix. On average, household heads in the sample are 48 years old, have four years of schooling, and are generally male. each household has, on average, a composition of four adults and two children, totaling six people. Aside from the head, average household members have more than four years of schooling and have barely attained the first level of education. In terms of ownership, each household in the sample owns on average 5 ha of land and very few other assets (both the Asset index and the Agricultural asset index are less than 15%). Households in the sample are generally poor, with a total gross income averaging below 3 thousand dollars.

Weiss et al. (2018)'s *Global Accessibility Map* was integrated with the IFAD10 database to derive the distance from the nearest urban center. The map quantifies travel time to cities in the year 2015, just before the survey data were collected at a spatial resolution of approximately one by one kilometer by integrating 10 global-scale surfaces characterizing factors affecting human movement rates and 13,840 high-density urban centers within an established geospatial-modeling framework (Weiss et al., 2018).[16]

On average, as shown in Table 1, the households under review are 43 km away from the primary market, positioning in the first quarter of the maximum observed distance range. Specifically, households in Brazil are furthest away from the main market, while those in Senegal and Mexico are the nearest. On the other hand, data from countries like Chad and Mexico show very high standard deviation values and put households 54-58 km away from the primary market on average. Lastly, distance measures are not available for all observations due to missing coordinates for a subsample of households, missing values were dropped.

Table 1: Distance from the Nearest Urban Center (km) – Descriptive Statistics

Variable name	N. of Observations	Mean	Standard Deviation	Minimum Value	Maximum Value
Bangladesh	1,968	46.41	17.72	11.80	81.90
Brazil	1,386	63.11	17.66	3.70	106.70
Chad	1,555	57.76	44.17	4.40	181.20
Indonesia	1,553	26.96	21.24	1	78.70
Mexico	1,631	54.29	23.89	4.50	108.30
Nepal	2,864	44.51	22.35	1.20	84.70
Sao Tomé & Principe	1,153	10.12	4.72	0.40	27.50
Senegal	2,177	35.51	23.21	1.70	107.90
Average	14,287	43.08	28.05	0.40	181.20

Table 2 gives summary statistics for the household-level raw FIES score. In this sample, the share of households that show some degree of food insecurity (i.e., households replying

[16] An urban center is defined by Weiss et al. (2018) as a contiguous area with 1,500 or more inhabitants per square kilometer or a majority of built-up land cover coincident with a population center of at least 50,000 inhabitants.

positively to at least one of the questions in the questionnaire) is, on average, close to 65% of the total interviewed.

Table 2: Raw FIES score – Descriptive statistics

Variable Name	N. of Observations	Mean	Standard Deviation
Bangladesh	1,970	2.32	2.39
Brazil	1,386	2.11	2.40
Chad	2,174	3.74	3.03
Indonesia	2,028	1.50	2.15
Mexico	1,760	1.91	1.94
Nepal	2,874	1.12	1.51
Sao Tomé & Principe	1,269	4.17	2.71
Senegal	2,181	3.10	2.41
Average	15,642	2.39	2.52

Households with severe food insecurity levels (raw FIES score equal to or above 7) make up over 10% of the total, and those with moderate food insecurity levels (raw FIES score equal or above 3) make up 41% of the total sample size. As in the case of market proximity, Chad is among the countries performing worst in the sample, with 493 households of the 2,174 interviewed with a raw FIES score equal to 8. Table A.3 in the Appendix provides the descriptive statistics by raw FIES score.

Finally, descriptive statistics are reported of the variable capturing household resilience, the ATR indicator. The ATR metric is constructed based on answers to the question: "To what extent were you and your household able to recover from shock *x*?". ATR is a self-assessment from the interviewed household taking the form of an ordinal variable on a scale ranging from 1 to 5:

a. Did not recover (=1);
b. Recovered to some extent, but worse off than before (=2);
c. Recovered to the same level as before (=3);
d. Recovered, and better off than before (=4);
e. Experienced the shock but was not significantly affected (=5)

The question is repeatedly asked for a roster of several different *x* shocks (droughts, floods, crop diseases, etc.) potentially experienced in the years before the survey. This work follows Garbero and Letta (2022) and compute household-level ATR as an average of all the values of the various abilities to recover reported by the household for each shock of the survey module.

As shown in Table 3, the investigated households tend to lack resilience to shocks, as they report, on average, an inability to recover to their previous level of welfare after the occurrence of a variety of shocks and stressors.

Table 3: Ability to Recover (ATR) – Descriptive Statistics

Variable Name	N. of Observations	Mean	Standard Deviation
Bangladesh	1,177	2.34	0.89
Brazil	1,345	2.26	1.22
Chad	1,981	1.62	0.90
Indonesia	1,104	3.69	1.02
Mexico	1,159	2.26	1.00
Nepal	1,304	2.61	1.23
Sao Tomé & Principe	567	2.39	1.26
Senegal	1,498	3.22	1.24
Average	10,135	2.49	1.26

Among the countries studied, only household samples from Senegal and Indonesia, show an average value of resilience above the resilience threshold of 3, signaling the ability to return to the same level of welfare as before the shocks. Still, on average, households can recover from shocks only to some extent, and are worse off, in terms of welfare, compared to the pre-shock situation. Observations for ATR are incomplete and reduce the sample of analysis to around 10,000 units.[17]

6. Results

This Section starts by presenting the results for the main outcome variable, food insecurity. The discussion of income results is reported in subsection 6.2.

6.1 Main Results on Food Insecurity

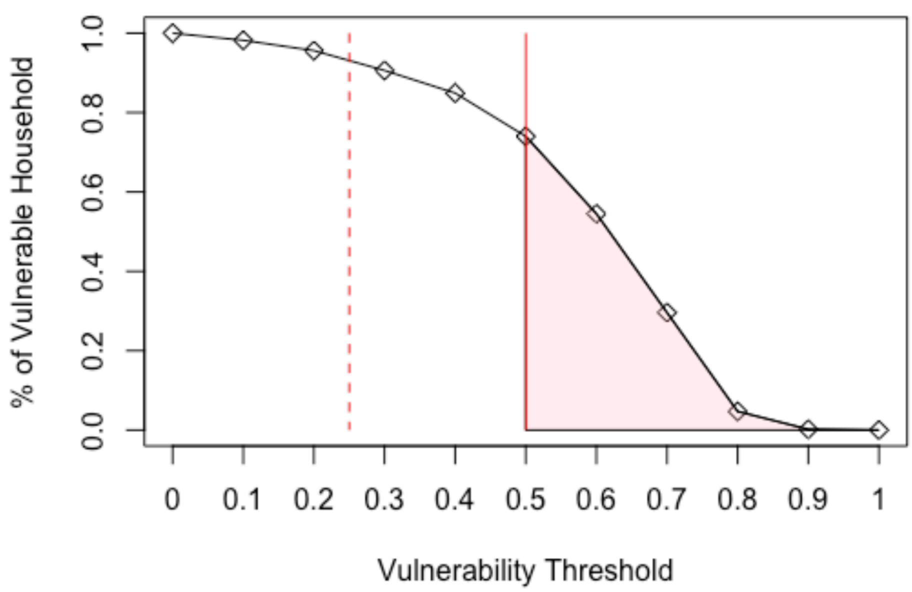
The results from the LASSO filtering procedure (Equation [1]) are reported in Table A.4 in the Appendix. The estimated LASSO residuals are then regressed on country dummies. In the second step (Equation [2]), the estimated residuals is regressed on the combinations of household characteristics previously selected by LASSO. As shown in Figure A.1 in the

[17] I am aware of the fact that this may cause some selection biases in the analyzed sample; specifically, households who provided a detailed response to the ATR part of the questionnaire may differ from those that have done so. However, the scattered nature of the FIES dataset does not allow to provide corrections for this possible source of bias. For this reason, establishing causality is not at the core of this work but seeing how, in the case of households with complete ATR answers, resilience drives vulnerability through market proximity.

Appendix, the resulting filtered residuals, capturing volatility to food insecurity, follow an approximately normal distribution, confirming the appropriateness of the filtering methodology.

After constructing the volatility dummy (considering as "volatile" only those households situated above the volatility median), one can proceed by applying the vulnerability procedure (Equations [4] and [6] in Section 4) and obtain through Equation 6 the adjusted vulnerability estimate, representing the household probability of being above the food insecurity line, equal to the median value of the standardized raw FIES score (in this case, equal to raw FIES score 2). The FIES vulnerability estimate $\widehat{V_h}$ is represented in Figure 3 below. As displayed in Figure 3, more than 60% of the households included in our cross-country sample is likely to be vulnerable in the near future (more than 80% of them if I reduce the vulnerability threshold to 25% of the probability of falling below the food insecurity threshold).

Figure 3 – The Adjusted FIES Vulnerability Estimate



Then, a vulnerability dummy is constructed based on the $\widehat{V_h}$ estimate obtained above, assuming as "vulnerable" only households with a probability of falling into food insecurity in the near future greater than 50% (i.e., more likely to be vulnerable than not). Please note that the vulnerability dummy is sensitive to both the adopted probability threshold, and food insecurity line. Some robustness checks are provided here. First, for the sake of consistency with the current literature (Adjognon et al., 2021), the food insecurity line is set equal to 3 (raw score), marking the first level of moderate food insecurity. Second, the probability threshold at 25% is tested instead of 50% to enlarge the population target.

Finally, as clarified above, the instrumented variable is the ATR resilience whereas the instrument is here proximity and access to markets, i.e., the inverse distance (in km) from the nearest urban center. Table 4 shows the estimated coefficients for the instrumental variable (IV) model described in Section 4, for three different outcomes : i) when the dependent variable is the estimated dummy volatility; ii) when the dependent variable is the vulnerability dummy resulting from the food insecurity line equal to the median of the standardized raw FIES score and vulnerability threshold 0.5 and, iii) when the dependent variable is the vulnerability dummy resulting from the food insecurity line equal to raw FIES score three and vulnerability threshold 0.25.[18]

Table 4: FIES Instrumental Variable Model

Dependent Variable:	Food Insecurity Volatility	Food Insecurity Vulnerability (FI Line = Median, vx >= 0.50)	Food Insecurity Vulnerability (FI Line = FIES Value 3, vx >= 0.25)
ATR	-0.194***	-0.157***	-0.212***
	(0.0257)	(0.0280)	(0.0289)
Observations	9,126	9,126	9,126
First Stage F Statistic	56.65	31.41	53.52
Wald Chi-Squared	56.66	31.42	53.53
Prob>Chi-Squared	0.0000	0.0000	0.0000

*Notes Robust standard errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001. The excluded instrument is the inverse of the distance from the nearest urban center. The FIES volatility dummy takes value one if FIES volatility is above the distribution's median and 0 otherwise. In the case of the food insecurity line equal to the median (FIES=2), the FIES vulnerability dummy takes value one if FIES vulnerability (vx) is above the distribution's median and 0 otherwise. In the case of the food insecurity line equal to FIES value 3, the FIES vulnerability dummy takes value one if FIES vulnerability (vx) is above the 25th percentile of the distribution and 0 otherwise. Robust standard errors in parentheses. Intercepts not reported.*

All estimates present consistent results, showing that a negative and statistically significant association exists between resilience (instrumented with market proximity), and food insecurity fluctuations. Besides, the Wald chi-square statistic and First Stage F statistic, both exceeding 10, making us confident that our instrument is not weak, validating its suitability for addressing

[18] In all cases, the F-test statistics from the first stage abundantly exceed the rule-of-thumb value of 10.

endogeneity concerns. The results of the first stage analysis in the instrumental variable model, along with the Stock and Yogo F Statistic,[19] are presented in Table A.5 in the Appendix. These findings confirm a positive relationship between resilience and market distance, highlighting the effectiveness of market distance as a valuable instrument for resilience. Farmers' higher levels of resilience cannot solely be attributed to location characteristics or individual factors, as studies like Meuwissen et al. (2019) have suggested. Proximity to final agri-food markets, which indicates better market chain positioning, enables farmers to enhance their coping strategies through spillover effects and information sharing mechanisms that promote governance and risk management. Additionally, being close to key clusters of actors and participating in core-periphery networks facilitates the rapid dissemination of information (Peres, 2014; Isaac et al., 2007), enabling farmers to adapt, seize new opportunities, and implement preventive measures against shocks (Blazquez-Soriano & Ramos-Sandoval, 2022). Therefore, proximity to urban clusters does not strictly refer to physical distance alone. Specifically, distance is defined as the distance to urban centers, which may not necessarily coincide with major cities.

To delve further into this issue, I propose here a mediation analysis to validate the hypothesis that a significant share of the mitigating impact of ATR on FIES fluctuations comes through the resilience-enhancing role of market proximity, as proxied by the inverse of the distance (in km) from the nearest urban center. To this end, the SEM analysis of Equations [7] and [8] in Section 4, picturing market proximity no longer as instrument but as a mediator, is applied. Table 5 reports the mediation analysis results, applied to food security volatility.

[19] The Stock and Yogo F statistic measures the effectiveness of instruments in addressing endogeneity concerns in an instrumental variable (IV) model, and a value higher than 10 is often suggested as a guideline, although not a fixed threshold, indicating that the instruments have sufficient strength to provide reliable estimates.

Table 5: FIES Structural Equation Model with Market Proximity as the Mediator

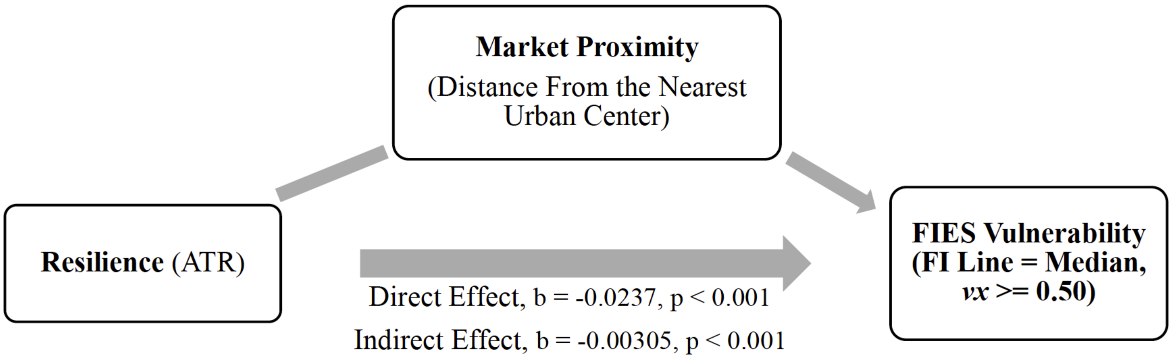
Dependent Variable:	Food Security Volatility	Food Security Vulnerability (FI Line = Median, vx >= 0.50)	Food Security Vulnerability (FI Line = FIES Value 3, vx >= 0.25)
Total Effect	-0.0556***	-0.0267***	-0.0438***
	(0.00405)	(0.00329)	(0.00395)
Direct Effect	-0.0523***	-0.0237***	-0.0399***
	(0.00405)	(0.00333)	(0.00396)
Mediated (or Indirect) Effect	-0.00323***	-0.00305***	-0.00393***
	(0.000646)	(0.000738)	(0.000661)
Observations	9,126	9,126	9,126
Mediation Effect as a Percentage of the Total Effect (%)	5.80%	11.42%	8.97%

Notes: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. *The excluded instrument is the inverse of the distance from the nearest urban center. Bootstrapped standard errors in parentheses. The FIES volatility dummy takes value one if FIES volatility is above the distribution's median and 0 otherwise. In the case of the food insecurity line equal to the median (FIES=2), the FIES vulnerability dummy takes value one if FIES vulnerability (vx) is above the distribution's median and 0 otherwise. In the case of the food insecurity line equal to FIES value 3, the FIES vulnerability dummy takes value one if FIES vulnerability (vx) is above the 25th percentile of the distribution and 0 otherwise.*

The model suggests that market proximity is mediated by almost 6% (-0.00323/-0.0556) of the total dampening effect of resilience on FIES volatility. The same procedure is replicated for the FIES vulnerability measures and report the results in the second and third column of Table 5. In this case, the share of the mediated indirect effect is more than 11% (-0.00305/-0.0267) for FIES vulnerability with the food insecurity line equal to the median of the standardized raw FIES score and vulnerability threshold equal to 0.50 and almost 9% (-0.00393/-0.0438) for FIES vulnerability with the food insecurity line equal to raw FIES score three and vulnerability threshold equal to 0.25. In short, I demonstrate, with empirical evidence, that being closer to the final market boosts household resilience and accounts for a significant share of the neutralizing role played by resilience in mitigating food security fluctuations and vulnerability to food insecurity.

Figure 4 shows the key results of the mediation analysis, picturing the critical mediating role of market proximity in the relationship between resilience and FIES vulnerability.

Figure 4: FIES Structural Equation Model



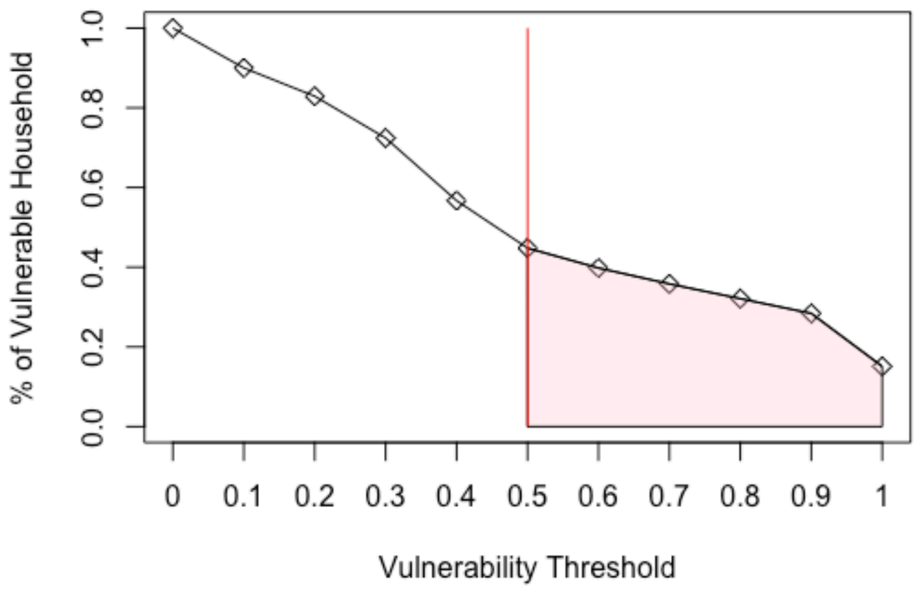
In brief, the IV approach does not allow to detect the mediation effect of market proximity in the relationship between resilience and food security volatility/vulnerability but it helps to confirm the *exogeneity* of market proximity in the dampening role exercised by (endogenous) resilience, on the final outcome, food security volatility/vulnerability fluctuations. According to Dippel et al. (2020), the exclusion restriction in standard IV models impacts their applicability. Remarkably, the SEM approach permits to explore the *strength* of the role of market positioning by considering it as mediator in the relationship between resilience and food security volatility/vulnerability. Results show that the mediation effect exercised by market proximity constitutes about a tenth of the total effect of resilience on food security vulnerability.

To ensure clarity, it is important to specify that market participation and positioning have a broader meaning in the development literature beyond simple geographical distance to main centers. This is supported by studies such as Montalbano et al. (2018), Minten et al. (2018), and Kaplinsky and Morris (2001). While better proximity to markets or positioning within them is considered exogenous when represented by geographic and topographic variables (Deichmann et al., 2009; Emran & Shilpi, 2012), it becomes endogenous when measured using more complex indicators like selling outlets and quantities sold. Therefore, considering the exogeneity requirement of the instrumental variable model, this research examines the effects of market proximity on farmers' resilience, specifically focusing on pure geographical distance from urban centers. The distance to main urban centers can be treated as fully exogenous in its relationship with food security fluctuations, except for the impact it has through resilience. However, this reasoning does not apply to the analysis of initial absolute levels of food security, which necessitates controlling for various essential household features, including distance to markets. In summary, fluctuations in food security triggered by shocks heavily depend on farmers' ability to cope with such shocks (i.e., resilience), and this capacity is largely influenced by proximity and participation to market chains, as extensively confirmed by the resilience and trade literature (see, *inter alia*, Alinovi et al., 2010, Antràs & Chor, 2022; Antràs et al., 2023).

6.2 Sensitivity Analysis Using Income

Table A.6 in the Appendix shows the outcomes of the LASSO filtering methodology for income. Just as for FIES, the resulting volatility distribution using the LASSO selected variables is a good approximation of the normal distribution (see Figure A.2 in the Appendix). The analysis then reproduces the FGLS and the vulnerability procedure applied for FIES, with a poverty line threshold equal to the median value of the considered income distribution. The adjusted vulnerability estimates $\widehat{V_h}$ for income are shown in Figure 5.

Figure 5 – The Adjusted Income Vulnerability Estimate



In the same way as for FIES, one constructs a volatility dummy for income considering as "volatile" only those households situated above the median of the income volatility distribution and a vulnerability dummy considering as "vulnerable" only households with a probability of being vulnerable $\widehat{V_h}$ greater than 50%.

The IV and SEM models of FIES are then replicated for income.

Table 6: Income Instrumental Variable Model

Dependent Variable:	Income Volatility	Income Vulnerability (PL Line = Median, *vx* >= 0.50)
ATR	-0.186***	-0.338***
	(0.0253)	(0.0294)
Observations	9,233	9,233
First Stage F Statistic	54.18	132.24
Wald Chi-Squared	56.19	132.27
Prob>Chi-Squared	0.0000	0.0000

Notes Robust standard errors in parentheses. * *p < 0.05,* ** *p < 0.01,* *** *p < 0.001. The excluded instrument is the inverse of the distance from the nearest urban center. The income dummy takes value one if income volatility is above the distribution's median and 0 otherwise. The income vulnerability dummy takes value one if income vulnerability (vx) is above the distribution's median and 0 otherwise. Robust standard errors in parentheses. Intercepts are not reported.*

Like in the case of FIES, resilience instrumented through market proximity is negatively related to both income volatility and vulnerability (see Table 6 above).[20] Overall, the results of the IV models on income align with the FIES ones.

With regard to the mediation analysis, Table 7 reports the results of the SEM for income.

Table 7: Income Structural Equation Model with Market Proximity as the Mediator

Dependent variable:	Income Volatility	Income Vulnerability (PL Line = Median, *vx* >= 0.50)
Total Effect	-0.0615***	-0.0535***
	(0.00382)	(0.00351)
Direct Effect	-0.0588***	-0.0474***
	(0.00384)	(0.00350)
Mediated (or Indirect) Effect	-0.00271***	-0.00618***
	(0.000599)	(0.000829)
Observations	9,233	9,233
Mediation Effect as a Percentage of the Total Tffect (%)	4.40%	11.55%

Notes Standard errors in parentheses. * *p < 0.05,* ** *p < 0.01,* *** *p < 0.001. The excluded instrument is the inverse of the distance from the nearest urban center. Bootstrapped standard errors in parentheses. The income volatility dummy takes value one if income volatility is above the distribution's median and 0 otherwise. The income vulnerability dummy takes value one if income vulnerability (vx) is above the distribution's median and 0 otherwise.*

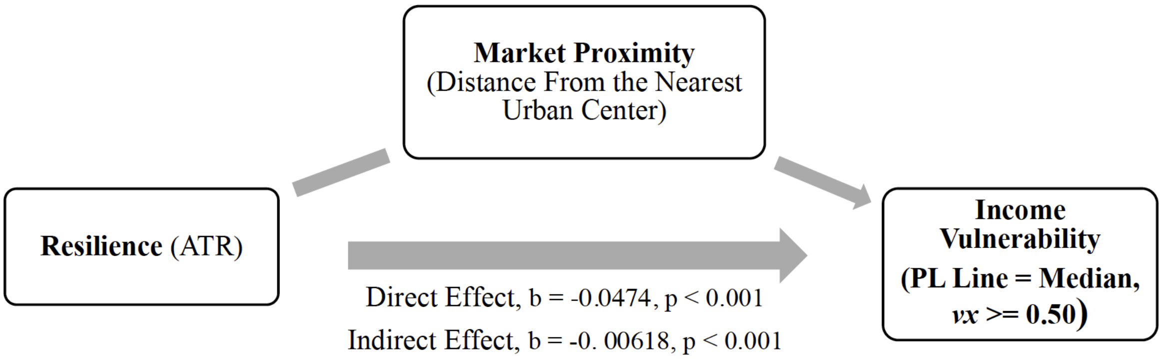
In a very similar way to FIES, proximity to markets accounts for approximately 4% of the total

[20] As in the case of FIES, F-test statistics from the first stage strongly reject the hypothesis of a weak instrument.

dampening effect of resilience on income volatility and 11.55% of the total dampening effect of resilience on household vulnerability to welfare fluctuations. The estimated effects are statistically significant at the 1% level.

Figure 6 summarizes the outcomes of the SEM model for income vulnerability.

Figure 6: Income Structural Equation Model



Therefore, like in the case of FIES and in line with the outlined IV models, the indirect effect of resilience (i.e., ATR) via market proximity on income volatility and vulnerability is always negative.

6.3 Discussion

Overall, according to our empirical analysis, resilience proxied by market proximity significantly influences vulnerability. As such, downward positioning in the market chain, i.e., being closer to the main markets, reduces FIES and income fluctuations. Previous studies (Pace et al., 2022, Slimane et al., 2013) reached a consensus on various factors influencing food security. Their evaluated mediator intensity was barely above 15% of the total effect. In line with these studies, according to the main estimates, the indirect effect of resilience (through closeness to markets) on food security, as well as income, vulnerability is above 11% of the total explained total effect, with the food security/poverty line set at the median value of the standardized raw score (equal to the raw FIES score 2 for food security). The sensitivity analysis conducted on income confirmed the results.

Table 8 provides an overview of the mediation analysis results across different specifications and outcome variables.

Table 8: Summary Table for The Mediation Analysis

	Point Estimate	Share of The Total Effect
Indirect Effect of ATR (Via Inverse Distance From the Market) on:		
Food Insecurity Volatility	-0.00323***	5.80%
Food Insecurity Vulnerability (FI Line = Median, *vx*>=0.50)	-0.00305***	11.42%
Food Insecurity Vulnerability (FI Line = FIES Value 3, *vx*>=0.25)	-0.00393***	8.97%
Income Volatility	-0.00271***	4.40%
Income Vulnerability	-0.00618***	11.55%

Additionally, Table A.7 in the Appendix presents the heterogeneity of the main findings for food security across continents. In line with the overall cross-country framework, the results of the mediation analysis indicate a significant positive mediation power for Asia and Latin America, while the effects are not statistically significant for Africa. Notably, among the Asian countries included in the sample, the mediated effect of market proximity on food security volatility and vulnerability amounts to nearly 20%.

7. Conclusions

Crop commercialization is one of the main drivers of modern-day economic development. Although the study of farmers' market decisions dates back to the 1990s (Fafchamps, 1992; von Braun, 1995; Key et al., 2000), a systematic approach to relations between market proximity, resilience and vulnerability to food insecurity is still missing. This work tests whether market proximity is associated, via increased resilience, with a reduction in farmers' food insecurity levels, welfare fluctuations and vulnerability. To achieve this, this paper utilizes an original microdata set developed by IFAD for cross-country impact assessments. Does proximity to the market have a significant association with higher resilience to shocks and food security? The preliminary correlation estimates suggest that the answer is yes. In contrast to previous research that often focused on specific case studies, a notable strength of this study lies in its cross-country approach. The empirical analysis consistently demonstrates that being positioned lower in the market chain enhances resilience, which subsequently leads to decreased levels of food insecurity and poverty. However, it is important to note that the estimates have certain limitations, and caution should be exercised in interpreting these findings as causal in nature.

This study highlights an important aspect that is often overlooked in standard theory and existing literature: the significance of market proximity in the dynamic relationship between resilience and food security volatility and vulnerability. By examining this interplay, the research sheds light on a crucial dimension that is frequently absent from traditional analyses. The results of this research show that the indirect effect of resilience (through closeness to markets) on food security vulnerability is above 11% of the total explained total effect, signaling the importance of market proximity in the relation between resilience and food vulnerability. The economic rationale behind this phenomenon lies in the impact of proximity to urban centers on farmers' resilience capacity and its subsequent effect on food security fluctuations. Specifically, the proximity to urban centers enables farmers to enhance their governance and risk management mechanisms by leveraging the information sharing and spillover effects originating from urban clusters and networks. This strengthened ability to cope with shocks, attributed to improved market positioning, enhances farmers' resilience and consequently reduces the magnitude of food security fluctuations.

Furthermore, this study adopts a comprehensive definition of resilience that encompasses the ability to recover from various types of shocks. Due to data limitations, it is not currently feasible to empirically test and measure resilience for each specific type of shock. However, as more detailed data on individual shock recovery becomes available, it would be valuable to replicate the proposed empirical framework for analyzing resilience in the context of singular shocks. Hence, the explicit identification and testing of these microchannels is deferred to future research.

Overall, these findings should motivate policymakers to prioritize agricultural-specific policies that target food insecurity hotspots and interventions such as improving transport infrastructure, reducing transaction costs, and providing accessible new technologies to enhance market proximity as crucial means of enhancing household resilience in rural developing contexts. Looking forward to future research, it will be essential to identify the risk channels that determine the fragility of local markets, enabling us to reconcile the absence of the welfare effects of positioning highlighted by theoretical literature with the empirical evidence of the welfare-enhancing effects of being closer to final markets. Household vulnerability to external shocks may indeed arise in the presence of markets (Bellemare et al., 2013) if this is not counterbalanced by higher resilience capacity. In this framework, policymakers must consider improving road and connectivity infrastructure, boosting farmers' market positioning, and enhancing access to markets as key measures to foster resilience and mitigate food security volatility and vulnerability. Additionally, there is a need for new and improved data concerning both food security and vulnerability estimates, as the current data is still fragmented and lacks specific survey-related features.

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Appendix

Table A.1 Variable Definitions and Other Basic Information

Variable name	Definition	Time Period	Source
Age of the Household Head	Age of the household head *(decimals)*	2017 – 2018	International Fund for Agricultural Development
Education Years of the Household Head	Years of schooling of the household head *(decimals)*	2017 – 2018	International Fund for Agricultural Development
Gender of the Household Head	Gender of the household head *(binary, 1=female)*	2017 – 2018	International Fund for Agricultural Development
Household Size	Number of people in the household *(decimals)*	2017 – 2018	International Fund for Agricultural Development
Household Average Education Level	Average education level attained by the household members *(values from 0 to 3)*	2017 – 2018	International Fund for Agricultural Development
Land Area	Area of land owned by the household *(ha)*	2017 – 2018	International Fund for Agricultural Development
Total Gross Income	Household total gross income from all sources *(USD)*	2017 – 2018	International Fund for Agricultural Development
Asset Index	Asset index based on common durable assets *(values from 0 to 1)*	2017 – 2018	International Fund for Agricultural Development
Agricultural Asset Index	Agricultural assets index based on common durable assets *(values from 0 to 1)*	2017 – 2018	International Fund for Agricultural Development

Table A.2. Summary Statistics – Whole Sample

Variable Name	N. of Observations	Mean	Standard Deviation	Minimum Value	Maximum Value
Age of the Household Head	15642	47.71	13.80	12	110
Education Years of the Household Head	15642	4.11	4.20	0	28
Gender of the Household Head	15642	0.17	0.37	0	1
Household Size	15642	5.76	3.83	1	30
Household Average Education Level	15642	0.94	0.85	0	3
Land Area	15642	5.33	10.25	0	281
Total Gross Income	15894	2732.39	6943.331	0	97497
Asset Index	15642	0.13	0.14	0	1
Agricultural Asset Index	15642	0.14	0.18	0	1
Treated	15642	0.48	0.50	0	1

'Gender of the household head' is a dummy taking value 1 if the household head is female and 0 otherwise. 'Household education level' is a categorical variable which can take the following values: 0=no education; 1=primary education; 2=secondary education; 3=higher education. 'Total gross income' is calculated as the sum of total cash and in-kind wage from agricultural employment; total cash and in-kind wage from all non-agricultural employment; sales of crop and other products, together with own consumption; sales of livestock, carcasses, and other products, together with own consumption; total sales and earnings from self-employment activities; private funds (remittances, transfers from individuals) and public funds (pensions, social transfers); and other sources of income like a land rental. 'Asset Index' and 'Agricultural Asset Index' are standardized measures of assets which range from 0 to 1 and have been generated for each country sample via factor analysis, using exclusively the assets that were common across all the datasets. 'Treated' is a dummy taking value 1 if the household was in the treatment group and 0 otherwise.

Table A.3: The FIES Questionnaire and Raw Score Descriptive Statistics

During the last 12 months, was there a time when a lack of money or other resources?
(Q1) You were worried you would not have enough food to eat (WORRIED)
(Q2) You were unable to eat healthy and nutritious food (HEALTHY)
(Q3) You ate only a few kinds of foods (FEW FOODS)
(Q4) You had to skip a meal (SKIPPED)
(Q5) You ate less than you thought you should (ATE LESS)
(Q6) You ran out of food (RAN OUT)
(Q7) You were hungry but did not eat (HUNGRY)
(Q8) You went without eating for a whole day (WHOLE DAY)

	Number of Observations by Raw FIES Score								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Bangladesh	737	157	198	358	138	110	109	108	55
Brazil	602	114	130	153	144	107	37	32	67
Chad	445	248	235	264	126	128	110	125	493
Indonesia	1,073	259	180	187	112	56	42	68	51
Mexico	541	371	302	204	126	83	76	57	0
Nepal	1,531	285	559	369	62	19	7	5	37
Sao Tomè & Principe	235	80	61	99	106	176	177	248	87
Senegal	473	165	258	433	261	174	182	108	127
Total	5,637	1,679	1,923	2,067	1,075	853	740	751	917

Table A.4: FIES LASSO Filtering Methodology

Dependent Variable:	**Standardized Raw FIES Score**
Age of the Household Head	-0.00185
Education Years of the Household Head	-0.0349
Household Size	0.0152
Land Area	-0.00404
Education Years of the Household Head^2	-0.000256
Gender of the Household Head *(1=female)Land Area**	-0.00252
Age of the Household Head*Asset index	-0.00298
Age of the Household Head*Treated	-0.0000811
Education Years of the Household Head*Treated	-0.00410
Asset Index*Agricultural Asset Index	-0.972
Asset index*Treated	0.0406
Asset Index^2	-0.427
Agricultural Asset Index^2	-0.284
Constant	0.249
Observations	15,865

*Notes: The variables whose coefficients were set to zero by the LASSO model are dropped. Only retained coefficients are shown. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Estimates signal correlation and not causality.*

Figure A.1 – FIES FGLS-Generated Variance

Standardized raw FIES Score with LASSO Controls

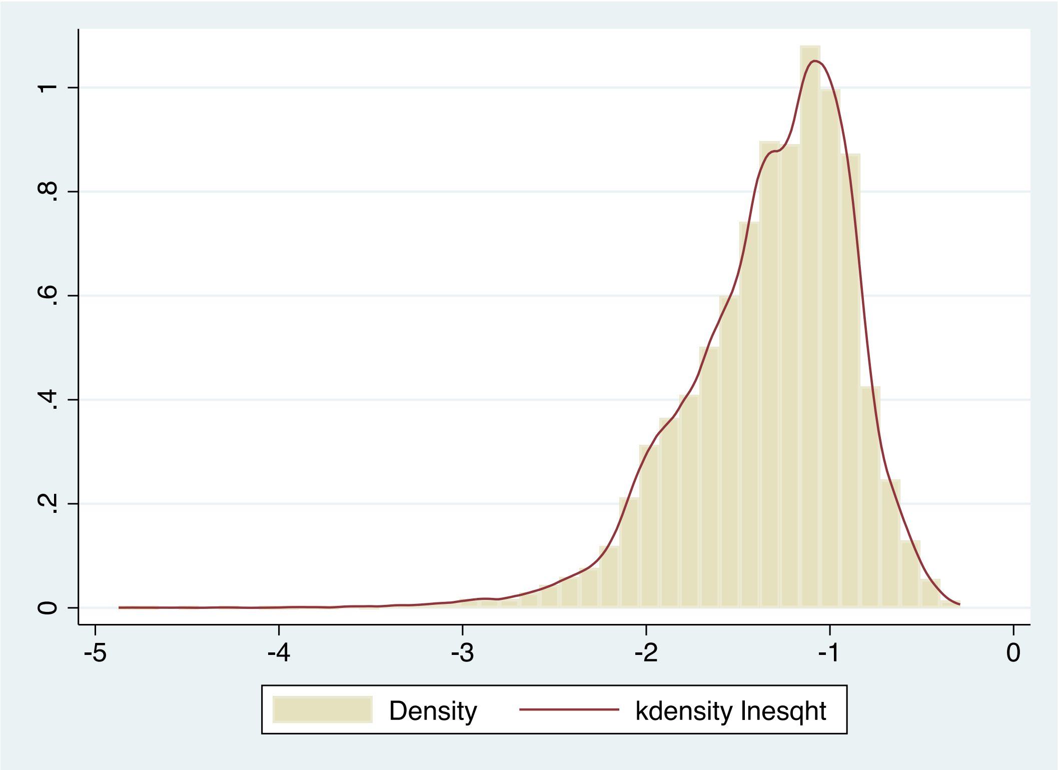

Table A.5: First Stage Results Instrumental Variable Model

Dependent Variable:	**ATR**
Inverse Distance	2.663*** (0.1992)
Observations	9,126
Stock and Yogo F statistic	100.839
Prob>Chi-Squared	0.0000

Notes Robust standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.6: Income LASSO Filtering Methodology

Dependent variable:	**Total gross income**
Age of the Household Head	0.0131
Education Years of the Household Head	0.133
Gender of the Household Head *(1=female)*	-0.376
Household Education Level	0.0332
Age of the Household Head*Household Size	0.000528
Age of the Household Head* Household Education Level	0.00192
Age of the Household Head*Land Area	0.000200
Household Size*Land Area	0.000197
Gender of the Household Head *(1=female)* *Land Area	0.00183
Age of the Household Head* Agricultural Asset Index	0.00200
Age of the Household Head*Treated	0.00221
Education Years of the Household Head*Treated	0.0303
Household Size*Treated	0.00652
Household Education Level*Asset Index	0.0620
Asset Index*Treated	-1.372
Asset Index^2	2.203
Agricultural Asset Index^2	3.435
Constant	4.243
Observations	16,119

Notes: The variables whose coefficients were set to zero by the LASSO model are dropped. Only retained coefficients are shown. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Estimates signal correlation and not causality.

Figure A.2 – Income FGLS-Generated Variance

Natural Log Income with LASSO Controls

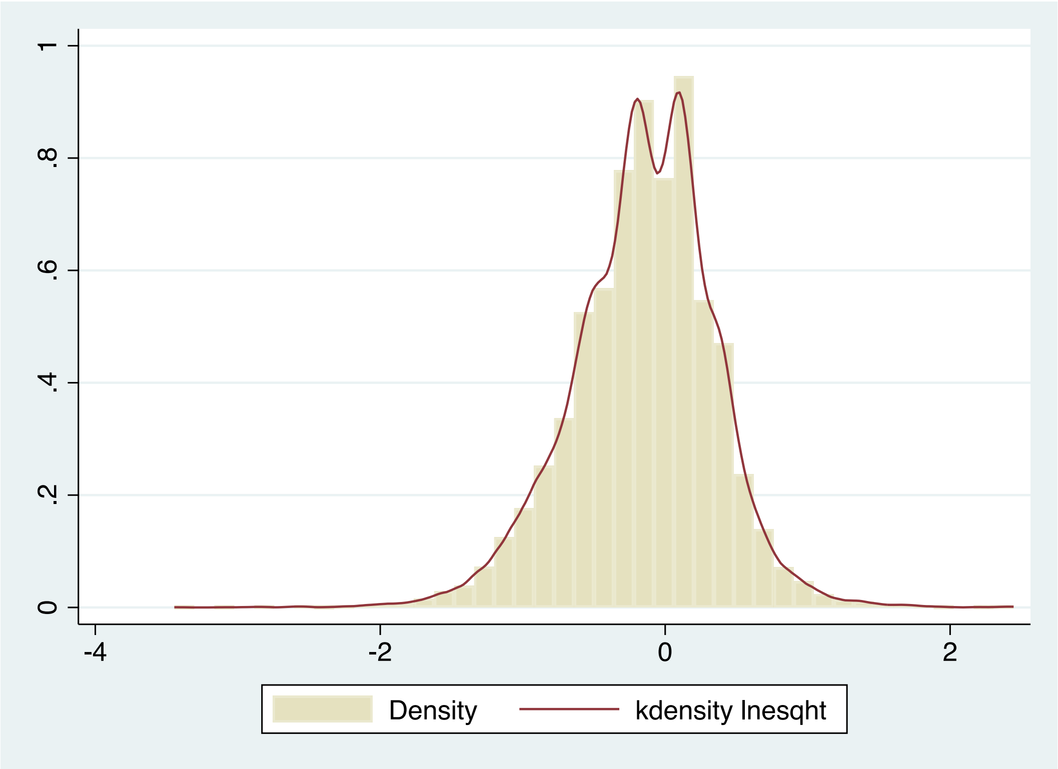

Table A.7: Summary Table for The Mediation Analysis by Continent

	ASIA		AFRICA		LATIN AMERICA	
	Point Estimate	**Share of The Total Effect**	**Point Estimate**	**Share of The Total Effect**	**Point Estimate**	**Share of The Total Effect**
Indirect Effect of ATR (Via Inverse Distance From the Market) on:						
Food Insecurity Volatility	-0.00940***	19.7%	-0.00150**	1.3%	-0.00308**	Only indirect effect is significant
Food Insecurity Vulnerability (FI Line = Median, *vx*>=0.50)	-0.00791***	19.3%	0.000849	Indirect effect is not significant	0.00200***	Only indirect effect is significant
Food Insecurity Vulnerability (FI Line = FIES Value 3, *vx*>=0.25)	-0.00281***	14.1%	0.0000873	Indirect effect is not significant	-0.000401*	Only indirect effect is significant

ESSAY 3

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FARMERS, FIRMS, AND VALUE CHAINS: EVIDENCE FROM SPATIAL PANEL DATA FROM ETHIOPIA[+]

Abstract

Scholars have advocated that the closeness of farmers to firms in global markets positively impacts their welfare levels; firms gain from this relationship in terms of productivity. However, empirical evidence is scarce. This paper sheds light on this issue by applying a spatial panel regression model to a combined longitudinal dataset of firm and farmer surveys. Specifically, this work tests the relationship between farmers' positioning in markets (in terms of geographical distance and positioning in value chains) and firms that import and export abroad, as well as the relationship between firms' closeness to farmers and their productivity levels. The key results are i) better farmers' positioning, both geographically with respect to firms in global markets and, in value chains, boosts the welfare of households; ii) firms' proximity to farmers operating in value chains affects their productivity. These findings highlight how better farmer-to-firm relationships are crucial to foster local development.

Keywords: Rural development; GVCs; Food security; Spatial regression

JEL-Codes: Q12; O12; C31

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Introduction

Value chains (VCs) represent a crucial opportunity for farmers in developing countries to move from subsistence-oriented and farm-centered systems to more commercialized, productive, and off-farm-centered ones (Montalbano et al., 2018b). However, farmers in developing areas risk becoming "locked" into value chain segments characterized by low value-added potentials (Mudambi, 2008; Gereffi & Lee, 2012). For instance, in VCs, firms shape the economic upgrading among their suppliers (Dolan & Humphrey, 2004; Maertens et al., 2012) by limiting their opportunities through costly contractual arrangements (Alford, 2020; Nadvi, 2008). However, according to Pasquali et al. (2021), recent changes in the geographical distribution of VCs are significantly altering these dynamics.

Many suppliers in developing countries now serve multiple buyers participating in VCs (Horner & Nadvi, 2018). Farmers selling to different buyers in VCs acts as a flywheel for higher welfare levels. Being part of a VC network generates higher incomes, and thanks to the technology spillovers on food production, it also improves income stability and food security (Barrett et al., 2017). Still, multi-chain selling strategies can also result in higher costs (Tessmann, 2018). Smallholder farmers, lacking technical and financial capacity, may not comply with diverse requirements (Reardon, 1999). For companies, transaction costs for monitoring compliance may be very high if they source from smallholders (Swinnen, 2016), inducing them to reduce sourcing from small suppliers.

Furthermore, decisions to locate farms spatially for farming households can be critical in several ways (Vroege et al., 2020). Positive spillover effects can result from the activities and characteristics of nearby farms and the interaction with other farmers (Case, 1992; Bandiera & Rasul, 2006; Matuschke & Qaim, 2009). Negative spillovers are, in contrast, identified as structural changes (Storm et al., 2015) and unproductive decision-making (Lapple & Kelley, 2015). Farmers who sell perishable products are subject to the seasonality and perishability of their crops (Pasquali et al., 2021). For these reasons, small suppliers must cleverly locate in new markets (Neilson et al., 2018).

For their part, companies reach out to farmers most likely to maximize their profits (Bellemare & Bloem, 2018). Location and VCs' involvement heavily affect firms' choices about allocating inputs (Barrett et al., 2012c) and involvement (Taglioni & Winkler, 2016). Better positioning in VCs increases local firms' chances to source raw materials locally and increase their productivity. Particularly, upstream specialization networks in VCs enhance local sourcing and support local suppliers (Amendolagine et al., 2019).

Most empirical evidence on agri-food VCs has arisen from case studies on products that assess the impact on national economies (Salvatici & Nenci, 2017). Few have been conducted on farmers, especially in multi-chain selling strategies (Horner & Nadvi, 2018). Recent studies have highlighted how developing agri-food chains can foster rural income, reduce poverty, and boost growth (Maertens & Swinnen, 2009; Rao et al., 2012). Studies at the micro-level have analyzed how farmers in developing countries enter agri-food value chains, stressing the importance of contract farming and standards (Minten et al., 2009; Maertens & Swinnen, 2009; Swinnen, 2016). However, all these analyses still need to be improved in studying the link between farmers commercializing their crops and firms operating in global markets. In this framework, how farmers are located in geographical and VC terms is crucial. As spatial heterogeneity among farmers and firms becomes increasingly dominant, one lacks evidence of its impact on the welfare of households and the productivity of companies. This work tackles the questions: "To what extent does farmers' distance to firms, in global markets, and their positioning in VCs, affect their food and total consumption levels?" and "What is the effect of the minimum distance to farmers operating in VCs on firms' productivity?".

This paper contributes to the literature in three ways: 1) it assesses farmers' positioning both in terms of mere geographical distance to firms in global markets and of upstream versus downstream positioning in VCs and proposes a new combined measure capturing both factors; 2) it tests for the presence of spatial spillovers in the bidirectional linkage between farmers and firms; 3) it estimates the sign and size of the causal relationships between farmers positioning (expressed as geographical distance from firms and downstreamness in value chains) and firms operating in a global context; as well as the sign and size of the causal relationship between distance to local farmers operating in value chains and firms' productivity, broadly defined as the output over input value ratio.

It is essential to emphasize that this study considers distance in multiple dimensions, encompassing both geographical distance and market positioning. The concept of market or value chain positioning involves measuring the distance to final markets, which incorporates the proximity of firms to end consumers. However, the distinction lies in the type of distance and firms under consideration. Geographical distance is evaluated with respect to firms operating in global contexts, indicating their involvement in global value chains rather than local ones. On the other hand, positioning refers to the placement of farmers within crop market chains. In this context, firms operating in global markets can be seen as an extension of local value chains. Therefore, combining downstream positioning in crop chains with selling to global market firms can serve as a reasonable indicator of participation in global value chains, rather than solely local ones.

However, farmer-firm relationships encompass mechanisms that go beyond the scope of pure crop market chains, as they represent broader demand and supply interactions. To better understand the dynamics of supply and demand, this study distinguishes between farmer-to-firm and firm-to-farmer relationships within two distinct sub-samples. The analysis of farmer-to-firm relationships focuses specifically on firms with international exposure, such as those involved in importing or exporting agricultural products, particularly raw materials sourced from local farmers (e.g., unmilled wheat, maize, and barley). Many of these firms are engaged in grain milling, bakery product manufacturing, and non-metallic mineral products and construction industries. While some of these firms import inputs from abroad due to insufficient domestic supply, their exports indicate potential involvement in global value chains. In contrast, the analysis of firm-to-farmer relationships encompasses all types of firms that interact with farmers engaged in crop market chains, specifically targeting local crop chain relations. By examining these different relationships, this study aims to shed light on the effects of farmers' engagement in global chains through local firms and the mutual benefits derived from such interactions.

In conclusion, this study emphasizes the significance of farmers and firms' participation in value chains and highlights the differences between them. Building on the existing literature on farmers and firms' value chain engagement (e.g., Montalbano et al., 2018; Manghnani et al., 2021), it is observed that farmers participate in crop value chains by selling to formal input buyers, and their positioning within these chains can be assessed based on factors such as the quantity sold, the type of crop buyer, and the selling location. On the other hand, firms' ability to engage in global value chains depends on their level of international exposure. Therefore, the intersection between farmers involved in local value chains and firms operating in global markets serves as a crucial focal point for studying the dynamics between local and global value chain participation. Moreover, being the firms considered all located in urban areas, the conclusions of this work catch a broader market phenomenon than simple input-output or supply-demand relations: the transformation of local into global value chains.

The rest of the paper is arranged as follows. Section 2 describes the literature backing the study and the theoretical framework. Section 3 presents the proposed positioning measure for market value chain positioning at the micro-level; it analyzes the structure of crop value chains in the Ethiopian market and exemplifies the empirical approach. Section 4 illustrates the data and reports some descriptive statistics. The empirical strategy and the results for both the farmer-to-firm analysis and firm-to-farmer analysis are presented in Section 5. Section 6 concludes the paper.

2. Literature Review

In the 1980s, scholars defined “farm people” as those confined in stationary conditions with no new possibilities (Schultz, 1975). In this regard, Schultz (1975) is a pioneer in stressing the importance of social learning as transformations not generated from within agriculture but from organized research and input improvements. As a result, modern agriculture is now described as a "progressive state" in which farmers are dealing with conditions of economic change (Gunnarsson, 2021). The literature has deeply explored the effects of farmers selling to local and urban traders (Kyomugisha et al., 2018). Farmers selling to firms that process products for markets that face foreign competition have yet to be investigated (Gunnarsson, 2021). When farmers become suppliers in agricultural VCs, they occupy a favorable position for adopting new technologies and crop varieties. However, technology spillovers to farmers in the intra-firm network may be challenging at times.

In particular, firms that participate in global markets usually use foreign technology that is difficult to transfer; as such, technology passed on to farmers needs to be better tailored to the needs of farmers (Amsden, 2009; Di Maio, 2009). One way to solve this issue is through networks or neighborhoods. According to Bandiera and Rasul (2006), adopting technological spillover from dealing with local firms in international markets is correlated with networks of family and friends. Farmers converge in networks where friends and neighbors share their ideas and opinions about a new technology they have encountered (Golub & Jackson, 2010; Banerjee et al., 2019). As scholars point out, the success of these networks critically depends on the network structure and its participants (Golub & Jackson, 2010).

Geographical location, and thus farmers' spatial heterogeneity, plays a vital role in determining the welfare benefits of proximity. The cost of communications and coordination increases with space (Rodriguez-Clare, 1996). As a result, innovation deteriorates rapidly with distance (Crescenzi et al., 2007). In addition, farmers must decide whether to remain confined to a single crop buyer or diversify their crops and sell them to a buyer portfolio (Pasquali et al., 2021). New studies show that, especially in agri-food chains, suppliers have strategically positioned themselves to capitalize on new markets(Neilson et al., 2018). This is the case for farmers of perishable crops, who are subject to the products' seasonality and perishability (Pasquali et al., 2021).

The literature does not provide a clear position on how farmers' networks and neighbors affect the welfare effects of international firms on households in a multi-selling, dynamic environment like VCs. Still, spatial differences in market participation can have important implications for agricultural productivity and welfare (Gáfaro & Pellegrina, 2022). The literature currently reveals different aspects of spatial heterogeneity in the activities of both farmers and firms. For instance, farmers' decisions on location have been found to significantly affect their economic opportunities (see, *inter alia*, Beharry-Borg et al., 2013; Storm et al., 2015; Saint-Cyr et al., 2019). Similarly, spatial proximity impacts firm productivity (Cainelli et al., 2018; Duranton & Puga, 2004). The literature on spatial spillovers for farming activities is highly diverse (e.g., Wollni & Andersson, 2014; Holloway & Lapar, 2007). Neighborhoods are commonly defined as all farmers within a certain distance, and the Euclidian distance usually determines their influence. Nonetheless, the weights and directions of their spillover effects may differ due to factors beyond simple geographical distance, like physical or institutional borders (Vroege et al., 2020).

There is increasing evidence of the role of neighborhood effects in adopting agricultural technologies (e.g., Bandiera & Rasul, 2006; Conley & Udry, 2010). Most of these studies argue that spatial heterogeneity is a vital aspect of the farmer's decision-making process; neighboring farmers' decisions are interdependent (Wollni & Andersson, 2014). However, most empirical works still need the reasons underlying the dependence on the agricultural decision-making of neighbors (Manski, 2000). Spatial dependence tends to be generally attributed to agglomeration economies (Lewis et al., 2011) rather than informal information exchange. Especially in low-potential regions characterized by the scarcity of information, knowledge is usually acquired through informal channels like neighbors (Wollni & Andersson, 2014). In this framework, farmers' decisions may require the acceptance of their neighbors (Moser & Barrett, 2006).

According to Holloway and Lapar (2007), two spatial factors affect farmer-to-farmer dynamics, especially in market participation choices: the tendency of neighbors to make the same decision and the size of the neighborhood. Indeed, farmers within the same neighborhood receive co-influence as they share information about markets, prices, and quantities. All these factors define the effect of regional-specific neighborhood social capital provided by participating neighbors (McCulloch, 2003; Johnston et al., 2005). For firms, spatial heterogeneity is crucial in positioning within global and local markets (Cainelli et al., 2018). According to economic theory, spatial agglomeration increases firm productivity, and this positive effect is often accredited to lower production costs and improved performance (Duranton & Puga, 2004).

However, according to Cainelli et al. (2018), proximity results in productivity benefits only for supplier firms (i.e., firms/suppliers located upstream in VCs), while the effect is negligible for final (i.e., downstream) firms. In this regard, forward and backward participation in VCs has different spatial spillover effects (Zhu et al., 2022). Hence, farmers' positioning in the value chain also matters for input allocation. According to Barrett et al. (2012), firms' local procurement choices arise sequentially. First, companies use geographic targeting for input procurement (Smith, 1981). Then, they strategically choose the farmers from whom they outsource raw materials. This creates a selection problem for researchers who wish to estimate the effects of such a firm-farmer relationship (Barrett et al., 2012).

In VCs, input allocation choices become even more critical to firms' production strategies and farmers' growth. In this context, the local sourcing of inputs is a tremendous source of spillover effects (e.g., Rodriguez-Clare, 1996; Giroud & Scott-Kennel, 2009; Jordaan, 2017; Newman et al., 2015). Especially in developing regions, efficiency and market-seeking motivations foster local sourcing (Nunnenkamp & Spatz, 2003). Local inputs procurement decisions might strictly depend on global VCs (GVCs) involvement (Taglioni & Winkler, 2016). Research studies demonstrate that higher participation in GVCs enhances local firms' capabilities (Paus & Gallagher, 2008; Farole & Winkler, 2014) and productivity, particularly in upstream stages (Del Prete et al., 2016; Montalbano et al., 2018). Notably, a more intense VC participation by local actors leads to a higher share of inputs sourced locally by firms (Amendolagine et al., 2019).

In conclusion, the causal relationships between farmers' positioning and firms' local sourcing decisions are complex. Farmers' location choices (Holloway and Lapar, 2007; Storm et al., 2015; Saint-Cyr et al., 2019) and positioning in the VCs affect their welfare and local firms' strategies. On the other hand, local companies' input allocation in matrices that maximize productivity is driven by suppliers' geographical targeting (Barrett et al., 2012; Smith, 1981) and participation in global markets (Del Prete et al., 2016; Montalbano et al., 2018a; Amendolagine et al., 2019). Although alluded to in scattered works, a thorough, specific investigation of all these farmer-to-firm and firm-to-farmer dynamics still needs to be appraised by current literature.

3. Empirical Framework

At the micro-level, one fundamental data limitation exists for measuring VC positioning: data does not usually permit the retrieval of further information on the market chain, such as the intermediate purchases or the value added generated by each line of crop selling to each buyer. Hence, it is impossible to consider the classic input-output tables applied in macro-studies on country-section GVCs positioning. Table 1 illustrates a generic farmers' market chain. It is important to note that it does not constitute an adaptation of a standard input-output table as it does not include the flows of inputs but rather only the sequential distribution of outputs. It is also important to clarify that one can only compute the value added with inputs. Hence, one must refrain from attempting to provide farmers' positioning in value chains but rather a commercialization positioning more sophisticated than those generally applied in the empirical development literature.

Table 1: Agricultural Value Chain Illustration Table

	Household Final Crop Sold			**Total Crop Sold per Household**
	Buyer 1	...	*Buyer S*	
Household 1	C_1^1	…	C_1^S	Y_1
…	…	C_i^r	…	Y_i
Household J	C_J^1	…	C_J^S	Y_J
Total Crop Sold per Buyer	C^1	…	C^S	

Following the trade literature on VC positioning and as suggested in Antràs & Chor (2019), a first measure of market positioning comes from simply revising the measure proposed by Antràs et al. (2012) to the share of output sold to final consumers. Hence, extending this logic to farmers, positioning in VCs is simply equal to the share of crop sold by each farming household, C_i^r, to the total crop sold along the chain, Y. In farmers' VCs, the selling position is interpreted by Montalbano et al. (2018) as the identity of the intermediary to whom farming households sell their crops along the chain. Following these authors' reasoning, commercialization stages are numbered according to the degree of downstream positioning in the chain of the acquiring intermediary (i.e., more downstream intermediaries are associated with higher values of Selling Position).

However, a few additional considerations are necessary: first, despite the inclusion of the selling position, expressed via the identity of the intermediary to whom the crop is sold in the chain, positioning, as it is, would consider only those farmers whose crop is most sold to downstreamness intermediaries without any indication on *where* it is sold (i.e., if outside/inside the village, the district or the region); secondly, there is no concern for the fact that farmers sell to multiple buyers/stages in the chain. Finally, the proposed proxy for the VC position needs to ponder the price elasticity of demand for the crop sold along the chain. On the basis of Antràs and Chor (2013)'s theory, if the price elasticity of the demand of the good sold is sufficiently low (as it usually is for crops) vertical integration will occur in the first stages of the chain. In particular, in the development literature on agricultural value chains, choosing a distant-buyer (i.e., selling outside the village, the district or the region) leads to higher level of performance and higher chances to be vertically integrated in the chain (Minten et al., 2019).

A stand-alone measure for farmers' positioning in VCs needs to consider the following factors: the ratio of the crop sold along the chain; the identity of the intermediary who bought the crop as a proxy for Antràs and Chor (2018)'s stage-positioning; the location where the transaction took place (i.e., an alternative measure of whether farmers choose a distant-buyer); the price elasticity of demand of the crop sold proxying the probability of being vertically integrated. In addition, a complete indicator would not relate to the length of the selling chain, but it would be presented as a score making the measure impartial to the different types of crop chains. Hence, a well-rounded indicator for farmers' VC positioning is:[21]

$$D_i^r = p_i^r \times \frac{C_i^r}{Y} \times {l_i^r}^{1/(1-\rho)}; \qquad [1]$$

[21] See Section 3 in Essay 1 for a detailed explanation of how the proposed VCs positioning indicator is constructed.

where p_{ij}^{rs} equals the ratio $\frac{Selling\ Position\ Number}{Total\ Number\ of\ Selling\ Positions}$, l_{ij}^{rs} the ratio $\frac{Selling\ Location\ Number}{Total\ Number\ of\ Selling\ Locations}$, C_i^r the quantity of crop sold, and Y the total quantity of that crop sold along the crop market selling chain. It is essential to mention that farming households are commonly involved in multiple crop value chains. Hence, the resulting positioning value attached to them will be the average of their positioning score in each single crop selling chain.

In Ethiopia, farmers are integrated into agricultural value chains via multiple layers (Babama'aji et al., 2022; Ayele et al., 2021). Village collectors usually constitute the first layer as the crop buyer closest to farmers. In addition, there are agricultural cooperatives offering storage for crops free of charge (USAID, 2017) and purchasing crops from farmers. Then, there are wholesale markets that are generally located in main districts/towns. Wholesalers may buy crops directly from farmers or through village middlemen or brokers; they then sell to processors and/or retailers (USAID, 2017).

Moreover, in addition to the actors described above, farmers may sell through mobile or commodity exchange markets. In particular, the Ethiopian Commodity Exchange (ECX) is a government-driven commodity exchange founded in 2008 to connect suppliers and exporters more efficiently and transparently (Gashaw & Kibret, 2018). Based on standard crop contracts, ECX is a trading platform for buyers and sellers.

The complex dynamics behind farmers' location and VC positioning can be challenging to tackle, even with the use of refined panel regression systems. Farmer-to-firm and firm-to-farmer dynamics embed factors, like spatial heterogeneity, commonly ignored in current analyses. In the most recent micro-level GVCs literature, absence of consideration for the spatial effects represents the main limitation for all types of estimates (Cainelli et al., 2023). For this reason, this work implements, together with the standard fixed effects, spatial models accounting for spatial effects.

Specifically, values of variables measured from observations of units that are geographically close to each other tend to be correlated (Tobler, 1970). What linear regression models fail to consider is that the independent variables that influence the dependent variable can be different at each unit location (Permai et al., 2019). Economic and sociodemographic variables, such as employment, and per-capita expenditures, often exhibit spatial clustering or geography-based correlation (Moscone & Knapp, 2006; Revelli, 2005; Elhorst & Fréret, 2009). Likewise, same farmer-to-firm or firm-to-farmer distance values may impact the dependent target variable differently as they are hindered by factors which are spatially correlated.

Standard regression models implemented to analyze panel data suppose that observations are independent of one another; this sounds extremely unrealistic if considering the observed variation in the dependent variable arising from unobserved or latent influences (LeSage, 2008). According to Anselin and Griffith (1988)'s theory, there exist two main phenomena causing endogenous variables, exogenous variables or the error term to be spatially correlated: autocorrelation, better referred to as spatial dependency; and heterogeneity or spatial non-stationarity. The authors define autocorrelation as the phenomenon occurring when there is similarity between observed values and their location; while heterogeneity refers to the idea that explanatory variables can be the same and yet not have the same effect at all points, causing the error term to differ by geographical zone. Therefore, spatial econometrics represents a valuable approach to account for spatial spillovers in farmer-to-firm and firm-to-farmer relationships. Empirically, such spatial spillovers in panel datasets have been measured through spatial panel-data models. Estimating spatial panel-data models commonly relies on the STATA command *xsmle*.

xsmle is a user-written command for spatial analysis that Belotti, Hughes, and Mortari developed in 2017. Through quasi-maximum likelihood estimation, it permits the assessment of both fixed- and random-effects spatial models for balanced panel data. *xsmle* enables the test of this work's hypotheses for two types of spatial models: the spatial autoregressive model (SAR) and the fixed-effects spatial autocorrelation model (SAC). The SAR model allows to to address the spatial autocorrelation in the dependent variable; while the SAC model also accounts for spatially autocorrelated errors, υ_t (equal to $\lambda M\upsilon_t + \varepsilon_t$). Most importantly, *xsmle* also allows to compute the direct, indirect, and total marginal effects coming from the effect of a change in the explanatory variable for a specific unit on the unit itself and, potentially, all other units indirectly.

The main caveat inborn in all spatial models is the requirement of a strictly balanced panel dataset to operate efficiently (Belotti et al., 2017; Floch & Le Saout, 2018). One way to solve this issue is to interpolate the missing values using geostatistical techniques (Anselin, 2001). However, this solution is only possible when the percentage of missing values is relatively small and even then, it is unapplicable for survey data (Floch & Le Saout, 2018). Hence, the analysis of this work must lie on a restricted sample composed of a balanced panel dataset with no missing value.

In addition, the analysis is divided according to the type of geographical distance considered, whether farming-household-to-firm (or simply household-to-firm or farmer-to-firm) or firm-to-farming-household (or simply firm-to-household or firm-to-farmer). The final sample for both types of analyses is generated using the STATA command *geonear*, which finds the nearest neighbors using geodetic distances, better defined as the length of the shortest curve between two points along the surface of a mathematical model of the earth. The resulting neighbors are set at a distance of 1,000 km from firms, in the case of the household-to-firm distance, and from households, in the case of the firm-to-household distance. Given the hypotheses highlighted in the Introduction and backing the analysis, the resulting distance value calculated in kilometers by *geonear* is grouped using the mean per household in the case of the farmer-to-firm empirical framework, while it is arranged by minimum value per firm in the case of the firm-to-farmer analysis.

A note of caution must be added regarding the interpretation of distance in this study. Distance, interpreted as the geographical distance alone between farmers and firms, represents a useful proxy for market proximity of farmers' crops. Development scholars have commonly assumed such geographical distance as a proxy for “remoteness”; which is usually perceived as one of the main indicators of market access (Bagchi et al., 2021). Nonetheless, the current development-trade literature takes a step forward in this definition by redefining distance as "travel distance" via road links (see, *inter alia*, Fiorini et al., 2021; Fiorini & Sanfilippo, 2022). Unfortunately, the exact geo-variables for farming households are confounded for privacy purposes in LSMS-ISA's household surveys not permitting the use of precise road links in the calculation of farmer-to-firm distances as well as firms-to-farmers distance.

Finally, the empirical strategy of the farmer-to-firm analysis is improved by including, as dependent variable, a more comprehensive measure combining the inverse of the geographical distance from firms operating in global markets with the mean results per household of the adjusted positioning indicator in value chains outlined above. In order to determine the sensitivity of these findings, the same empirical strategy proposed for food and total consumption is implemented on the variable "food quantity." Robustness checks for this analysis rely on replicating the strategy with different weight matrices and on a test considering the distance to firms with no international exposure. Panel regressions are conducted on fixed effects after the Durbin–Wu–Hausman test results confirmed this choice over random effects. Similarly, in the firm-to-farmer analysis, robustness checks comprise different weighting matrices for the spatial models.

4. Data and Descriptive Statistics

This work employs data from the Ethiopia LSMS-ISA farming household dataset gathered by the Ethiopian Central Statistics Agency (CSA) in collaboration with the World Bank and firm data gathered by the CSA directly. The Ethiopia LSMS-ISA socioeconomic survey was conducted in four waves between 2011 and 2018. However, there is clear information about crop buyers and input sellers thanks to a detailed network roster up to the third wave, i.e., 2015. The CSA firm surveys (mentioned as "CSA surveys") conducted, instead, cover the years from 2012 to 2015 in three waves. Given the need for a strictly balanced panel for spatial regression, this work confines its focus only to the surveying waves between the years 2011-2015. The LSMS-ISA surveys are representative at the national, urban or rural, and regional levels. Possible panel attrition issues have been addressed by conducting unconditional ANOVA tests between samples. The CSA surveys cover all firms with at least ten persons using electricity in their production process. The dataset includes information at the level of the single productive establishment. All surveyed firms must comply with CSA requirements, and the census is therefore representative of more structured and formal firms in Ethiopia.

The farmers' results are based on two sets of data: household data and agricultural data; the first dataset includes modules for the characteristics of the households, while the second entails relevant post-harvest and post-planting information such as buying outlets and selling locations. Specifically, in the LSMS-ISA post-harvest questionnaire, farmers provide evidence of their main commercial partners by answering the question: "who bought the largest part of your sold crop?" As in Montalbano et al. (2018b), answers to this question are used to design the indicator of positioning in the value chain. In addition, the same network roster is used for input sellers in the post-planting questionnaire. The firms' results are based on the CSA survey data, which contains basic information about the company, such as the year of commencement and the headquarters location. The CSA data comprise detailed figures about input allocation, such as the quantities of local and imported material. In addition, the CSA dataset includes detailed information at the establishment level on location (i.e., town/village).

The CSA and LSMS-ISA datasets provide a unique source of information on the possible linkages between farmers and firms that operate in VCs. As explained in Section 3, the two datasets are unified when calculating the distance household-to-firm and firm-to-farmer. The final samples include only observations that fit the "strictly balanced" assumption of the spatial models described in Section 3 as well as it adapts to the limitations of the spatial modeling computational algorithm processes requiring no duplicates in the geographical coordinates. A description of the variables considered in both household-to-firm and firm-to-household analysis is available in the Appendix (Table A.1). The household-to-firm panel dataset includes 687 observations divided equally across three surveying years, 2011, 2013, and 2015. As required by spatial modeling via *xsmle*, there are no missing values.

Table 2 summarizes household characteristics.

Table 2: Household-to-Firm – Summary Statistics

	N. of observations	Mean	Standard Deviation	Minimum Value	Maximum Value
Gender of the Household Head ***(binary, 1=female)***	687	0.14	0.36	0	1
Number of HH Members in the Labor Force ***(decimals)***	687	2.53	1.28	0	7
Household Size ***(decimals)***	687	5.42	2.03	1	12
Average Years of Education for HH Adults ***(decimals, years of schooling)***	687	1.20	1.41	0	6.33
Number of HH Children ***(decimals***	687	2.05	1.52	0	8
Number of HH Infants ***(decimals)***	687	0.45	0.71	0	3
Getting Free Seeds ***(binary)***	687	1.95	0.21	1	2
Purchasing Seeds ***(binary, 2=yes)***	687	1.96	0.19	1	2
Using Fertilizers ***(binary, 2=yes)***	687	1.83	0.37	1	2
Seed Type ***(categorical)***	687	1.20	0.50	1	3

Specifically, household heads are generally male, and each household consists of., on average, five people with two children and almost no infants. Average household adult members have more than one year of schooling, and more than two household members are generally in the workforce. Regarding inputs, each household, on average, utilize fertilizers, purchase seeds, and get some for free. The seed type most frequently used is the traditional one.

As mentioned, LSMS-ISA data provides incredible insights into the selling activity of farmers during the considered surveying years. Frequencies on both farmers' selling positions and location across VCs are calculated through the provided network rosters. As detailed in Table A.2 and A.3 in the Appendix, more than 50% of the surveyed farmers do not sell in VCs; among those who do sell in VCs, they sell predominately in the primary market or through private traders near their town or district. Similarly, network rosters allow for a more profound analysis of input suppliers. As shown in Table A.4 in the Appendix, 60% of the analyzed sample does not use urea as a fertilizer or has yet to specify its supplier. However, for those farmers using urea, its leading suppliers are agricultural cooperatives followed by government agencies, actors constituting the most upstream part of the chain.

The main analysis of this work on farmers-firms relations includes only firms that have exposure to global markets, i.e., they either import and/or export goods. This exposure to global markets is defined as GVC involvement by Manghnani et al. (2021). According to the authors (2021), companies in GVCs are those companies that satisfy at least one of the following characteristics: 1) they import inputs, 2) they export sales; and 3) they have access to international networks. In the household-to-firm-distance-calculation, firms have two main features: they export and/or import raw materials that could be provided by the farmers locally (i.e., wheat, maize, and barley).

Instead, the firm-to-household dataset considers all types of firms (i.e., those operating in global markets and not) and all types of raw materials (not only those provided by farmers in the LSMS-ISA dataset). Unfortunately, unlike households in the LSMS-ISA data, there is no clear information on the firm's latitude and longitude, so one can only rely on their locating village coordinates. For this reason, the strictly balanced panel resulting from the firm-to-household-distance-calculation is constituted by only 432 non-repeating observations from 2012-2015. Table 3 summarizes the firms' characteristics in their respective section of analysis.

Table 3: Firm-to-Household – Summary Statistics

	N. of observations	Mean	Standard Deviation	Minimum Value	Maximum Value
Employees ***(decimals)***	432	73.18	161.46	0	2,394
Exports ***(decimals, ETB)***	432	3,575,513	37,100,000	0	519,000,000
Male Owners ***(decimals)***	432	4.42	37.55	0	457
Keeping Accounting Books ***(categorical)***	432	1.58	0.70	1	3
Initial Paid-Up Capital ***(decimals, ETB)***	432	2,834,691	5,585,533	0	61,200,000

On average, companies in the final sample have 73 employees, four male owners, and they keep their accounting books. These companies generally have an initial paid-up capital of around 3 million ETB and a total export value of about 3.6 billion ETB. Nevertheless, it must be specified that only nine firms, in the considered sample, export abroad. Importing firms are, instead, 52. Regarding inputs allocation, 84% of the firms importing raw materials are importing wheat. Interestingly, wheat is the raw material mostly acquired locally by firms in the sample. As highlighted in Table A.5 in the Appendix, almost all firms acquire their inputs locally, and only some rely on international imports. Following wheat, flour is the second most locally acquired raw material.

Lastly, dependent variables are classified according to the dataset, considered either households or firms. In the household-to-firm panel, "food quantity" is also used in sensitivity testing. The summary statistics for all dependent variables are shown in Table 4 below. All monetary values are deflated in order to convert nominal values into real/constant values using the Consumer Price Index (CPI) computed by the World Bank.[22] Moreover, they are expressed in 2010 local currency value.

[22] Available at http://data.worldbank.org/indicator/FP.CPI.TOTL.

Table 4: Dependent Variables Summary Statistics

		N. of observations	Mean	Standard Deviation	Minimum Value	Maximum Value
Main Results per Household[23]	**Annual Food Consumption** ***(decimals, ETB)***	687	2,026.13	1,244.54	436.10	12,718.68
	Annual Total Consumption ***(decimals, ETB)***	687	2,487.38	1,413.85	492.29	14,087.28
Sens. Test. Hous.	Food Quantity *(decimals, Kg)*	684	3.51	11.71	0.05	250
Main Results Firms	**Total Sales** ***(decimals, ETB)***	432	30,800,000	69,700,000	0	712,000,000
	Productivity ***(decimals, ETB)***	432	9.03	38.01	0	630.78

Specifically, households spent, on average, about ETB 2,500, ETB 2,000 on food per adult equivalent. Generally, food quantity does not go over 3.5 Kg. Productivity in companies is defined following the classical OECD manual's definition as the ratio of the value of outputs over the one of inputs used (OECD, 2001). Although one is aware of the fact that revenue-based productivity measures may confound the effects of trade on firms' productivity (e.g., De Loecker, 2011 and De Loecker et al., 2016), physical factor productivity is not possible to calculate. This is due to the scattered nature of the considered census on Ethiopian establishments for the considered year and the fact that this study is restricted to the analysis of a strictly balanced panel resulting from firm-to-household-distance-calculation. Firms in the sample have approximately 30 million ETB worth of total sales in real terms and a productivity ratio of around 9%. All real consumption estimates are normalized via the adult equivalent measures provided in the LSMS-ISA dataset.

Unlike dependent variables, independent variables are very similar; they are the same measures (positioning in terms of geographical distance and value chain positioning) applied to different datasets. In particular, all household-to-firm results, as well as the sensitivity testing, evaluate distance geographically and via the combined variable, positioning in value chains times the

[23] Consumption estimates are adjusted for the per adult equivalencies in consumption aggregates reported in the LSMS-ISA dataset.

inverse of geographical distance considering the entire LSMS-ISA households' dataset to the sample of firms with global exposure (i.e., firms exporting and/or importing and with raw material procurement limited to the crops sold by the households). However, in the case of one of the tests of the robustness checks, the firms considered are those firms neither importing nor exporting and getting all raw materials except for those potentially provided by farmers. In the case of the firm-to-household analysis, no restriction is imposed on the firm dataset, but households from whom distance to firms is calculated are those whose value of downstreamness is above zero. Hence, it considers only households in value chains.

Descriptive statistics for the independent variables are reported in Table 5. Specifically, in the household-to-firm analysis, the mean physical distance between households and firms is both for the main results and the robustness testing around 450 km. Although, in the case of the firm-to-household section, the minimum firm-to-household distance is around 20 km. As anticipated in Section 3, geodetic distances are calculated across the two datasets using the STATA command *geonear*.

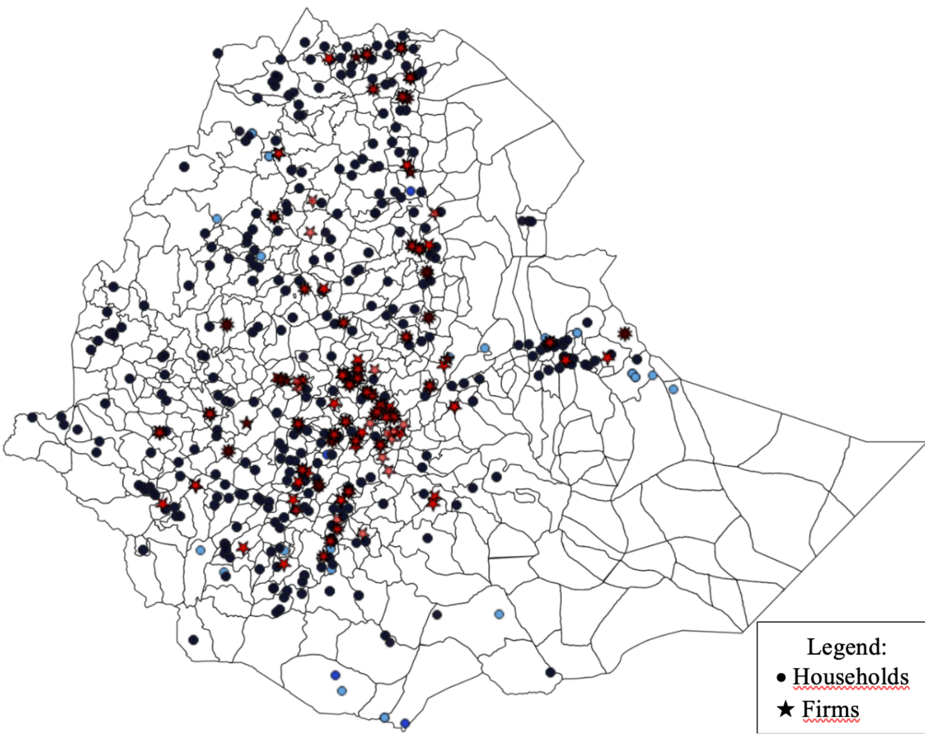
Lastly, as an independent variable, this work also uses a combined variable putting together the inverse of physical geographical distance with downstreamness level. Figures in Appendix A.1 and A.2 display the distribution of the score on the proposed indicator on farmers' positioning in value chains. Farmers are located far upstream in VCs. Nonetheless, minimal variations in the indicator may signal significant differences in positioning. Farmers who sell outside the market and score zero in positioning are excluded from the analysis; they receive a downstreamness value of zero. Table 5 reports the main statistics for distance and the combined positioning indicators. The composite indicator (positioning score and inverse distance) yields small. values because of the low positioning scores. Nonetheless, although minimal, its variation constitutes an important analysis factor.

Table 5: Independent Variables Summary Statistics

		N. of observations	Mean	Standard Deviation	Minimum Value	Maximum Value
Main Results HHs	**Distance Households – Firms *(decimals, Km)***	687	465.98	86.65	288.92	642.36
	Households Downstreamness *(decimals)*	687	0.01	0.06	0	0.70
Robust. Diff. Sample	Distance Households – Firms ***(decimals, Km)***	687	440.13	85.17	265.10	623.35
Main Results Firms	**Distance Firm-to-Household *(decimals, Km)***	432	19.82	13.41	0.96	104.52

Finally, the last factor to consider in household-to-firm and firm-to-household analyses is spatial heterogeneity among the observations. Figure 3 and Figure 4 show the graphical representation of households and firms in the household-to-firm and firm-to-household analyses, respectively.

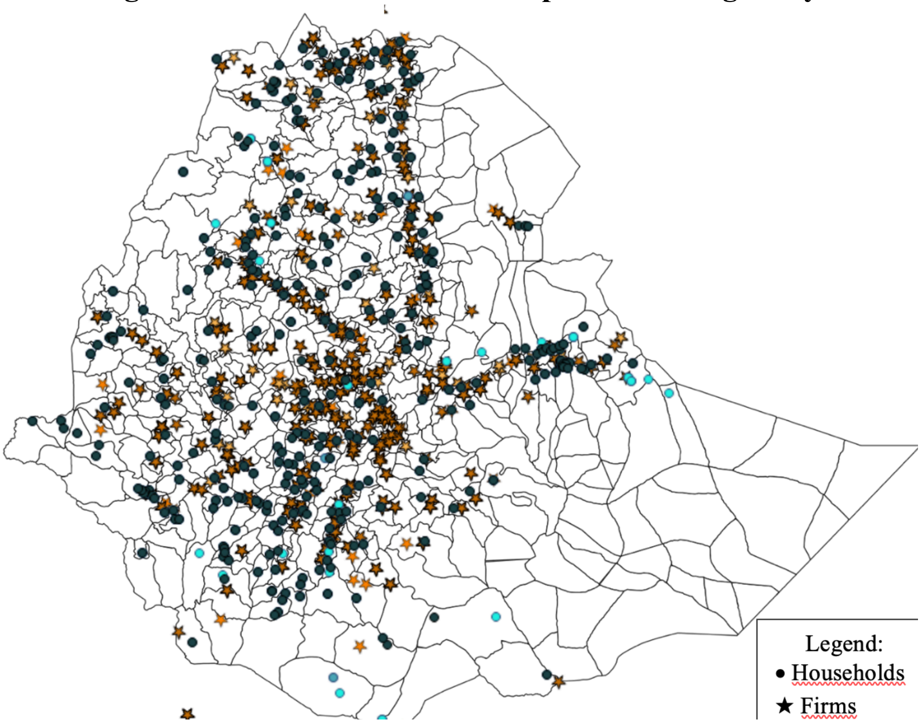
Figure 3: Household-to-Firm – Spatial Heterogeneity



Source: Author's elaboration.

In both cases, spatial clustering across households and firms seems significant. The yearly graphing of the maps below is shown in the Appendix (see from Figure A.3 to Figure A.8).

Figure 4: Firm-to-Household – Spatial Heterogeneity



Source: Author's elaboration.

5. Empirics

5.1 Identification Strategy

Based on the literature considering continuous variables in a logarithmic specification, the identification strategy of this work tests the impacts of the natural logarithm of the independent variable, geographical distance, on the natural logarithm of the dependent variable, food or total consumption in the farmer-to-firm analysis and total sales and productivity in the firm-to-farmer analysis. All dependent-independent variable relations are considered in the log-log format. In the case of the enhanced analysis in farmer-to-firm relationships dealing with the combined variable considering distance and positioning in value chains simultaneously, the resulting value of the product of inverse distance and positioning score is considered via its natural logarithm.

The identification strategy of this work tests the presence of a statistically significant relationship between the outlined dependent and independent variables by standing on three different panel data models: the fixed effects model, the SAR model, and the SAC model.

In the fixed effects model, the following specification is implemented:

$$Y_{i,t} = \alpha_i + \beta_t + \phi_1 Pos_{i,t} + \delta X_{i,t} + \varepsilon_{i,t}; \qquad [2]$$

where $Y_{h,t}$ is alternatively the natural log of household food consumption and total consumption per adult equivalent in the farmer-to-firm analysis and firms' total sales and productivity in the firm-to-farmer analysis, $Pos_{h,t}$ represents positioning in terms of geographical distance or distance*value-chain-positioning, α_h controls fixed effects in the regression. In contrast, β_t time/wave represents the fixed effects. ϕ_1 describes the impact of positioning on consumption levels. Rejecting $H_{(0)}: \phi_1$=0 implies that *changes* in market positioning are empirically associated to *changes* in household food/total consumption. $X_{h,t}$, is the vector of controls for household heterogeneity and includes observable household and production characteristics. The empirical strategy also controls for unobserved heterogeneity with a set of α_h controls for household fixed effects in the regression, region/zone dummies, and a set of β_t time/wave fixed effects.

Following the procedure of Floch & Le Saout (2018), before specifying any identification strategy for spatial econometrics models, it is important to ensure that there is indeed the need to account for a spatial phenomenon. The main indicator used to test for spatial autocorrelation is the Moran indicator I. The Moran indicator I (better known as Moran's I) is a measure of the overall spatial association between the values of the target dependent variable and unit location. In particular, the Moran I indicator can be summarized as follows:

$$I = \frac{N}{\sum_i \sum_j w_{ij}} * \frac{\sum_i \sum_j w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_i \sum_j (y_i - \bar{y})^2}. \qquad [3]$$

In Equation [3], w_{ij}t represents the weight of the coefficient situated on the i-th line and j-th column of neighborhood matrix W. The values of the Moran I indicator range from minus one to one and rely on the weight matrix used. A positive value of the Moran I indicator means that areas with high or low values for the dependent variable cluster together, while a negative correlation indicates that close geographical zones have very different values for the dependent variable. If the p-values associated with the Moran indicator are sufficiently low to reject the null hypothesis, $H_0: I = 0$ then there exists spatial autocorrelation. The neighborhood matrix W used in the cited indicator is constructed such that each off-diagonal entry [i, j] in the matrix is equal to 1/(distance between point i and point j). Thus, the matrix entries for pairs of points that are close together are higher than for pairs of points that are far apart.

Once the results of Moran's I confirm the presence of spatial autocorrelation for all target variables (i.e., food and total consumption in the household-to-firm analysis and total sales and productivity ratio in the firm-to-farmer analysis), one can integrate the classic panel fixed effects regression model proposed in Eq. [2] with spatial effects via the SAR and SAC models estimation procedure introduced in Section 3. In particular, the SAR model used is

$$\boldsymbol{y_t} = \rho \boldsymbol{W} \boldsymbol{y}_t + \boldsymbol{X}_t \beta + \boldsymbol{\mu} + \varepsilon_t \qquad t = 1 \ldots, 3. \qquad [4]$$

Equation [4] signifies by $\boldsymbol{Y_t}$ the $n \times 1$ column vector of the independent variable, and by $\boldsymbol{X}_{\mathrm{t}}$ the $n \times k$ matrix of regressors (including the geographical as well as households' characteristics), where $t = 1 \ldots, 3$ represents the wave of interest. In addition, for each cross-section, the model includes $\boldsymbol{W}$, the $n \times n$ matrix that depicts the spatial arrangements of the n units, where each entry $\mathrm{w_{it}}$ symbolize the spatial weight of two units. For self-neighbors' exclusion, the diagonal elements $\mathrm{w_{it}}$ are commonly set to zero (Belotti et al., 2017). Furthermore, it is assumed that $\boldsymbol{\mu}$ is the vector of fixed effects to be estimated.

Finally, according to Belotti et al., 2017, the SAC model is commonly defined as a SAR model with spatially autocorrelated errors, and the following equations can describe it.

$$\boldsymbol{y_t} = \rho \boldsymbol{W} \boldsymbol{y}_t + \boldsymbol{X}_t \beta + \boldsymbol{\mu} + \boldsymbol{v}_t \qquad t = 1 \ldots, 3; \qquad [5]$$

$$\boldsymbol{v_t} = \varphi \boldsymbol{M} \boldsymbol{v}_t + \varepsilon_t \qquad t = 1 \ldots, 3; \qquad [6]$$

where **M** is a matrix of spatial weights that might be equal to **W.**

Furthermore, to avoid additional sources of unobserved heterogeneity, this analysis proposes two additional specifications for each panel or spatial-panel regression: (i) the addition of a full set of region/zone-wave dummies to control time-variant unobservable covariate characteristics at the region/zone level; (ii) the further addition of household linear wave/time-trends to control time-variant unobservable confounders. This latter specification allows controlling for additional predictable unobservable components which may not be captured by the existing controls, thus further reducing the role of the stochastic components. Possible reverse causality between food/total consumption and market positioning is not supposed to affect the estimates.

To account for seasonality, an extra dummy is added to the analysis, one considering the month of the interview.

In addition, results for the spatial model regression do not provide R-squared adjusted values. For this reason, only the values of the R-squared (within) are reported in the estimates. Time/wave-fixed effects are not controlled in the second and third specification as including them interferes with the region/zone-wave dummy in spatial models. Finally, only linear time trends are incorporated in the third specification as the further supplement of non-linear trends challenges the computational tools of spatial models.

In the farmer-to-firm analysis, sensitivity testing and a battery of robustness checks are provided. Sensitivity tests replicate the described identification strategy substituting, food quantity, and land productivity yield as alternative outcome variables. For robustness checks, instead, two different analyses are proposed: one replicating Eq. [2] with the population sampling weights and Eq. [4] and Eq. [5] with a different weighting matrix and, another one reproducing all models with the same LSMS-ISA household panel data but different firms from whom distance is calculated.

Specifically, the weights used in the spatial weighting in the main SAC and SAR models are geographic and economic distance-based and created using latitude and longitude. In the main results, the weights are built based on the 'economic' distance for the dependent variable of interest. In contrast, the weights are calculated via distance decay in the robustness checks. Hence, in the main results, the spatial matrix accounts for socioeconomic variations in the target variable, while in the robustness checks, it does not. Lastly, as already anticipated in Section 3, in the second robustness check, the principal farmer-to-firm analysis is replicated for a sample of firms with opposite features to the main analysis (i.e., no international exposure and using as raw materials all those not sold by the households in the sample).

Subsection 5.2 presents the main results for the household-to-firm panel dataset. Subsection 5.3 discusses sensitivity testing and robustness testing for the household-to-firm sample. Subsection 5.4 presents the main findings for the firm-to-household section, and Subsection 5.5 the robustness checks. All specifications for the reported results are in the Tables in the Appendix (from A.6. to A.27). All estimates with several decimals above six are rounded to the third decimal unit.

5.2 Household-to-Firm - Main Results

Table 6 reports the results of the panel fixed effects (FE), SAR and SAC models.

Table 6: Household-to-Firm – Main Results

	Food Consumption			Total Consumption		
	FE	**SAR**	**SAC**	**FE**	**SAR**	**SAC**
Distance	-4.348***	-3.759***	-3.588***	-2.997***	-2.479***	-1.509*
	(0.740)	(0.926)	(0.876)	(0.625)	(0.811)	(0.775)
Female Head	0.0239	-0.0149	-0.0264	0.0263	-0.00763	0.132+
	(0.134)	(0.110)	(0.104)	(0.118)	(0.0963)	(0.0911)
Household Labor	-0.0667*	-0.0613**	-0.0570**	-0.0585*	-0.0545**	-0.0422*
	(0.0388)	(0.0272)	(0.0257)	(0.0348)	(0.0238)	(0.0221)
Household Size	0.0354	0.00845	0.0112	0.0445	0.0264	-0.00731
	(0.0371)	(0.0256)	(0.0240)	(0.0329)	(0.0224)	(0.0218)
Education Adults	0.00770	-0.00326	0.00295	0.0100	-0.000193	-0.0188
	(0.0214)	(0.0187)	(0.0174)	(0.0206)	(0.0164)	(0.0168)
N. of Child	-0.0920***	-0.0673**	-0.0764***	-0.0971***	-0.0785***	-0.0299
	(0.0334)	(0.0274)	(0.0256)	(0.0315)	(0.0240)	(0.0234)
N. of Infants	0.0636	0.0780*	0.0771*	0.0571+	0.0676*	0.0600*
	(0.0456)	(0.0433)	(0.0402)	(0.0391)	(0.0379)	(0.0365)
Free Seed	-0.145	0.00617	-0.0488	-0.0776	0.0387	0.0944*
	(0.129)	(0.0924)	(0.0989)	(0.117)	(0.0808)	(0.0559)
Seed Purchase	0.209	0.139+	0.145*	0.0610	0.0419	0.0370
	(0.163)	(0.0894)	(0.0860)	(0.132)	(0.0782)	(0.0724)
Fertilizer Use	0.125*	0.0833+	0.0879*	0.137**	0.104**	0.0876*
	(0.0700)	(0.0539)	(0.0508)	(0.0581)	(0.0472)	(0.0451)
Seed Type Dummy*	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-
Region/Zone-Wave Dummy* Trends	-	-	-	-	-	-
Constant	35.02***			27.27***		
	(4.698)			(3.963)		
Rho		0.000237	-0.00148*		0.000158	0.00207***
		(0.000202)	(0.000757)		(0.000199)	(0.00002)
Lambda			0.00140***			-0.00384***
			(0.000352)			(0.000456)
Sigma2_e		0.103***	0.143***		0.0787***	0.0933***
		(0.00554)	(0.00726)		(0.00425)	(0.00402)
Observations	687	687	687	687	687	687
Number of HH_id	229	229	229to	229	229	229
R-squared (within)	0.467	0.354	0.349	0.460	0.352	0.322

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: $^{+}$p<0.15, *** p<0.01, ** p<0.05, * p<0.1

The result is a negative correlation between physical distance from firms in global markets and consumption levels. The strength of this relationship varies according to the spatial model and is particularly strong using SAR. But spatial factors, rho and lambda, are statistically significant only for SAC signaling the preference of this spatial model over the former.

Hence, after controlling for factors such as the region/zone-wave dummies and time trends for the survey year, farmers getting closer to firms with international exposure, experience, on average and *ceteris paribus*, a 2% increase in consumption levels per adult equivalent than those farmer households that have the same characteristics but are 10 km (1% of the 1000 km, the maximum range over which distance is calculated) more distant from the considered firms. Specifically, this negative relationship's strength is higher in food expenditures, with target log-distance-coefficients reaching values close to 4% in spatial regressions. All specifications for the results in Table 6 are reported in detail in Table A.6 and Table A.7 in the Appendix.

To validate the construction of the combined variable "Downstramness*Inv.Distance" this analysis considers simultaneously the positioning score in VCs obtained via the amended à la Antràs and Chor indicator in Eq. [1] and the inverse value of geographical distance. Tables 7 and 8 show the results of the proposed regression model applied separately to inverse distance and downstreamness.

As shown in Table 7, the results of the proposed regression model for geographical distance reflected in its inverse form perfectly align with those in Table 6. After controlling for factors such as the region/zone-wave dummies and time trends for the survey year, farmers getting 1% closer in terms of geographical distance to firms with international exposure, register, on average and *ceteris paribus*, a rise in food and total consumption levels adjusted per adult equivalent of around 2% in the case of total consumption and 4% in the case of food expenditures. All specifications for Table 7 are reported in Tables A.8 and A.9 in the Appendix.

Table 7: Household-to-Firm – Main Results with Inverse-Distance

	Food Consumption			Total Consumption		
	FE	**SAR**	**SAC**	**FE**	**SAR**	**SAC**
Inverse Distance	4.348***	3.759***	3.588***	2.997***	2.479***	1.501*
	(0.740)	(0.926)	(0.876)	(0.625)	(0.811)	(0.774)
Female Head	0.0239	-0.0149	-0.0264	0.0263	-0.00763	0.133+
	(0.134)	(0.110)	(0.104)	(0.118)	(0.0963)	(0.0910)
Household Labor	-0.0667*	-0.0613**	-0.0570**	-0.0585*	-0.0545**	-0.0416*
	(0.0388)	(0.0272)	(0.0257)	(0.0348)	(0.0238)	(0.0221)
Household Size	0.0354	0.00845	0.0112	0.0445	0.0264	-0.00762
	(0.0371)	(0.0256)	(0.0240)	(0.0329)	(0.0224)	(0.0218)
Education Adults	0.00770	-0.00326	0.00295	0.0100	-0.000193	-0.0188
	(0.0214)	(0.0187)	(0.0174)	(0.0206)	(0.0164)	(0.0168)
N. of Child	-0.0920***	-0.0673**	-0.0764***	-0.0971***	-0.0785***	-0.0301
	(0.0334)	(0.0274)	(0.0256)	(0.0315)	(0.0240)	(0.0234)
N. of Infants	0.0636	0.0780*	0.0771*	0.0571+	0.0676*	0.0623*
	(0.0456)	(0.0433)	(0.0402)	(0.0391)	(0.0379)	(0.0364)
Free Seed	-0.145	0.00618	-0.0488	-0.0776	0.0387	0.0918*
	(0.129)	(0.0924)	(0.0989)	(0.117)	(0.0808)	(0.0557)
Seed Purchase	0.209	0.139+	0.145*	0.0610	0.0419	0.0426
	(0.163)	(0.0894)	(0.0860)	(0.132)	(0.0782)	(0.0723)
Fertilizer Use	0.125*	0.0833+	0.0879*	0.137**	0.104**	0.0836*
	(0.0700)	(0.0539)	(0.0508)	(0.0581)	(0.0472)	(0.0451)
Seed Type Dummy*	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-
Region/Zone-Wave Dummy* Trends	-	-	-	-	-	-
Constant	35.02***			27.27***		
	(4.698)			(3.963)		
Rho		0.000237	-0.00148*		0.000158	0.00207***
		(0.000202)	(0.000757)		(0.000199)	(0.00002)
Lambda			0.00140***			-0.00386***
			(0.000352)			(0.000456)
Sigma2_e		0.103***	0.143***		0.0787***	0.0929***
		(0.00554)	(0.00726)		(0.00425)	(0.00400)
Observations	687	687	687	687	687	687
Number of HH_id	229	229	229	229	229	229
R-squared (within)	0.467	0.354	0.349	0.460	0.352	0.323

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: $^{+}$p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Analogously, Table 8 tells the results of the proposed regression model for the proposed downstreamness indicator (see Eq. [1]).

Table 8: Household-to-Firm – Main Results with Downstreamness Scores

	Food Consumption			Total Consumption		
	FE	SAR	SAC	FE	SAR	SAC
Downstreamness	0.201**	0.242***	0.199***	0.156**	0.184***	0.150**
	(0.0831)	(0.0653)	(0.0704)	(0.0757)	(0.0568)	(0.0604)
Female Head	0.148	-0.0133	-0.00568	0.0943	-0.0312	-0.0385
	(0.143)	(0.120)	(0.121)	(0.132)	(0.104)	(0.104)
Household Labor	-0.0333	-0.0352	-0.0121	-0.0258	-0.0229	0.00454
	(0.0448)	(0.0337)	(0.0338)	(0.0391)	(0.0293)	(0.0291)
Household Size	0.0629	0.0353	0.0251	0.0715+	0.0510*	0.0371
	(0.0509)	(0.0335)	(0.0337)	(0.0458)	(0.0291)	(0.0292)
Education Adults	-0.0334	-0.0363+	-0.0512**	-0.0248	-0.0302+	-0.0459**
	(0.0271)	(0.0225)	(0.0243)	(0.0248)	(0.0196)	(0.0212)
N. of Child	-0.0972**	-0.0823**	-0.0597*	-0.120***	-0.109***	-0.0785**
	(0.0422)	(0.0349)	(0.0358)	(0.0404)	(0.0304)	(0.0313)
N. of Infants	0.0438	0.0508	0.0230	0.0558	0.0638	0.0396
	(0.0698)	(0.0549)	(0.0558)	(0.0572)	(0.0478)	(0.0479)
Free Seed	-0.213	0.164	0.206*	-0.0721	0.183*	0.244***
	(0.212)	(0.123)	(0.105)	(0.197)	(0.106)	(0.0886)
Seed Purchase	0.0116	0.0809	0.0867	-0.0995	0.0231	0.0489
	(0.247)	(0.112)	(0.110)	(0.191)	(0.0978)	(0.0948)
Fertilizer Use	0.168*	0.135*	0.150**	0.164**	0.141**	0.165***
	(0.0877)	(0.0706)	(0.0726)	(0.0771)	(0.0613)	(0.0630)
Seed Type Dummy*	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-
Region/Zone-Wave Dummy* Trends	-	-	-	-	-	-
Constant	11.40***			10.58***		
	(1.701)			(1.649)		
Rho		-0.000374	0.00107***		-0.000393	0.00106***
		(0.000349)	(0.000381)		(0.000329)	(0.000327)
Lambda			-0.00302***			-0.00338***
			(0.000842)			(0.000772)
Sigma2_e		0.0992***	0.133***		0.0750***	0.0963***
		(0.00676)	(0.00732)		(0.00511)	(0.00547)
Observations	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144
R-squared (within)	0.525	0.403	0.409	0.528	0.412	0.420

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10

Robust standard errors in parentheses: $^{+}$p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Results show that higher values of downstreamness (in logarithm form) lead, on average and *ceteris paribus*, to higher consumption levels per adult equivalent. Precisely, when controlling region/zone-wave dummies and time trends, farmers have better positioning in VCs, register, on average and *ceteris paribus*, a change in food and total consumption per adult equivalent of around 0.2% higher than those farming households that have the same characteristics and that have a final downstreamness score lower than 1%. The effects of positioning in VCs on food and total consumption seem much lower than those of geographical distance. Nevertheless, it must be considered how changing downstreamness is more approachable for farmers than changes in geographical distance. Further specifications for Table 8 are reported in Tables A.10 and A.11 in the Appendix**.**

Moreover, it must be noted that the effects of time trends are almost negligible in most of the proposed regression models. This stands on the ability of the spatial models to grasp autocorrelations among the error terms. In addition, although mostly in line with the coefficients of the fixed effects model, SAC model coefficients are generally lower than FE and SAR, indicating the ability of this regression model (the most complete among the three proposed) to correct for bias in the correlations under study.

Before creating the combined variable, a little note of caution is required. Households selling in the market chain are less than half the ones surveyed. Moreover, spatial modeling through *xsmle* requires the panel to be perfectly balanced, with few "zeros" interacting across the control variables. Hence, when combining downstreamness with inverse distance, a series of outliers are excluded from the regression. The results of the proposed regression model in Table 6 are replicated via the (logarithm for the) combined variable and are shown in Table 9.

Given the estimates of the regressions considering the inverse distance and downstreamness separately (Tables 7 and 8), it is unsurprising that the combined effect of distance and VCs positioning score is a positive correlation between overall positioning in VCs and consumption levels. Hence, farmers whose overall position is better physically and in downstreamness terms in value chains consume more, on average, than do farming households with the same characteristics but with lower positioning (see Table 9). Interesting to note that in all estimates, unlike total consumption, lambda values in the SAC model for food consumption are positive and statistically significant suggesting for the error term to be spatially autoregressive. All specifications for the regression models in Table 9 are reported in Tables A.12 and A.13 in the Appendix.

Table 9: Household-to-Firm – Main Results with Downstreamness*Inverse-Distance

	Food Consumption			Total Consumption		
	FE	**SAR**	**SAC**	**FE**	**SAR**	**SAC**
Down.*Inv. Dist.	0.219***	0.256***	0.162***	0.170**	0.194***	0.159***
	(0.0826)	(0.0648)	(0.0520)	(0.0751)	(0.0564)	(0.0599)
Female Head	0.147	-0.0158	0.0308	0.0930	-0.0329	-0.0397
	(0.144)	(0.120)	(0.0989)	(0.132)	(0.104)	(0.104)
Household Labor	-0.0328	-0.0340	-0.0406+	-0.0254	-0.0220	0.00489
	(0.0446)	(0.0336)	(0.0276)	(0.0389)	(0.0293)	(0.0291)
Household Size	0.0626	0.0350	0.0216	0.0712+	0.0508*	0.0373
	(0.0509)	(0.0334)	(0.0274)	(0.0458)	(0.0291)	(0.0292)
Education Adults	-0.0334	-0.0363	-0.0286*	-0.0247	-0.0302+	-0.0457**
	(0.0271)	(0.0225)	(0.0173)	(0.0248)	(0.0196)	(0.0212)
N. of Child	-0.0968**	-0.0823**	-0.0773***	-0.120***	-0.109***	-0.0790**
	(0.0422)	(0.0348)	(0.0281)	(0.0404)	(0.0304)	(0.0312)
N. of Infants	0.0438	0.0508	0.0688+	0.0558	0.0638	0.0396
	(0.0698)	(0.0548)	(0.0434)	(0.0571)	(0.0477)	(0.0479)
Free Seed	-0.213	0.166	0.0300	-0.0717	0.184*	0.245***
	(0.211)	(0.122)	(0.114)	(0.196)	(0.106)	(0.0887)
Seed Purchase	0.00980	0.0802	0.110	-0.101	0.0227	0.0482
	(0.247)	(0.112)	(0.0958)	(0.190)	(0.0976)	(0.0947)
Fertilizer Use	0.168*	0.135*	0.127**	0.164**	0.141**	0.164***
	(0.0875)	(0.0704)	(0.0560)	(0.0770)	(0.0612)	(0.0630)
Seed Type Dummy*	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-
Region/Zone-Wave Dummy* Trends	-	-	-	-	-	-
Constant	13.10***			11.87***		
	(2.118)			(2.025)		
Rho		-0.000377	-0.00476***		-0.000395	0.00105***
		(0.000349)	(0.000485)		(0.000329)	(0.000330)
Lambda			0.00302***			-0.00333***
			(0.00004)			(0.000773)
Sigma2_e		0.0988***	0.106***		0.0748***	0.0964***
		(0.00673)	(0.00539)		(0.00509)	(0.00546)
Observations	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144
R-squared (within)	0.527	0.406	0.197	0.530	0.418	0.422

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: $^{+}$p<0.15, *** p<0.01, ** p<0.05, * p<0.1

All specifications for Table 9 are reported in Tables A.12 and A.13 in the Appendix.

5.3 Household-to-Firm – Sensitivity and Robustness Testing

Table A.14 and Table A.15 in the Appendix testimony the solidity of the above results via sensitivity testing using food quantity.[24] Estimates for food quantity align with those of the main regression reported in Tables 6 and 9. After controlling for factors such as the region/zone-wave dummies and time trends for the survey year, farmers getting 1% closer to firms with international exposure, register, on average and *ceteris paribus*, increases of around 8% in food quantity per household. Analogous considerations apply when considering the combined positioning variables Downstreamness*Inv.Distance (see Table A.15 in the Appendix). Likewise, all spatial factors are statistically significant in the SAC model with values of rho positive confirming the presence of spatial autocorrelation across observations.

The choice of food quantity as a sensitivity variable depends on the availability of food quantity data and national and local unit conversion tables in the LSMS-ISA datasets. Other variables, besides household expenditures, like harvest crop or the crop yield ratio, could have been considered for this sensitivity testing. However, all variables related to farmer land have been excluded on purpose from this exercise, given the controversial debate on the literature regarding the effects of commercialization on farmer land. Higher crop commercialization may lead to reduced periods of land rest that, if not sustained by proper fertilizers and new technologies, may reduce soil productivity (Binswanger-Mkhize H. & Savastano S., 2017).

Results for the robustness checks conducted in the household-to-firm analysis are reported in the Appendix from Table A.16 to Table A.23. Indeed, two types of robustness checks are conducted in the household-to-firm analysis: a check on results using different weighting routines for the proposed regression model and a test using a farmers-to-firms-distance sample dealing with firms with opposite features to the ones used in the primary sample.

Tables A.16, A.17, A.18, and A.19 in the Appendix reproduce all empirical models (namely, fixed effects, SAR and SAC) by employing population sampling weights in the fixed effect case and a weighting matrix based on distance decay in the spatial regression. Again, as in the case of the main results, food and total consumption are positively affected by lower distances and better VC positioning. In particular, farming households closer to firms with international

[24] As in the case of downstreamness, to let the computational algorithms of *xsmle* perform in spatial regressions, some outliers are removed from the starting sample; this clarifies the reduction in sample size in the sensitivity analysis performed.

exposure, register, on average and *ceteris paribus*, a food and total consumption per adult equivalent to around 4% higher than those farmer households that have the same characteristics that are 10 km more distant from the considered firms in the case of food consumption and more than 2% higher in the case of total consumption. As in the main results, spatial factors are mainly significant.

The strengths of the main results are also confirmed in Table A.18 and A.19, considering the combined variable "Downstreamness*Inverse Distance." Coefficients values are more or less equal to the spatial regressions in the main model. The choice of a weighting matrix accounting for socioeconomic variations in the target variable versus the traditional one accounting for the distance decay is thus not determinant in the value of the coefficients for the combined positioning variable.

Results for the second robustness test considering firms with no international exposure and sourcing raw materials different from those provided by farmers are reported in Tables A.20, A.21, A.22, and A.23 in the Appendix. In this second robustness test, the intensity of the relationships between positioning and consumption levels are lower than the main results in Tables 6 and 9. In particular, the negative effect of distance on food consumption per adult equivalent is, on average and *ceteris paribus*, hardly above 3%. Hence, although there is no difference in the sign of the associations between consumption levels and VCs positioning (both in terms of distance and overall positioning), sampling makes its difference in the strength of this relationship. Being far from firms with no international exposure and using raw materials different from those sold by farmers has less detrimental effects on farmer welfare than being far from firms with international exposure and using raw materials of the same crop sold by farmers.

5.4 Firm-to-Household – Main Results

Lastly, this work conducts a parallel analysis of firms to discover the effects of farmers' overall positioning on productivity and to draw some conclusions on input allocation strategies for local suppliers. Table 10 elucidates the results of a spatial panel data model.

Table 10: Firm-to-Household – Main Results

	Total Sales			Productivity		
	FE	SAR	SAC	FE	SAR	SAC
Distance	-0.333*	-0.339***	-0.410	-0.344**	-0.217*	-0.327
	(0.188)	(0.116)	(0)	(0.152)	(0.112)	(0.821)
Male Owners	-0.152	-0.0360	-0.0000007	0.154*	0.223**	0.151
	(0.162)	(0.0958)	(0.128)	(0.0901)	(0.0939)	(0.108)
Employees	0.00127***	0.00157***	0.000303	0.000575+	0.000708*	0.000700
	(0.000373)	(0.000435)	(0.00829)	(0.000382)	(0.000426)	(0.000840)
Initial Paid-Up Capital	-0. 00000004	-0. 00000002	0. 00000003	1.470.0000000	1.370.0000000	2.750.0000000
	(0. 00000003)	(0. 00000003)	(0. 0000002)	(0.00000002)	(0.00000002)	(0.00000003)
Export Value	0. 00000001	0. 00000002	0. 000000007	0.000000002	0.000000005	0.000000004
	(0. 00000001)	(0. 00000001)	(0. 00000001)	(0.000000006)	(0.00000001)	(0.000000009)
Raw Material Dummy*	-	-	-	-	-	-
Keeping Accounting Books Dummy*	-	-	-	-	-	-
Region/Zone-Wave Dummy* Trends	-	-	-	-	-	-
Constant	18.78***			3.674*		
	(2.693)			(1.942)		
Rho		-0.00007	0.00006		-0.00757***	-0.00392
		(0.00005)	(0.000816)		(0.00206)	(0.0142)
Lambda			-0.000222			-0.00885
			(0.00343)			(0.0804)
Sigma2_e		0.585***	1.500***		0.561***	1.142***
		(0.0214)	(0.223)		(0.0198)	(0.0764)
Observations	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144
R-squared (within)	0.632	0.377	0.0007	0.454	0.449	0.447

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.05
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

In particular, firms getting 100 km (10% of the total range) closer to farmers in value chains, register, on average and *ceteris paribus*, an increase in total sales higher than 3%. In terms of productivity, the increase is around 0.02 percent per km closer to farmers in value chains. As in the case of household-to-firm analysis, spatial factors are generally significant. All specifications for the regression models in Table 10 are detailed in Tables A.24 and A.25 in the Appendix.

The results positively correlate farmers' overall positioning in VCs and firms' welfare levels. Firms closer to farmers better positioned in value chains have, on average, significantly higher productivity (both in terms of higher sales and productivity) than firms with the same characteristics but are at greater distances from farmers in VCs.

It is important to note that despite the results of Moran's I, the spatial factor rho is statistically significant only in the case of the productivity ratio and not in the case of total sales. This is not surprising for two reasons: an econometric reason and a pure economic one. First, and most importantly, the firm dataset relies on longitudinal data related to the village coordinates of the firm location. The absence of more granular geospatial data does not permit to retrieve spatial differences which would be more evident in the case of more firm-specific coordinates. Secondly, firms' decisions on productivity tend to be much more spatially influenced than those on total sales, given the scarcity of inputs used for production (Anselin, 2002).

5.5 Firm-to-Household – Robustness Checks

Tables A.26 and A.27 in the Appendix exhibit the results of the robustness checks in the firm-to-farmer analysis. Robustness checks are reported only for the spatial regression using different spatial weights. Unlike in the LSMS-ISA data, population weights are not reported in the firm datasets. Like in the robustness tests for farmer-to-firm analysis, spatial models are now calculated weighted by the distant decay within the range of 1000 km. Results confirm and surpasses what was reported in the principal analysis: firms that are getting 100 km closer to farmers in value chains experience, on average and *ceteris paribus*, almost 4% higher total sales and 2% higher productivity levels.

Finally, it is important to acknowledge that although spatial techniques were employed in this study, there are other potential sources of endogeneity related to both positioning and geographical distance that were not included as covariates due to data limitations. It is possible that unobserved factors could affect the estimated coefficients, but the main relationships examined are unlikely to change direction based on the robustness checks conducted. However, caution should be exercised when interpreting the magnitude of the coefficients in light of potential unobserved endogeneity.

6. Conclusions

Participation in VCs guarantees open access to unique flows of knowledge, capital, and inputs (International Monetary Fund, 2015; Montalbano et al., 2018b), leading to an accelerated and extensive path of structural transformation and income growth. However, participation alone is insufficient to foster economic development (Barrientos et al., 2010; Fagerberg et al., 2018). In agro-food chains, suppliers need to think strategically about how to profit from markets, and firms need to allocate inputs according to the most profitable options.

In this context, the geographical distance between farmers and firms, as well as firms and farmers, plays a crucial role. While distance defines spillover potentials and opportunities for local firms to purchase local inputs from domestic suppliers (Havranek & Irsova, 2011); on the other hand, intrahousehold spatial heterogeneity influences farmer-to-firm relations. Spatial lags are important in leading farmers' agricultural productivity and welfare (Gáfaro & Pellegrina, 2022). Equally, linkages and impacts on production are significantly weaker for those producers located more than 500 kilometers from their clients (Farole and Winkler, 2014).

This work assesses first the benefits of farmer-to-firm relations in an environment where firms that participate in global markets source inputs locally and where farmers sell crops in value chains. In addition, it reports a similar analysis from the point of view of firms involved in firm-to-farmer relations and who are able to consider input allocation choices that may diverge from the local sourcing of raw materials. By doing so via spatial panel modeling, this paper seeks to fill the gap in the literature on the effects of spatial heterogeneity in complex farmer-firm systems.

Furthermore, farmers' positioning is defined in terms of geographical distance to firms in global markets and in value chains through the proposed adjusted indicator set on the basis of Antràs & Chor's theory. A spatial weighting matrix considers potential spatial clusters emerging in farmer-to-firm and firm-to-farmer relations. In this framework, the main analysis conducted on farmer-to-firm relationships on farmers' food and total consumption levels, with fixed-effects and spatial panel regression models, confirms the existence of spatial spillover in farmers' proximity to firms, the benefits of locating closer to firms in global markets, and the advantages of better positioning in value chains. These results are confirmed by robustness checks as well as sensitivity testing. Moreover, in the case of firm-to-farmer relations, closeness to farmers in value chains has positive effects on firms' productivity proxied by the total sales value over the raw materials value ratio.

In particular, estimates are outstanding regarding farmer-to-firm relations and firm-to-farmer ones. On the one hand, farming households closer to firms with international exposure, register, on average and *ceteris paribus,* higher food and total consumption per adult equivalent than those farmer households that have the same characteristics but are more distant from firms. Robustness checks confirm these results. The results for the sensitivity analysis conducted via food quantity are in line with the main results. In the case of firms, being closer to farmers have several relevant effects on productivity.

While firms tend to operate in value chains where seller-buyer relations can persist over time, switching to new trading partners costs are low (Giovannetti & Marvasi, 2016; Gereffi et al., 2005), as such, farmers' positioning, both in terms of geographical distance and positioning in the value chain, has very significant effects on farmers' welfare and firms' productivity. Better farmer positioning drives the linkage between households and firms that source locally. The spatial model confirms the results and symptoms of the spillover effects among farmers and firms. Spatial factors in the SAR and the SAC regressions are most significant, testifying that the presence of spatial spillovers among farmers affects the strength of the farmer-to-firm relationship and the one firm-to-farmer relationship.

Ultimately, it is important to consider the underlying mechanisms of the examined relationships. Farmer-to-firm relationships are likely to contribute to increased consumption levels for farmers due to their proximity to Global Value Chains (GVCs). Farmers who position themselves better in value chains and have closer ties to firms with international exposure benefit from technological spillovers, reliable trading partners, and potential knowledge transfer in terms of managerial practices (Bandiera and Rasul, 2006). On the other hand, firms that establish close relationships with local farmers operating in market chains experience improved sales and productivity levels. This is because sourcing from these farmers locally creates secure and long-term supply relationships that are valuable for future business prospects (Macchiavello, 2022).

This work's findings have relevant and actionable policy implications. They can help prioritize interventions to improve farmer-to-firm and firm-to-farmer relations as a crucial means to boost household welfare and firm productivity. They will also allow policymakers to identify the challenges of this relationship and the effects of spatial dispersion on the clustering of farming households. Although this work is based on data collection before the COVID-19 pandemic, its findings will allow scholars and policymakers to comment on VCs' traits, even post-pandemic. Furthermore, the empirical spatial analysis paves the way for additional future research. Given the relevance of VCs' structuring at the micro-level, new and better data will be gathered on farmer-firm relations in developing rural contexts.

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Appendix

Table A.1: Variable Definitions and Other Basic Information

Variable name	Definition	Time period	Source
Gender of the Household Head	Gender of the household head ***(binary, 1=female)***	2011-2015	World Bank LSMS-ISA
Number of Household Members in the Labor Force *(decimals)*	Number of household members ***(binary, 1=female)***	2011-2015	World Bank LSMS-ISA
Household Size *(decimals)*	Number of people in the household ***(decimals)***	2011-2015	World Bank LSMS-ISA
Average Years of Education for Household Adults *(decimals, years of schooling)*	Average education level attained by the household adult members ***(values from 0 to 8)***	2011-2015	World Bank LSMS-ISA
Number of Household Infants *(decimals)*	Number of household members in the infant age range ***(decimals)***	2011-2015	World Bank LSMS-ISA
Number of Household Children *(decimals)*	Number of household members in the children age range ***(decimals)***	2011-2015	World Bank LSMS-ISA
Free Seed	Event of receiving free seed ***(binary, 1=no and 2=yes)***	2011-2015	World Bank LSMS-ISA
Seed Purchase	Necessity of purchasing seed ***(binary, 1=no and 2=yes)***	2011-2015	World Bank LSMS-ISA
Fertilizer Use	Use of fertilizers ***(binary, 1=no and 2=yes)***	2011-2015	World Bank LSMS-ISA
Seed Type	Seed Typology ***(categorical, 1=Traditional, 2=Improved and 3=Improved)***	2011-2015	World Bank LSMS-ISA
Employees *(decimals)*	Number of employees ***(decimals)***	2012-2015	Central Statistics Agency of Ethiopia
Exports *(decimals, ETB)*	Value of total exports in ETB ***(decimals)***	2012-2015	Central Statistics Agency of Ethiopia
Male Owners *(decimals)*	Number of male owners ***(decimals)***	2012-2015	Central Statistics Agency of Ethiopia
Keeping Accounting Books *(categorical)*	Accounting books keeping ***(categorical, 1=Yes, full books, 2=Yes, only records of income and expenses 3=No)***	2012-2015	Central Statistics Agency of Ethiopia
Initial Paid-Up Capital *(decimals, ETB)*	Value in ETB of the initial paid-up capital	2012-2015	Central Statistics Agency of Ethiopia

Table A.2.: Frequencies per Farmer's Position Score

	Frequencies	%
Position n.1 ***(selling roadside)***	1	0.15
Position n.2 ***(selling to agricultural cooperatives or farm-based associations)***	4	0.58
Position n.3 ***(selling to government agents or political leaders)***	1	0.15
Position n.4 ***(selling to a private trader in a local market or a local merchant/grocery)***	39	5.68
Position n.5 ***(selling via mobile market or to the local market)***	84	12.23
Position n.6 ***(selling to a private trader in the main market or the main market)***	127	18.49
Position n.7 ***(selling to a private company or to the auction market)***	-	-
N/A ***(not selling in value chains or value not available)***	431	62.74
Average	687	100

Table A.3.: Frequencies per Farmer's Selling Location Score

	Frequencies	%
Selling Location n.1 ***(selling within the village or near the village)***	93	13.54
Selling Location n.2 ***(selling in/near the town or in/near the district)***	171	22.27
Selling Location n.3 ***(selling outside the district or outside the region)***	10	1.46
N/A ***(not selling in value chains or value not available)***	431	62.74
Average	687	100

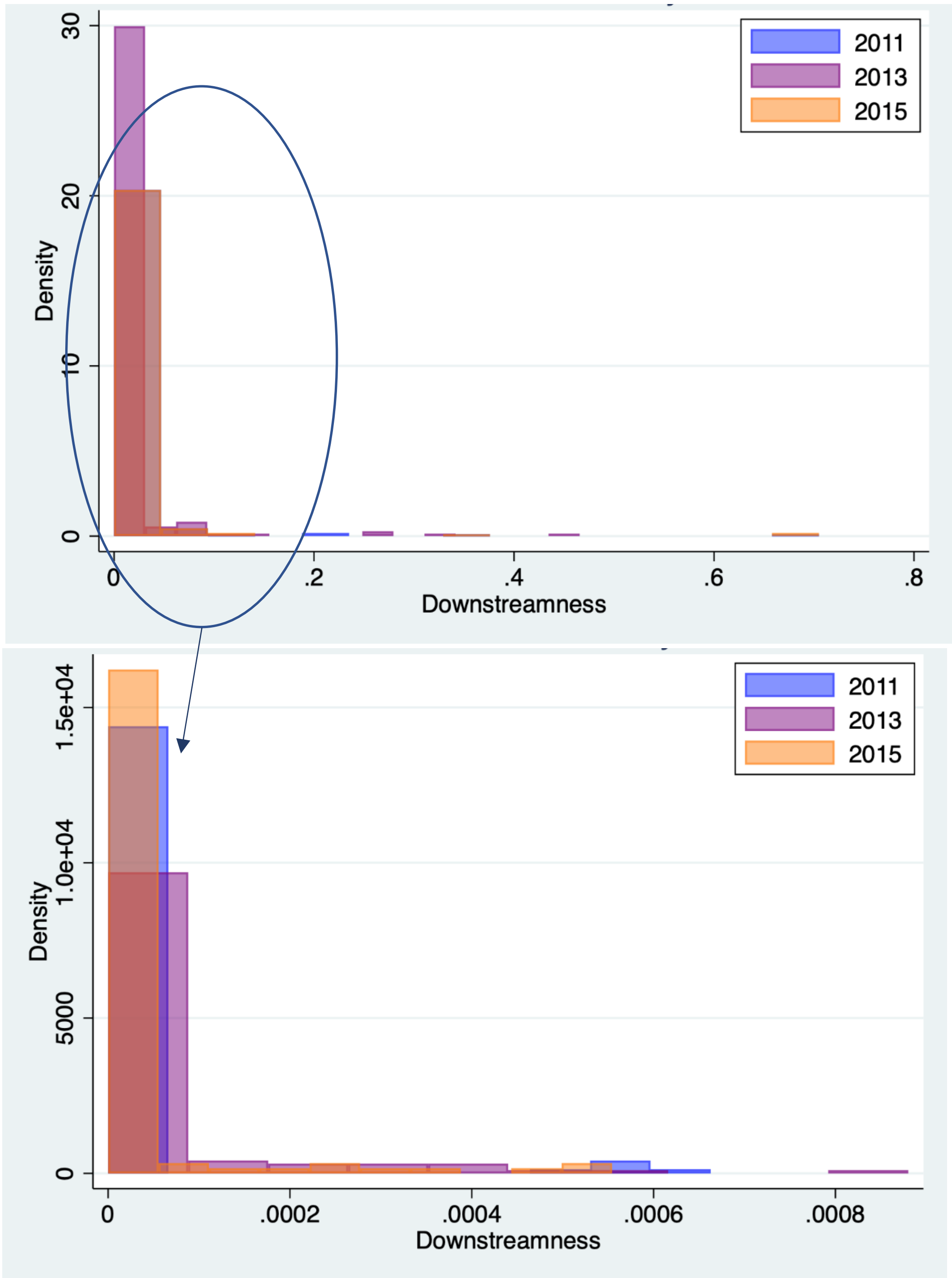
Table A.4: Household-to-Firm – Frequencies per Input (Urea) Seller

	Frequencies	%
Relative	13	1.89
Friend/Neighbor	5	0.73
Mobile Market	1	0.15
Local Market	5	0.73
Private Trader in Local Market	3	0.44
Local Merchant/Grocery	1	0.15
Main Market	3	0.44
Private trader in Main Market	1	0.15
Government Agency	33	4.80
Private Microfinance Institution	2	0.29
Savings & Credit Cooperatives	27	3.93
Government-Financed Lender	10	1.46
Agricultural Cooperative	139	20.23
Farmer-based Club/Association	26	3.78
NGO	1	0.15
Other	2	0.29
N/A	415	60.41
Total	687	100

Table A.5: Firm-to-Household – Local Raw Material Value per Raw Material

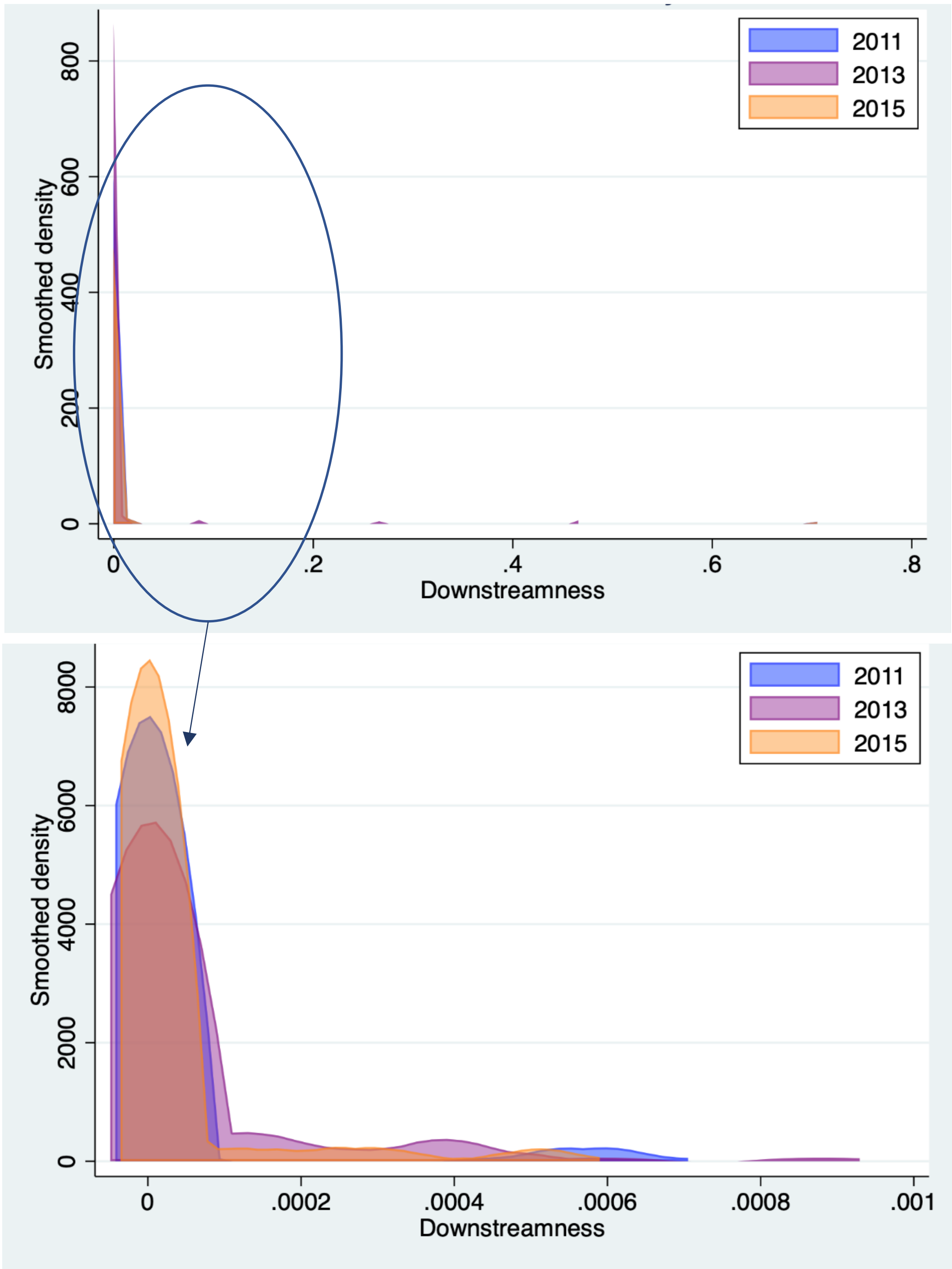
	Mean	Frequencies
Milk (raw)	3,171,079	13
Orange	1,251,886	2
Wheat (unmilled)	16,700,000	224
Maize	32,600,000	3
Sugar Cane	1,321,600	1
Hides and Skins	57,100,000	4
Cotton (yarn)	195,900	2
Meat	197,000,000	6
Polytheline	6,133,420	17
Flour	6,379,737	137
Sugar	245,364.7	6
Glucose	990,000	2
Edible Oil	5,347,610	5
Pulses	32,900,000	4
Cattle	114,000,000	3
Raw Cotton	7,896,878	1
Yeast	61,200	2

Figure A.1: Downstreamness Positioning Indicator Ethiopia - Densities



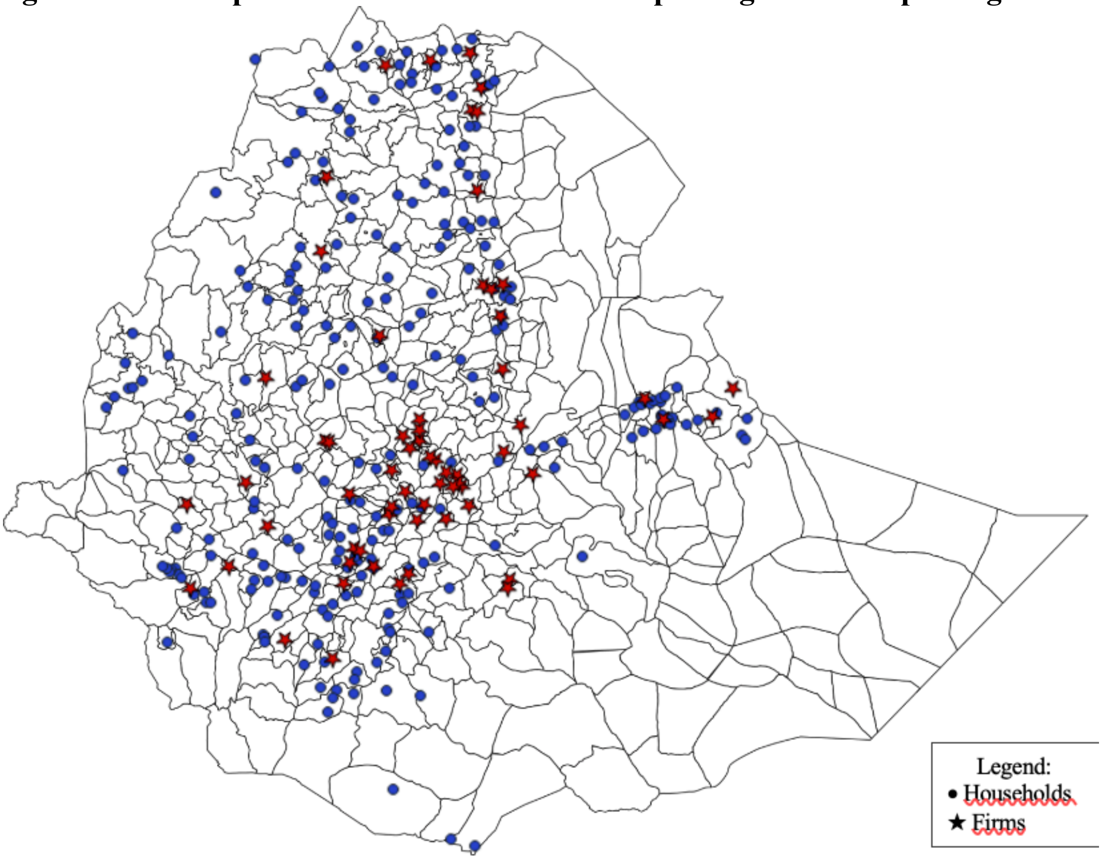
Source: Author's elaboration.

Figure A.2: Downstreamness Positioning Indicator Ethiopia - Kernel Densities



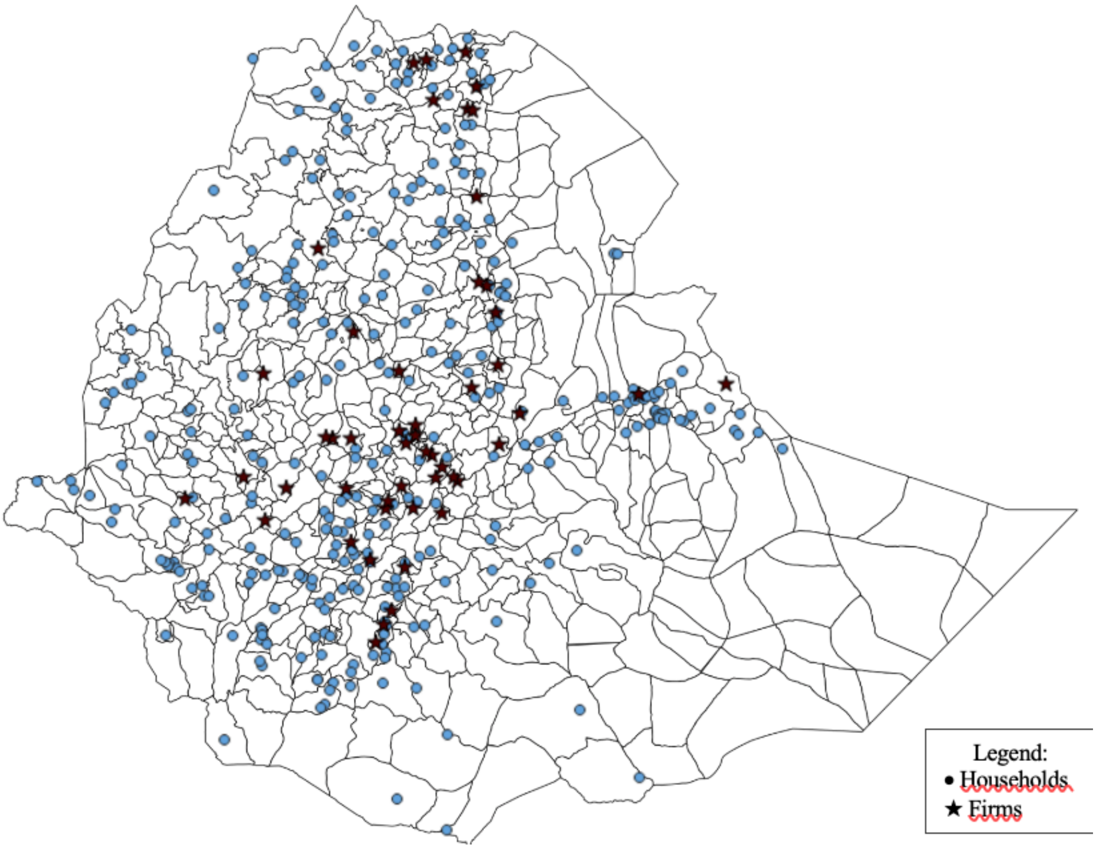
Source: Author's elaboration.

Figure A.3: Ethiopian Households and Firms Exporting and/or Importing in 2011



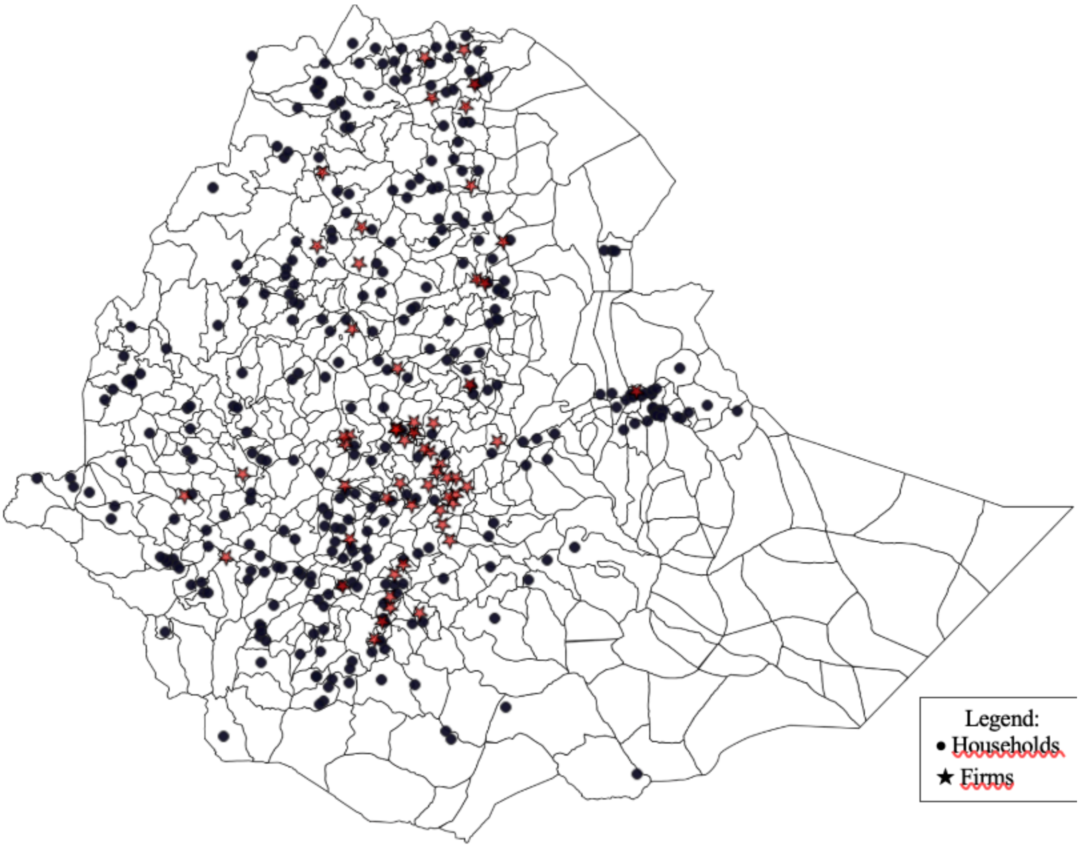
Source: Author's elaboration.

Figure A.4: Ethiopian Households and Firms Exporting and/or Importing in 2013



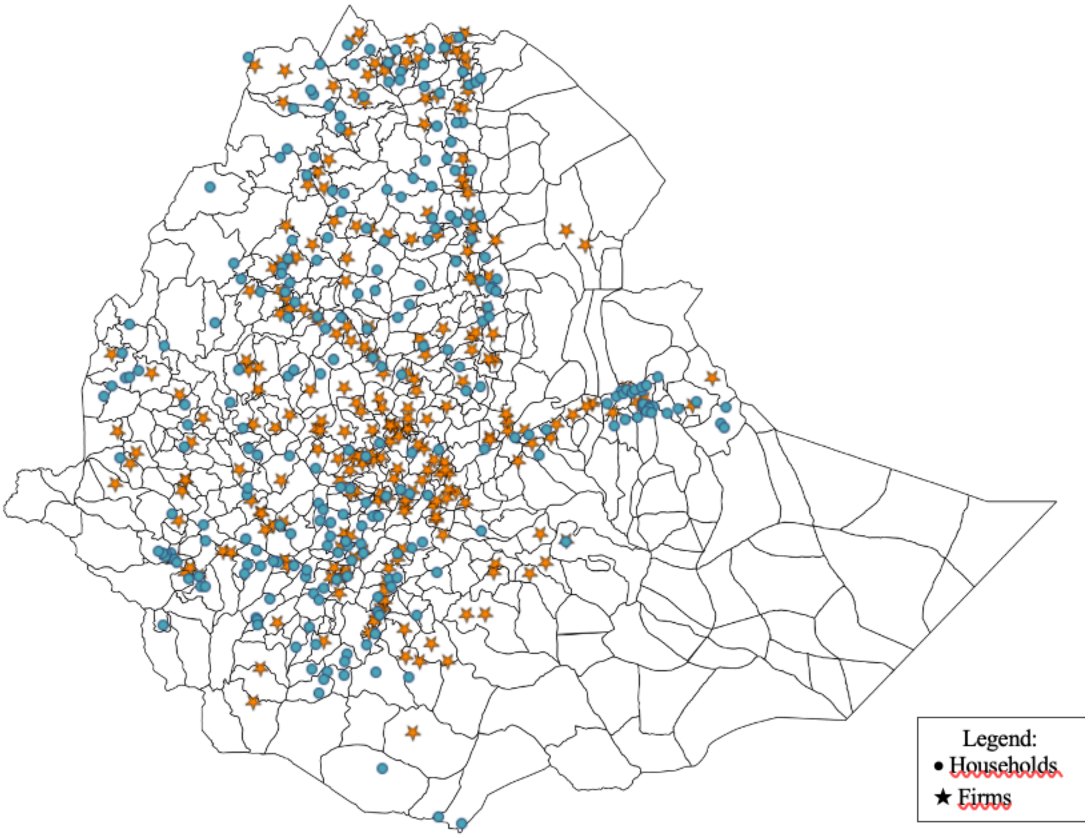
Source: Author's elaboration.

Figure A.5: Ethiopian Households and Firms Exporting and/or Importing in 2015



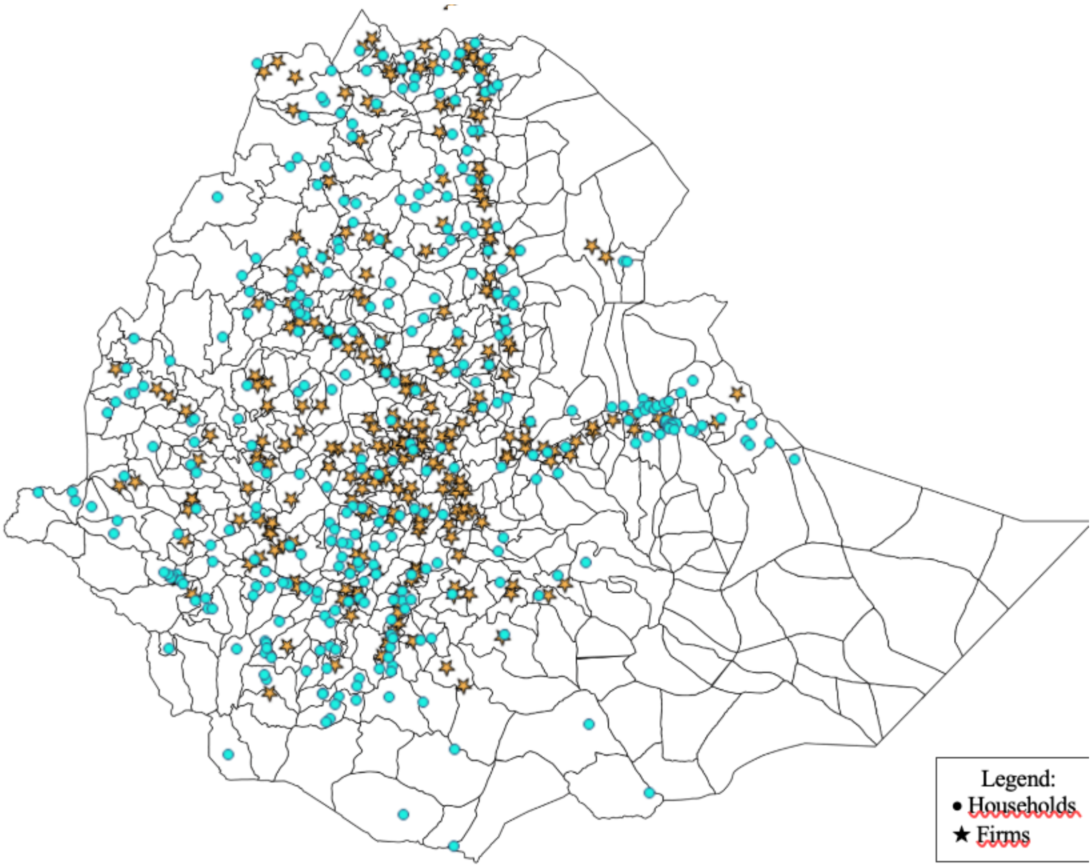
Source: Author's elaboration.

Figure A.6: (All Kinds of) Firms and Households in Value Chains in 2011



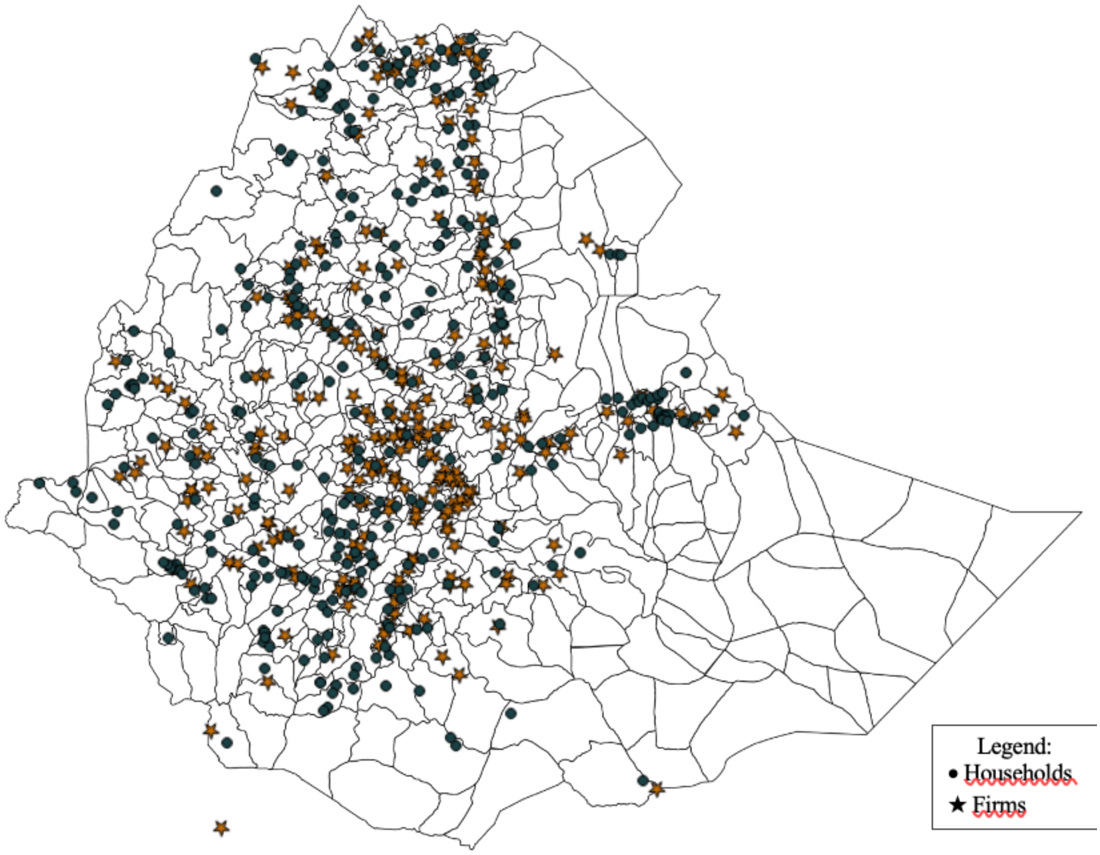
Source: Author's elaboration.

Figure A.7: (All Kinds of) Firms and Households in Value Chains in 2013



Source: Author's elaboration.

Figure A.8: (All Kinds of) Firms and Households in Value Chains in 2015



Source: Author's elaboration.

Table A.6: Household-to-Firm – Main Results Food Consumption

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	SAR	SAC	FE	SAR	SAC	FE	SAR	SAC
Distance	-2.840***	-2.821***	-2.844***	-4.348***	-3.759***	-3.588***	-4.348***	-3.759***	-3.588***
	(0.730)	(0.893)	(0.913)	(0.740)	(0.926)	(0.876)	(0.740)	(0.926)	(0.876)
Female Head	-0.0606	-0.0118	-0.0119	0.0239	-0.0149	-0.0264	0.0239	-0.0149	-0.0264
	(0.137)	(0.113)	(0.113)	(0.134)	(0.110)	(0.104)	(0.134)	(0.110)	(0.104)
Household Labor	-0.101***	-0.0862***	-0.0860***	-0.0667*	-0.0613**	-0.0570**	-0.0667*	-0.0613**	-0.0570**
	(0.0351)	(0.0270)	(0.0270)	(0.0388)	(0.0272)	(0.0257)	(0.0388)	(0.0272)	(0.0257)
Household Size	0.00733	0.00498	0.00515	0.0354	0.00845	0.0112	0.0354	0.00845	0.0112
	(0.0300)	(0.0241)	(0.0242)	(0.0371)	(0.0256)	(0.0240)	(0.0371)	(0.0256)	(0.0240)
Education Adults	-0.0107	-0.00810	-0.00765	0.00770	-0.00326	0.00295	0.00770	-0.00326	0.00295
	(0.0261)	(0.0189)	(0.0192)	(0.0214)	(0.0187)	(0.0174)	(0.0214)	(0.0187)	(0.0174)
N. of Child	-0.0861***	-0.0842***	-0.0849***	-0.0920***	-0.0673**	-0.0764***	-0.0920***	-0.0673**	-0.0764***
	(0.0310)	(0.0274)	(0.0278)	(0.0334)	(0.0274)	(0.0256)	(0.0334)	(0.0274)	(0.0256)
N. of Infants	0.102*	0.0889**	0.0890**	0.0636	0.0780*	0.0771*	0.0636	0.0780*	0.0771*
	(0.0525)	(0.0439)	(0.0439)	(0.0456)	(0.0433)	(0.0402)	(0.0456)	(0.0433)	(0.0402)
Free Seed	0.106	0.0742	0.0710	-0.145	0.00617	-0.0488	-0.145	0.00617	-0.0488
	(0.112)	(0.0864)	(0.0910)	(0.129)	(0.0924)	(0.0989)	(0.129)	(0.0924)	(0.0989)
Seed Purchase	0.103	0.0801	0.0806	0.209	0.139+	0.145*	0.209	0.139+	0.145*
	(0.138)	(0.0913)	(0.0915)	(0.163)	(0.0894)	(0.0860)	(0.163)	(0.0894)	(0.0860)
Fertilizer Use	0.0827	0.0837+	0.0839+	0.125*	0.0833+	0.0879*	0.125*	0.0833+	0.0879*
	(0.0634)	(0.0527)	(0.0530)	(0.0700)	(0.0539)	(0.0508)	(0.0700)	(0.0539)	(0.0508)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	25.27***			33.05***			35.02***		
	(4.514)			(4.349)			(4.698)		
Rho		0.00104***	0.00100***		0.000237	-0.00148*		0.000237	-0.00148*
		(0.000141)	(0.000354)		(0.000202)	(0.000757)		(0.000202)	(0.000757)
Lambda			0.00008			0.00140***			0.00140***
			(0.000619)			(0.000352)			(0.000352)
Sigma2_e		0.116***	0.175***		0.103***	0.143***		0.103***	0.143***
		(0.00633)	(0.00652)		(0.00554)	(0.00726)		(0.00554)	(0.00726)
Observations	687	687	687	687	687	687	687	687	687
Number of HH_id	229	229	229	229	229	229	229	229	229
R-squared (within)	0.204	0.216	0.215	0.467	0.354	0.349	0.467	0.354	0.349

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.7: Household-to-Firm – Main Results Total Consumption

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	SAR	SAC	FE	SAR	SAC	FE	SAR	SAC
Distance	-2.017***	-1.958**	-1.933**	-2.997***	-2.479***	-1.509*	-2.997***	-2.479***	-1.509*
	(0.619)	(0.779)	(0.781)	(0.625)	(0.811)	(0.775)	(0.625)	(0.811)	(0.775)
Female Head	-0.0648	-0.0202	-0.0206	0.0263	-0.00763	0.132+	0.0263	-0.00763	0.132+
	(0.131)	(0.0984)	(0.0982)	(0.118)	(0.0963)	(0.0911)	(0.118)	(0.0963)	(0.0911)
Household Labor	-0.0844***	-0.0743***	-0.0743***	-0.0585*	-0.0545**	-0.0422*	-0.0585*	-0.0545**	-0.0422*
	(0.0301)	(0.0235)	(0.0234)	(0.0348)	(0.0238)	(0.0221)	(0.0348)	(0.0238)	(0.0221)
Household Size	0.0171	0.0152	0.0146	0.0445	0.0264	-0.00731	0.0445	0.0264	-0.00731
	(0.0262)	(0.0210)	(0.0210)	(0.0329)	(0.0224)	(0.0218)	(0.0329)	(0.0224)	(0.0218)
Education Adults	-0.00384	-0.00238	-0.00315	0.0100	-0.000193	-0.0188	0.0100	-0.000193	-0.0188
	(0.0229)	(0.0165)	(0.0167)	(0.0206)	(0.0164)	(0.0168)	(0.0206)	(0.0164)	(0.0168)
N. of Child	-0.0883***	-0.0876***	-0.0864***	-0.0971***	-0.0785***	-0.0299	-0.0971***	-0.0785***	-0.0299
	(0.0276)	(0.0239)	(0.0243)	(0.0315)	(0.0240)	(0.0234)	(0.0315)	(0.0240)	(0.0234)
N. of Infants	0.0772*	0.0678*	0.0675*	0.0571+	0.0676*	0.0600*	0.0571+	0.0676*	0.0600*
	(0.0441)	(0.0383)	(0.0382)	(0.0391)	(0.0379)	(0.0365)	(0.0391)	(0.0379)	(0.0365)
Free Seed	0.108	0.0779	0.0822	-0.0776	0.0387	0.0944*	-0.0776	0.0387	0.0944*
	(0.0989)	(0.0754)	(0.0753)	(0.117)	(0.0808)	(0.0559)	(0.117)	(0.0808)	(0.0559)
Seed Purchase	0.0387	0.0113	0.0121	0.0610	0.0419	0.0370	0.0610	0.0419	0.0370
	(0.113)	(0.0797)	(0.0795)	(0.132)	(0.0782)	(0.0724)	(0.132)	(0.0782)	(0.0724)
Fertilizer Use	0.0787+	0.0857*	0.0851*	0.137**	0.104**	0.0876*	0.137**	0.104**	0.0876*
	(0.0521)	(0.0460)	(0.0457)	(0.0581)	(0.0472)	(0.0451)	(0.0581)	(0.0472)	(0.0451)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	20.42***			24.82***			27.27***		
	(3.816)			(3.678)			(3.963)		
Rho		0.000889***	0.000954***		0.000158	0.00207***		0.000158	0.00207***
		(0.000141)	(0.000267)		(0.000199)	(0.00002)		(0.000199)	(0.00002)
Lambda			-0.000140			-0.00384***			-0.00384***
			(0.000513)			(0.000456)			(0.000456)
Sigma2_e		0.0885***	0.132***		0.0787***	0.0933***		0.0787***	0.0933***
		(0.00481)	(0.00495)		(0.00425)	(0.00402)		(0.00425)	(0.00402)
Observations	687	687	687	687	687	687	687	687	687
Number of HH_id	229	229	229	229	229	229	229	229	229
R-squared (within)	0.224	0.236	0.239	0.460	0.352	0.322	0.460	0.352	0.322

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.8: Household-to-Firm – Main Results Food Consumption - Inverse Distance

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	**SAR**	**SAC**	**FE**	**SAR**	**SAC**	**FE**	**SAR**	**SAC**
Distance	2.840***	2.821***	2.844***	4.348***	3.759***	3.588***	4.348***	3.759***	3.588***
	(0.730)	(0.893)	(0.913)	(0.740)	(0.926)	(0.876)	(0.740)	(0.926)	(0.876)
Female Head	-0.0606	-0.0118	-0.0119	0.0239	-0.0149	-0.0264	0.0239	-0.0149	-0.0264
	(0.137)	(0.113)	(0.113)	(0.134)	(0.110)	(0.104)	(0.134)	(0.110)	(0.104)
Household Labor	-0.101***	-0.0862***	-0.0860***	-0.0667*	-0.0613**	-0.0570**	-0.0667*	-0.0613**	-0.0570**
	(0.0351)	(0.0270)	(0.0270)	(0.0388)	(0.0272)	(0.0257)	(0.0388)	(0.0272)	(0.0257)
Household Size	0.00733	0.00498	0.00515	0.0354	0.00845	0.0112	0.0354	0.00845	0.0112
	(0.0300)	(0.0241)	(0.0242)	(0.0371)	(0.0256)	(0.0240)	(0.0371)	(0.0256)	(0.0240)
Education Adults	-0.0107	-0.00810	-0.00765	0.00770	-0.00326	0.00295	0.00770	-0.00326	0.00295
	(0.0261)	(0.0189)	(0.0192)	(0.0214)	(0.0187)	(0.0174)	(0.0214)	(0.0187)	(0.0174)
N. of Child	-0.0861***	-0.0842***	-0.0849***	-0.0920***	-0.0673**	-0.0764***	-0.0920***	-0.0673**	-0.0764***
	(0.0310)	(0.0274)	(0.0278)	(0.0334)	(0.0274)	(0.0256)	(0.0334)	(0.0274)	(0.0256)
N. of Infants	0.102*	0.0889**	0.0890**	0.0636	0.0780*	0.0771*	0.0636	0.0780*	0.0771*
	(0.0525)	(0.0439)	(0.0439)	(0.0456)	(0.0433)	(0.0402)	(0.0456)	(0.0433)	(0.0402)
Free Seed	0.106	0.0742	0.0710	-0.145	0.00618	-0.0488	-0.145	0.00618	-0.0488
	(0.112)	(0.0864)	(0.0910)	(0.129)	(0.0924)	(0.0989)	(0.129)	(0.0924)	(0.0989)
Seed Purchase	0.103	0.0801	0.0806	0.209	0.139+	0.145*	0.209	0.139+	0.145*
	(0.138)	(0.0913)	(0.0915)	(0.163)	(0.0894)	(0.0860)	(0.163)	(0.0894)	(0.0860)
Fertilizer Use	0.0827	0.0837+	0.0839	0.125*	0.0833+	0.0879*	0.125*	0.0833+	0.0879*
	(0.0634)	(0.0527)	(0.0530)	(0.0700)	(0.0539)	(0.0508)	(0.0700)	(0.0539)	(0.0508)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	25.27***			33.05***			35.02***		
	(4.514)			(4.349)			(4.698)		
Rho		0.00104***	0.00100***		0.000237	-0.00148*		0.000237	-0.00148*
		(0.000141)	(0.000354)		(0.000202)	(0.000757)		(0.000202)	(0.000757)
Lambda			0.00008			0.00140***			0.00140***
			(0.000619)			(0.000352)			(0.000352)
Sigma2_e		0.116***	0.175***		0.103***	0.143***		0.103***	0.143***
		(0.00633)	(0.00652)		(0.00554)	(0.00726)		(0.00554)	(0.00726)
Observations	687	687	687	687	687	687	687	687	687
Number of HH_id	229	229	229	229	229	229	229	229	229
R-squared (within)	0.204	0.216	0.349	0.467	0.354	0.349	0.467	0.354	0.349

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.9: Household-to-Firm – Main Results Total Consumption – Inverse Distance

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	SAR	SAC	FE	SAR	SAC	FE	SAR	SAC
Distance	2.017***	1.958**	1.933**	2.997***	2.479***	1.509*	2.997***	2.479***	1.501*
	(0.619)	(0.779)	(0.781)	(0.625)	(0.811)	(0.775)	(0.625)	(0.811)	(0.774)
Female Head	-0.0648	-0.0202	-0.0206	0.0263	-0.00763	0.132	0.0263	-0.00763	0.133+
	(0.131)	(0.0984)	(0.0982)	(0.118)	(0.0963)	(0.0911)	(0.118)	(0.0963)	(0.0910)
Household Labor	-0.0844***	-0.0743***	-0.0743***	-0.0585*	-0.0545**	-0.0422*	-0.0585*	-0.0545**	-0.0416*
	(0.0301)	(0.0235)	(0.0234)	(0.0348)	(0.0238)	(0.0221)	(0.0348)	(0.0238)	(0.0221)
Household Size	0.0171	0.0152	0.0146	0.0445	0.0264	-0.00731	0.0445	0.0264	-0.00762
	(0.0262)	(0.0210)	(0.0210)	(0.0329)	(0.0224)	(0.0218)	(0.0329)	(0.0224)	(0.0218)
Education Adults	-0.00384	-0.00238	-0.00315	0.0100	-0.000193	-0.0188	0.0100	-0.000193	-0.0188
	(0.0229)	(0.0165)	(0.0167)	(0.0206)	(0.0164)	(0.0168)	(0.0206)	(0.0164)	(0.0168)
N. of Child	-0.0883***	-0.0876***	-0.0864***	-0.0971***	-0.0785***	-0.0299	-0.0971***	-0.0785***	-0.0301
	(0.0276)	(0.0239)	(0.0243)	(0.0315)	(0.0240)	(0.0234)	(0.0315)	(0.0240)	(0.0234)
N. of Infants	0.0772*	0.0678*	0.0675*	0.0571+	0.0676*	0.0600*	0.0571+	0.0676*	0.0623*
	(0.0441)	(0.0383)	(0.0382)	(0.0391)	(0.0379)	(0.0365)	(0.0391)	(0.0379)	(0.0364)
Free Seed	0.108	0.0779	0.0822	-0.0776	0.0387	0.0944*	-0.0776	0.0387	0.0918*
	(0.0989)	(0.0754)	(0.0753)	(0.117)	(0.0808)	(0.0559)	(0.117)	(0.0808)	(0.0557)
Seed Purchase	0.0387	0.0113	0.0121	0.0610	0.0419	0.0370	0.0610	0.0419	0.0426
	(0.113)	(0.0797)	(0.0795)	(0.132)	(0.0782)	(0.0724)	(0.132)	(0.0782)	(0.0723)
Fertilizer Use	0.0787+	0.0857*	0.0851*	0.137**	0.104**	0.0876*	0.137**	0.104**	0.0836*
	(0.0521)	(0.0460)	(0.0457)	(0.0581)	(0.0472)	(0.0451)	(0.0581)	(0.0472)	(0.0451)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	20.42***			24.82***			27.27***		
	(3.816)			(3.678)			(3.963)		
Rho		0.000889***	0.000954***		0.000158	0.00207***		0.000158	0.00207***
		(0.000141)	(0.000267)		(0.000199)	(0.00002)		(0.000199)	(0.00002)
Lambda			-0.000140			-0.00384***			-0.00386***
			(0.000513)			(0.000456)			(0.000456)
Sigma2_e		0.0885***	0.132***		0.0787***	0.0933***		0.0787***	0.0929***
		(0.00481)	(0.00495)		(0.00425)	(0.00402)		(0.00425)	(0.00400)
Observations	687	687	687	687	687	687	687	687	687
Number of HH_id	229	229	229	229	229	229	229	229	229
R-squared (within)	0.224	0.236	0.239	0.460	0.352	0.322	0.460	0.352	0.323

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.10: Household-to-Firm – Main Results Food Consumption – Downstreamness Scores

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	SAR	SAC	FE	SAR	SAC	FE	SAR	SAC
Downstreamness	0.175**	0.183***	0.136**	0.201**	0.242***	0.199***	0.201**	0.242***	0.199***
	(0.0711)	(0.0641)	(0.0620)	(0.0831)	(0.0653)	(0.0704)	(0.0831)	(0.0653)	(0.0704)
Female Head	-0.0307	-0.00437	-0.0795	0.148	-0.0133	-0.00568	0.148	-0.0133	-0.00568
	(0.161)	(0.123)	(0.119)	(0.143)	(0.120)	(0.121)	(0.143)	(0.120)	(0.121)
Household Labor	-0.0870**	-0.0751**	-0.0712**	-0.0333	-0.0352	-0.0121	-0.0333	-0.0352	-0.0121
	(0.0438)	(0.0333)	(0.0307)	(0.0448)	(0.0337)	(0.0338)	(0.0448)	(0.0337)	(0.0338)
Household Size	0.0548+	0.0484+	0.0339	0.0629	0.0353	0.0251	0.0629	0.0353	0.0251
	(0.0367)	(0.0311)	(0.0284)	(0.0509)	(0.0335)	(0.0337)	(0.0509)	(0.0335)	(0.0337)
Education Adults	-0.0395	-0.0408*	-0.0519**	-0.0334	-0.0363+	-0.0512**	-0.0334	-0.0363+	-0.0512**
	(0.0314)	(0.0224)	(0.0216)	(0.0271)	(0.0225)	(0.0243)	(0.0271)	(0.0225)	(0.0243)
N. of Child	-0.119***	-0.112***	-0.0958***	-0.0972**	-0.0823**	-0.0597*	-0.0972**	-0.0823**	-0.0597*
	(0.0392)	(0.0339)	(0.0311)	(0.0422)	(0.0349)	(0.0358)	(0.0422)	(0.0349)	(0.0358)
N. of Infants	0.0745	0.0653	0.0591	0.0438	0.0508	0.0230	0.0438	0.0508	0.0230
	(0.0679)	(0.0550)	(0.0511)	(0.0698)	(0.0549)	(0.0558)	(0.0698)	(0.0549)	(0.0558)
Free Seed	0.340**	0.256**	0.248***	-0.213	0.164	0.206*	-0.213	0.164	0.206*
	(0.140)	(0.111)	(0.0852)	(0.212)	(0.123)	(0.105)	(0.212)	(0.123)	(0.105)
Seed Purchase	0.0746	0.0497	0.0373	0.0116	0.0809	0.0867	0.0116	0.0809	0.0867
	(0.185)	(0.112)	(0.105)	(0.247)	(0.112)	(0.110)	(0.247)	(0.112)	(0.110)
Fertilizer Use	0.139	0.136**	0.102*	0.168*	0.135*	0.150**	0.168*	0.135*	0.150**
	(0.0856)	(0.0663)	(0.0582)	(0.0877)	(0.0706)	(0.0726)	(0.0877)	(0.0706)	(0.0726)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	9.113***			9.967***			11.40***		
	(0.724)			(1.138)			(1.701)		
Rho		0.000972***	0.00182***		-0.000374	0.00107***		-0.000374	0.00107***
		(0.000244)	(0.000233)		(0.000349)	(0.000381)		(0.000349)	(0.000381)
Lambda			-0.00249***			-0.00302***			-0.00302***
			(0.000774)			(0.000842)			(0.000842)
Sigma2_e		0.116***	0.156***		0.0992***	0.133***		0.0992***	0.133***
		(0.00792)	(0.00836)		(0.00676)	(0.00732)		(0.00676)	(0.00732)
Observations	432	432	432	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144	144	144	144
R-squared (within)	0.278	0.290	0.320	0.525	0.403	0.409	0.525	0.403	0.409

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.11: Household-to-Firm – Main Results Total Consumption – Downstreamness Scores

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	SAR	SAC	FE	SAR	SAC	FE	SAR	SAC
Downstreamness	0.128**	0.134**	0.101*	0.156**	0.184***	0.150**	0.156**	0.184***	0.150**
	(0.0623)	(0.0554)	(0.0523)	(0.0757)	(0.0568)	(0.0604)	(0.0757)	(0.0568)	(0.0604)
Female Head	-0.0381	-0.0201	-0.0900	0.0943	-0.0312	-0.0385	0.0943	-0.0312	-0.0385
	(0.156)	(0.107)	(0.103)	(0.132)	(0.104)	(0.104)	(0.132)	(0.104)	(0.104)
Household Labor	-0.0652*	-0.0570**	-0.0490*	-0.0258	-0.0229	0.00454	-0.0258	-0.0229	0.00454
	(0.0354)	(0.0288)	(0.0264)	(0.0391)	(0.0293)	(0.0291)	(0.0391)	(0.0293)	(0.0291)
Household Size	0.0540+	0.0506*	0.0277	0.0715+	0.0510*	0.0371	0.0715+	0.0510*	0.0371
	(0.0334)	(0.0269)	(0.0249)	(0.0458)	(0.0291)	(0.0292)	(0.0458)	(0.0291)	(0.0292)
Education Adults	-0.0299	-0.0312+	-0.0440**	-0.0248	-0.0302+	-0.0459**	-0.0248	-0.0302+	-0.0459**
	(0.0267)	(0.0194)	(0.0187)	(0.0248)	(0.0196)	(0.0212)	(0.0248)	(0.0196)	(0.0212)
N. of Child	-0.126***	-0.124***	-0.0969***	-0.120***	-0.109***	-0.0785**	-0.120***	-0.109***	-0.0785**
	(0.0339)	(0.0292)	(0.0272)	(0.0404)	(0.0304)	(0.0313)	(0.0404)	(0.0304)	(0.0313)
N. of Infants	0.0597	0.0561	0.0416	0.0558	0.0638	0.0396	0.0558	0.0638	0.0396
	(0.0553)	(0.0475)	(0.0438)	(0.0572)	(0.0478)	(0.0479)	(0.0572)	(0.0478)	(0.0479)
Free Seed	0.311**	0.248***	0.231***	-0.0721	0.183*	0.244***	-0.0721	0.183*	0.244***
	(0.128)	(0.0956)	(0.0725)	(0.197)	(0.106)	(0.0886)	(0.197)	(0.106)	(0.0886)
Seed Purchase	0.0266	0.00143	-0.0109	-0.0995	0.0231	0.0489	-0.0995	0.0231	0.0489
	(0.148)	(0.0965)	(0.0906)	(0.191)	(0.0978)	(0.0948)	(0.191)	(0.0978)	(0.0948)
Fertilizer Use	0.120*	0.117**	0.0791+	0.164**	0.141**	0.165***	0.164**	0.141**	0.165***
	(0.0701)	(0.0573)	(0.0497)	(0.0771)	(0.0613)	(0.0630)	(0.0771)	(0.0613)	(0.0630)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	8.956***			9.901***			10.58***		
	(0.655)			(1.001)			(1.649)		
Rho		0.000808***	0.00165***		-0.000393	0.00106***		-0.000393	0.00106***
		(0.000235)	(0.000219)		(0.000329)	(0.000327)		(0.000329)	(0.000327)
Lambda			-0.00256***			-0.00338***			-0.00338***
			(0.000746)			(0.000772)			(0.000772)
Sigma2_e		0.0867***	0.116***		0.0750***	0.0963***		0.0750***	0.0963***
		(0.00592)	(0.00627)		(0.00511)	(0.00547)		(0.00511)	(0.00547)
Observations	432	432	432	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144	144	144	144
R-squared (within)	0.310	0.320	0.345	0.528	0.412	0.420	0.528	0.412	0.420

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.12: Household-to-Firm – Main Results Food Consumption with Downstreamness*Inverse-Distance

	Wave Fixed Effects			**Region/Zone-Wave Fixed Effects**			**Wave Fixed Effects HH Trends**		
	FE	**SAR**	**SAC**	**FE**	**SAR**	**SAC**	**FE**	**SAR**	**SAC**
Down.*Inv. Dist.	0.189***	0.198***	0.148**	0.219***	0.256***	0.215***	0.219***	0.256***	0.162***
	(0.0689)	(0.0641)	(0.0626)	(0.0826)	(0.0648)	(0.0698)	(0.0826)	(0.0648)	(0.0520)
Female Head	-0.0321	-0.00565	-0.0791	0.147	-0.0158	-0.00791	0.147	-0.0158	0.0308
	(0.161)	(0.123)	(0.119)	(0.144)	(0.120)	(0.120)	(0.144)	(0.120)	(0.0989)
Household Labor	-0.0863**	-0.0744**	-0.0706**	-0.0328	-0.0340	-0.0117	-0.0328	-0.0340	-0.0406+
	(0.0436)	(0.0333)	(0.0307)	(0.0446)	(0.0336)	(0.0338)	(0.0446)	(0.0336)	(0.0276)
Household Size	0.0546+	0.0482+	0.0342	0.0626	0.0350	0.0253	0.0626	0.0350	0.0216
	(0.0366)	(0.0311)	(0.0285)	(0.0509)	(0.0334)	(0.0337)	(0.0509)	(0.0334)	(0.0274)
Education Adults	-0.0397	-0.0411*	-0.0521**	-0.0334	-0.0363	-0.0508**	-0.0334	-0.0363	-0.0286*
	(0.0314)	(0.0224)	(0.0216)	(0.0271)	(0.0225)	(0.0243)	(0.0271)	(0.0225)	(0.0173)
N. of Child	-0.119***	-0.112***	-0.0967***	-0.0968**	-0.0823**	-0.0605*	-0.0968**	-0.0823**	-0.0773***
	(0.0393)	(0.0338)	(0.0311)	(0.0422)	(0.0348)	(0.0358)	(0.0422)	(0.0348)	(0.0281)
N. of Infants	0.0751	0.0658	0.0599	0.0438	0.0508	0.0234	0.0438	0.0508	0.0688+
	(0.0678)	(0.0549)	(0.0511)	(0.0698)	(0.0548)	(0.0558)	(0.0698)	(0.0548)	(0.0434)
Free Seed	0.342**	0.258**	0.250***	-0.213	0.166	0.207*	-0.213	0.166	0.0300
	(0.140)	(0.110)	(0.0857)	(0.211)	(0.122)	(0.105)	(0.211)	(0.122)	(0.114)
Seed Purchase	0.0741	0.0491	0.0366	0.00980	0.0802	0.0857	0.00980	0.0802	0.110
	(0.184)	(0.111)	(0.105)	(0.247)	(0.112)	(0.110)	(0.247)	(0.112)	(0.0958)
Fertilizer Use	0.139	0.136**	0.103*	0.168*	0.135*	0.150**	0.168*	0.135*	0.127**
	(0.0856)	(0.0662)	(0.0584)	(0.0875)	(0.0704)	(0.0724)	(0.0875)	(0.0704)	(0.0560)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	10.40***			11.14***			13.10***		
	(1.106)			(1.452)			(2.118)		
Rho		0.000975***	0.00181***		-0.000377	0.00104***		-0.000377	-0.00476***
		(0.000244)	(0.000237)		(0.000349)	(0.000385)		(0.000349)	(0.000485)
Lambda			-0.00244***			-0.00295***			0.00302***
			(0.000783)			(0.000841)			(0.00002)
Sigma2_e		0.116***	0.156***		0.0988***	0.133***		0.0988***	0.106***
		(0.00790)	(0.00837)		(0.00673)	(0.00728)		(0.00673)	(0.00539)
Observations	432	432	432	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144	144	144	144
R-squared (within)	0.280	0.292	0.321	0.527	0.406	0.414	0.527	0.406	0.197

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.13: Household-to-Firm – Main Results Total Consumption with Downstreamness*Inverse Distance

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	SAR	SAC	FE	SAR	SAC	FE	SAR	SAC
Down.*Inv. Dist.	0.140**	0.145***	0.110**	0.170**	0.194***	0.159***	0.170**	0.194***	0.159***
	(0.0608)	(0.0554)	(0.0528)	(0.0751)	(0.0564)	(0.0599)	(0.0751)	(0.0564)	(0.0599)
Female Head	-0.0393	-0.0212	-0.0901	0.0930	-0.0329	-0.0397	0.0930	-0.0329	-0.0397
	(0.156)	(0.107)	(0.103)	(0.132)	(0.104)	(0.104)	(0.132)	(0.104)	(0.104)
Household Labor	-0.0647*	-0.0564**	-0.0486*	-0.0254	-0.0220	0.00489	-0.0254	-0.0220	0.00489
	(0.0352)	(0.0288)	(0.0264)	(0.0389)	(0.0293)	(0.0291)	(0.0389)	(0.0293)	(0.0291)
Household Size	0.0539+	0.0504*	0.0279	0.0712+	0.0508*	0.0373	0.0712+	0.0508*	0.0373
	(0.0334)	(0.0269)	(0.0250)	(0.0458)	(0.0291)	(0.0292)	(0.0458)	(0.0291)	(0.0292)
Education Adults	-0.0301	-0.0314+	-0.0441**	-0.0247	-0.0302+	-0.0457**	-0.0247	-0.0302+	-0.0457**
	(0.0267)	(0.0194)	(0.0187)	(0.0248)	(0.0196)	(0.0212)	(0.0248)	(0.0196)	(0.0212)
N. of Child	-0.127***	-0.125***	-0.0977***	-0.120***	-0.109***	-0.0790**	-0.120***	-0.109***	-0.0790**
	(0.0340)	(0.0292)	(0.0273)	(0.0404)	(0.0304)	(0.0312)	(0.0404)	(0.0304)	(0.0312)
N. of Infants	0.0601	0.0565	0.0423	0.0558	0.0638	0.0396	0.0558	0.0638	0.0396
	(0.0553)	(0.0475)	(0.0438)	(0.0571)	(0.0477)	(0.0479)	(0.0571)	(0.0477)	(0.0479)
Free Seed	0.313**	0.249***	0.233***	-0.0717	0.184*	0.245***	-0.0717	0.184*	0.245***
	(0.128)	(0.0955)	(0.0728)	(0.196)	(0.106)	(0.0887)	(0.196)	(0.106)	(0.0887)
Seed Purchase	0.0262	0.000966	-0.0114	-0.101	0.0227	0.0482	-0.101	0.0227	0.0482
	(0.148)	(0.0964)	(0.0906)	(0.190)	(0.0976)	(0.0947)	(0.190)	(0.0976)	(0.0947)
Fertilizer Use	0.119*	0.117**	0.0794+	0.164**	0.141**	0.164***	0.164**	0.141**	0.164***
	(0.0700)	(0.0573)	(0.0498)	(0.0770)	(0.0612)	(0.0630)	(0.0770)	(0.0612)	(0.0630)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	9.919***			10.75***			11.87***		
	(0.996)			(1.302)			(2.025)		
Rho		0.000809***	0.00164***		-0.000395	0.00105***		-0.000395	0.00105***
		(0.000235)	(0.000221)		(0.000329)	(0.000330)		(0.000329)	(0.000330)
Lambda			-0.00252***			-0.00333***			-0.00333***
			(0.000752)			(0.000773)			(0.000773)
Sigma2_e		0.0865***	0.116***		0.0748***	0.0964***		0.0748***	0.0964***
		(0.00590)	(0.00627)		(0.00509)	(0.00546)		(0.00509)	(0.00546)
Observations	432	432	432	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144	144	144	144
R-squared (within)	0.312	0.321	0.346	0.530	0.418	0.422	0.530	0.418	0.422

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.14: Household-to-Firm – Sensitivity Testing Food Quantity

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	SAR	SAC	FE	SAR	SAC	FE	SAR	SAC
Distance	-4.945	-4.679	-4.266	-42.38+	-8.672+	-11.04**	-42.38+	-8.673+	-11.04**
	(5.053)	(4.187)	(4.020)	(26.49)	(5.945)	(5.503)	(26.49)	(5.925)	(5.240)
Female Head	0.217	0.316	0.353	0.325	0.163	0.00006	0.325	0.163	-0.000003
	(0.427)	(0.290)	(0.290)	(0.338)	(0.295)	(0.639)	(0.338)	(0.293)	(0.287)
Household Labor	-0.0725	-0.0307	0.0299	0.0280	0.0123	0.127+	0.0280	0.0124	0.127*
	(0.0967)	(0.0770)	(0.0771)	(0.0881)	(0.0765)	(0.0782)	(0.0881)	(0.0737)	(0.0761)
Household Size	0.187**	0.158**	0.115*	0.0961	0.0951	0.0388	0.0961	0.0951	0.0388
	(0.0810)	(0.0656)	(0.0648)	(0.0958)	(0.0666)	(0.0690)	(0.0958)	(0.0666)	(0.0675)
Education Adults	0.184***	0.175***	0.147***	0.280***	0.213***	0.159***	0.280***	0.213***	0.159***
	(0.0633)	(0.0470)	(0.0484)	(0.0611)	(0.0453)	(0.0463)	(0.0611)	(0.0453)	(0.0464)
N. of Child	-0.0140	-0.0206	-0.0195	-0.0465	0.0128	0.0506	-0.0465	0.0129	0.0506
	(0.102)	(0.0697)	(0.0697)	(0.0967)	(0.0695)	(0.0684)	(0.0967)	(0.0682)	(0.0685)
N. of Infants	-0.282*	-0.276**	-0.252**	-0.211	-0.282**	-0.227**	-0.211	-0.282**	-0.227**
	(0.147)	(0.110)	(0.111)	(0.157)	(0.112)	(0.112)	(0.157)	(0.110)	(0.112)
Free Seed	0.336	0.329+	0.296	0.739*	0.195	0.202	0.739*	0.195	0.202
	(0.250)	(0.212)	(0.211)	(0.427)	(0.244)	(0.233)	(0.427)	(0.244)	(0.231)
Seed Purchase	0.0370	0.0549	0.122	0.530	0.152	0.167	0.530	0.152	0.167
	(0.306)	(0.297)	(0.297)	(0.424)	(0.299)	(0.349)	(0.424)	(0.304)	(0.298)
Fertilizer Use	-0.0476	-0.0328	-0.0122	-0.0772	-0.152	-0.147	-0.0772	-0.152	-0.147
	(0.170)	(0.137)	(0.137)	(0.186)	(0.138)	(0.139)	(0.186)	(0.138)	(0.139)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	28.87			262.7			254.6		
	(30.65)			(162.0)			(160.6)		
Rho		0.0500***	0.109***		0.0449***	0.110***		0.0449***	0.110***
		(0.00990)	(0.00595)		(0.0105)	(0.00575)		(0.0105)	(0.00570)
Lambda			-0.0364*			-0.122***			-0.122***
			(0.0220)			(0.0262)			(0.0248)
Sigma2_e		0.431***	0.642***		0.350***	0.484***		0.350***	0.484***
		(0.0288)	(0.0286)		(0.0233)	(0.0225)		(0.0233)	(0.0221)
Observations	453	453	453	453	453	453	453	453	453
Number of HH_id	151	151	151	151	151	151	151	151	151
R-squared (within)	0.140	0.148	0.039	0.475	0.316	0.314	0.475	0.316	0.314

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.15: Household-to-Firm – Sensitivity Testing Food Quantity with Downstreamness*Inverse-Distance

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	**SAR**	**SAC**	**FE**	**SAR**	**SAC**	**FE**	**SAR**	**SAC**
Down.*Inv. Dist.	0.0649	0.0548	0.0449	0.123+	0.0967*	0.0996**	0.123+	0.0967*	0.0996**
	(0.0673)	(0.0516)	(0.0517)	(0.0782)	(0.0507)	(0.0497)	(0.0782)	(0.0507)	(0.0497)
Female Head	0.331	0.399	0.388	0.464	0.547+	0.627*	0.464	0.547	0.627*
	(0.412)	(0.366)	(0.371)	(0.465)	(0.354)	(0.340)	(0.465)	(0.354)	(0.340)
Household Labor	0.184	0.182+	0.174+	0.204+	0.175+	0.195*	0.204+	0.175+	0.195*
	(0.140)	(0.111)	(0.111)	(0.134)	(0.108)	(0.107)	(0.134)	(0.108)	(0.107)
Household Size	0.120	0.124	0.129	-0.0303	0.102	0.0766	-0.0303	0.102	0.0766
	(0.143)	(0.0959)	(0.0968)	(0.144)	(0.0994)	(0.0982)	(0.144)	(0.0994)	(0.0982)
Education Adults	0.136*	0.142**	0.149**	0.170**	0.160***	0.160***	0.170**	0.160***	0.160***
	(0.0802)	(0.0654)	(0.0647)	(0.0811)	(0.0613)	(0.0613)	(0.0811)	(0.0613)	(0.0613)
N. of Child	0.00729	0.00225	0.00456	-0.0590	-0.0145	-0.00824	-0.0590	-0.0145	-0.00825
	(0.140)	(0.100)	(0.100)	(0.154)	(0.0967)	(0.0943)	(0.154)	(0.0969)	(0.0943)
N. of Infants	-0.0581	-0.120	-0.162	-0.142	-0.142	-0.144	-0.142	-0.142	-0.144
	(0.203)	(0.156)	(0.153)	(0.224)	(0.148)	(0.149)	(0.224)	(0.148)	(0.149)
Free Seed	0.210	0.102	0.0574	-0.219	-0.141	-0.0622	-0.219	-0.141	-0.0622
	(0.427)	(0.280)	(0.288)	(0.676)	(0.295)	(0.280)	(0.676)	(0.295)	(0.280)
Seed Purchase	-0.0517	-0.0481	-0.0675	-0.0450	-0.197	-0.175	-0.0450	-0.197	-0.175
	(0.282)	(0.278)	(0.278)	(0.352)	(0.263)	(0.257)	(0.352)	(0.263)	(0.257)
Fertilizer Use	-0.00473	-0.0147	-0.0504	-0.456*	-0.206	-0.163	-0.456*	-0.206	-0.163
	(0.198)	(0.167)	(0.166)	(0.272)	(0.164)	(0.165)	(0.272)	(0.164)	(0.165)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	1.923			-4.347			15.41***		
	(1.514)			(2.632)			(4.558)		
Rho		0.0608***	0.0262		0.0482***	0.0701***		0.0482***	0.0701***
		(0.0102)	(0.0238)		(0.0117)	(0.0102)		(0.0117)	(0.0102)
Lambda			0.0499**			-0.0702**			-0.0702**
			(0.0200)			(0.0298)			(0.0298)
Sigma2_e		0.810***	1.209***		0.642***	0.916***		0.642***	0.916***
		(0.0557)	(0.0553)		(0.0440)	(0.0450)		(0.0440)	(0.0450)
Observations	432	432	432	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144	144	144	144
R-squared (within)	0.144	0.124	0.132	0.489	0.353	0.374	0.489	0.353	0.374

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.16: Household-to-Firm — Robustness Test n.1 — Main Results Food Consumption

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	SAR	SAC	FE	SAR	SAC	FE	SAR	SAC
Distance	-2.534***	-2.916***	-2.242***	-4.266***	-3.778***	-3.762***	-4.266***	-3.778***	-3.762***
	(0.797)	(0.900)	(0.797)	(0.720)	(0.926)	(0.879)	(0.720)	(0.926)	(0.879)
Female Head	-0.0541	-0.0441	-0.0979	0.0160	-0.0212	-0.00484	0.0160	-0.0212	-0.00484
	(0.133)	(0.113)	(0.102)	(0.150)	(0.110)	(0.105)	(0.150)	(0.110)	(0.105)
Household Labor	-0.0934**	-0.0885***	-0.0906***	-0.0872*	-0.0601**	-0.0521**	-0.0872*	-0.0601**	-0.0521**
	(0.0373)	(0.0272)	(0.0237)	(0.0476)	(0.0272)	(0.0253)	(0.0476)	(0.0272)	(0.0253)
Household Size	0.0193	0.00790	-0.00206	0.0603	0.00893	0.0155	0.0603	0.00893	0.0155
	(0.0296)	(0.0242)	(0.0202)	(0.0409)	(0.0256)	(0.0236)	(0.0409)	(0.0256)	(0.0236)
Education Adults	-0.00431	-0.00400	-0.0101	0.0161	-0.00241	-0.00240	0.0161	-0.00241	-0.00240
	(0.0264)	(0.0191)	(0.0169)	(0.0231)	(0.0187)	(0.0174)	(0.0231)	(0.0187)	(0.0174)
N. of Child	-0.0804**	-0.0821***	-0.0605**	-0.127***	-0.0671**	-0.0759***	-0.127***	-0.0671**	-0.0759***
	(0.0330)	(0.0276)	(0.0242)	(0.0383)	(0.0274)	(0.0256)	(0.0383)	(0.0274)	(0.0256)
N. of Infants	0.101*	0.0882**	0.0708*	0.131**	0.0768*	0.0785**	0.131**	0.0768*	0.0785**
	(0.0568)	(0.0443)	(0.0403)	(0.0523)	(0.0433)	(0.0395)	(0.0523)	(0.0433)	(0.0395)
Free Seed	0.0798	0.0759	0.0984+	-0.143	-0.000164	-0.0309	-0.143	-0.000164	-0.0309
	(0.116)	(0.0872)	(0.0646)	(0.142)	(0.0924)	(0.0991)	(0.142)	(0.0924)	(0.0991)
Seed Purchase	-0.0362	0.0969	0.0840	0.0129	0.143	0.136+	0.0129	0.143	0.136+
	(0.186)	(0.0920)	(0.0825)	(0.231)	(0.0892)	(0.0836)	(0.231)	(0.0892)	(0.0836)
Fertilizer Use	0.130*	0.0949*	0.0811*	0.161**	0.0849+	0.106**	0.161**	0.0849+	0.106**
	(0.0711)	(0.0532)	(0.0457)	(0.0783)	(0.0539)	(0.0510)	(0.0783)	(0.0539)	(0.0510)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	23.10***			34.78***			32.32***		
	(4.885)			(4.540)			(4.070)		
Rho		0.231***	0.526***		0.0604	-0.276**		0.0604	-0.276**
		(0.0376)	(0.0481)		(0.0424)	(0.122)		(0.0424)	(0.122)
Lambda			-0.425***			0.335***			0.335***
			(0.0741)			(0.110)			(0.110)
Sigma2_e		0.118***	0.146***		0.103***	0.143***		0.103***	0.143***
		(0.00643)	(0.00716)		(0.00554)	(0.00745)		(0.00554)	(0.00745)
Observations	687	687	687	687	687	687	687	687	687
Number of HH_id	229	229	229	229	229	229	229	229	229
R-squared (within)	0.197	0.202	0.212	0.469	0.355	0.351	0.469	0.355	0.351

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.17: Household-to-Firm –- Robustness Test n.1 –- Main Results Total Consumption

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	**SAR**	**SAC**	**FE**	**SAR**	**SAC**	**FE**	**SAR**	**SAC**
Distance	-1.615***	-2.023***	-1.582**	-2.944***	-2.488***	-2.507***	-2.944***	-2.488***	-2.507***
	(0.599)	(0.782)	(0.708)	(0.600)	(0.810)	(0.764)	(0.600)	(0.810)	(0.764)
Female Head	-0.0827	-0.0483	-0.0941	0.0305	-0.0103	0.00957	0.0305	-0.0103	0.00958
	(0.111)	(0.0986)	(0.0909)	(0.119)	(0.0961)	(0.0913)	(0.119)	(0.0960)	(0.0912)
Household Labor	-0.0810**	-0.0760***	-0.0763***	-0.0685+	-0.0536**	-0.0464**	-0.0685+	-0.0536**	-0.0464**
	(0.0318)	(0.0236)	(0.0211)	(0.0424)	(0.0238)	(0.0220)	(0.0424)	(0.0238)	(0.0220)
Household Size	0.0275	0.0170	0.00661	0.0629*	0.0261	0.0266	0.0629*	0.0261	0.0266
	(0.0260)	(0.0211)	(0.0182)	(0.0372)	(0.0224)	(0.0205)	(0.0372)	(0.0224)	(0.0205)
Education Adults	-0.00414	0.000606	-0.00544	0.00675	0.000431	0.00119	0.00675	0.000431	0.00119
	(0.0248)	(0.0166)	(0.0151)	(0.0232)	(0.0163)	(0.0151)	(0.0232)	(0.0164)	(0.0151)
N. of Child	-0.0813***	-0.0848***	-0.0659***	-0.123***	-0.0781***	-0.0819***	-0.123***	-0.0781***	-0.0819***
	(0.0298)	(0.0240)	(0.0218)	(0.0362)	(0.0240)	(0.0223)	(0.0362)	(0.0239)	(0.0223)
N. of Infants	0.0738+	0.0659*	0.0538+	0.0996**	0.0664*	0.0654*	0.0996**	0.0664*	0.0654*
	(0.0496)	(0.0385)	(0.0358)	(0.0482)	(0.0379)	(0.0344)	(0.0482)	(0.0379)	(0.0344)
Free Seed	0.0656	0.0809	0.0907+	-0.0844	0.0334	0.00668	-0.0844	0.0334	0.00667
	(0.104)	(0.0758)	(0.0584)	(0.133)	(0.0807)	(0.0861)	(0.133)	(0.0807)	(0.0864)
Seed Purchase	-0.0856	0.0331	0.0327	-0.104	0.0449	0.0387	-0.104	0.0449	0.0387
	(0.161)	(0.0799)	(0.0733)	(0.182)	(0.0780)	(0.0727)	(0.182)	(0.0780)	(0.0727)
Fertilizer Use	0.125**	0.0885*	0.0792*	0.172***	0.105**	0.114***	0.172***	0.105**	0.114***
	(0.0586)	(0.0462)	(0.0408)	(0.0646)	(0.0471)	(0.0441)	(0.0646)	(0.0471)	(0.0440)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	17.72***			26.38***			24.14***		
	(3.668)			(3.781)			(3.439)		
Rho		0.209***	0.482***		0.0562	-0.289***		0.0561	-0.289***
		(0.0384)	(0.0559)		(0.0427)	(0.107)		(0.0427)	(0.107)
Lambda			-0.384***			0.343***			0.343***
			(0.0835)			(0.0942)			(0.0942)
Sigma2_e		0.0892***	0.115***		0.0785***	0.108***		0.0785***	0.108***
		(0.00485)	(0.00565)		(0.00424)	(0.00536)		(0.00424)	(0.00535)
Observations	687	687	687	687	687	687	687	687	687
Number of HH_id	229	229	229	229	229	229	229	229	229
R-squared (within)	0.202	0.223	0.233	0.447	0.353	0.352	0.447	0.353	0.352

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.18: Household-to-Firm — Robustness Test n.1 — Main Results Food Consumption with Downstreamness*Inverse-Distance

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	SAR	SAC	FE	SAR	SAC	FE	SAR	SAC
Down.*Inv. Dist.	0.152**	0.187***	0.166**	0.218**	0.254***	0.235***	0.218**	0.254***	0.235***
	(0.0761)	(0.0641)	(0.0725)	(0.0924)	(0.0649)	(0.0702)	(0.0924)	(0.0649)	(0.0702)
Female Head	0.0369	-0.000867	-0.0370	0.213	0.000709	-0.0241	0.213	0.000716	-0.0241
	(0.174)	(0.123)	(0.134)	(0.154)	(0.111)	(0.123)	(0.154)	(0.117)	(0.123)
Household Labor	-0.0941*	-0.0764**	-0.0809**	-0.0785+	-0.0331	-0.0313	-0.0785+	-0.0331	-0.0313
	(0.0481)	(0.0333)	(0.0332)	(0.0494)	(0.0338)	(0.0338)	(0.0494)	(0.0337)	(0.0338)
Household Size	0.0582*	0.0497+	0.0501*	0.0912*	0.0340	0.0342	0.0912*	0.0340	0.0342
	(0.0342)	(0.0311)	(0.0302)	(0.0504)	(0.0335)	(0.0337)	(0.0504)	(0.0335)	(0.0337)
Education Adults	-0.0350	-0.0359+	-0.0376*	-0.0304	-0.0364+	-0.0412*	-0.0304	-0.0364+	-0.0412*
	(0.0277)	(0.0224)	(0.0224)	(0.0272)	(0.0225)	(0.0233)	(0.0272)	(0.0225)	(0.0233)
N. of Child	-0.108***	-0.113***	-0.113***	-0.139***	-0.0854**	-0.0854**	-0.139***	-0.0854**	-0.0854**
	(0.0389)	(0.0338)	(0.0332)	(0.0442)	(0.0348)	(0.0352)	(0.0442)	(0.0350)	(0.0352)
N. of Infants	0.0303	0.0625	0.0653	0.0655	0.0506	0.0539	0.0655	0.0506	0.0539
	(0.0763)	(0.0550)	(0.0542)	(0.0731)	(0.0547)	(0.0553)	(0.0731)	(0.0550)	(0.0553)
Free Seed	0.392***	0.279**	0.278***	-0.195	0.146	0.145	-0.195	0.146	0.145
	(0.150)	(0.110)	(0.103)	(0.240)	(0.123)	(0.118)	(0.240)	(0.123)	(0.118)
Seed Purchase	-0.145	0.0656	0.0639	-0.329	0.0720	0.0714	-0.329	0.0720	0.0714
	(0.274)	(0.111)	(0.110)	(0.300)	(0.113)	(0.112)	(0.300)	(0.112)	(0.112)
Fertilizer Use	0.217**	0.141**	0.137**	0.245**	0.141**	0.141**	0.245**	0.141**	0.141**
	(0.0879)	(0.0663)	(0.0649)	(0.0993)	(0.0706)	(0.0712)	(0.0993)	(0.0705)	(0.0712)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	9.657***			10.74***			9.426***		
	(1.197)			(1.774)			(2.279)		
Rho		0.170***	0.251**		0.0329	0.141		0.0329	0.141
		(0.0464)	(0.122)		(0.0507)	(0.114)		(0.0506)	(0.115)
Lambda			-0.113			-0.143			-0.143
			(0.168)			(0.144)			(0.144)
Sigma2_e		0.116***	0.170***		0.0991***	0.146***		0.0991***	0.146***
		(0.00793)	(0.00936)		(0.00675)	(0.00735)		(0.00674)	(0.00734)
Observations	432	432	432	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144	144	144	144
R-squared (within)	0.325	0.141	0.148	0.549	0.292	0.294	0.549	0.291	0.294

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.19: Household-to-Firm — Robustness Test n.1 — Main Results Total Consumption with Downstreamness*Inverse-Distance

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	**SAR**	**SAC**	**FE**	**SAR**	**SAC**	**FE**	**SAR**	**SAC**
Down.*Inv. Dist.	0.141**	0.138**	0.135**	0.186**	0.192***	0.191***	0.186**	0.192***	0.191***
	(0.0660)	(0.0555)	(0.0599)	(0.0859)	(0.0565)	(0.0573)	(0.0859)	(0.0565)	(0.0573)
Female Head	-0.00947	-0.0184	-0.0266	0.132	-0.0198	-0.0232	0.132	-0.0198	-0.0232
	(0.154)	(0.107)	(0.123)	(0.140)	(0.104)	(0.111)	(0.140)	(0.104)	(0.111)
Household Labor	-0.0659*	-0.0591**	-0.0598**	-0.0537	-0.0221	-0.0219	-0.0537	-0.0221	-0.0219
	(0.0374)	(0.0288)	(0.0291)	(0.0418)	(0.0293)	(0.0295)	(0.0418)	(0.0293)	(0.0295)
Household Size	0.0502+	0.0511*	0.0507*	0.0895*	0.0501*	0.0502*	0.0895*	0.0501*	0.0502*
	(0.0311)	(0.0269)	(0.0270)	(0.0457)	(0.0292)	(0.0292)	(0.0457)	(0.0292)	(0.0292)
Education Adults	-0.0353	-0.0253	-0.0261	-0.0309	-0.0297+	-0.0303+	-0.0309	-0.0297+	-0.0303+
	(0.0272)	(0.0194)	(0.0203)	(0.0251)	(0.0196)	(0.0208)	(0.0251)	(0.0196)	(0.0208)
N. of Child	-0.120***	-0.123***	-0.123***	-0.160***	-0.113***	-0.113***	-0.160***	-0.113***	-0.113***
	(0.0345)	(0.0293)	(0.0293)	(0.0435)	(0.0304)	(0.0305)	(0.0435)	(0.0304)	(0.0305)
N. of Infants	0.0313	0.0510	0.0513	0.0799	0.0628	0.0634	0.0799	0.0628	0.0634
	(0.0655)	(0.0476)	(0.0476)	(0.0629)	(0.0478)	(0.0482)	(0.0629)	(0.0478)	(0.0482)
Free Seed	0.341**	0.264***	0.264***	-0.0470	0.168+	0.169+	-0.0470	0.168+	0.169+
	(0.140)	(0.0952)	(0.0938)	(0.226)	(0.107)	(0.107)	(0.226)	(0.107)	(0.107)
Seed Purchase	-0.144	0.0161	0.0171	-0.328	0.0133	0.0146	-0.328	0.0133	0.0146
	(0.227)	(0.0963)	(0.0966)	(0.241)	(0.0977)	(0.0987)	(0.241)	(0.0977)	(0.0987)
Fertilizer Use	0.186**	0.121**	0.121**	0.237***	0.145**	0.146**	0.237***	0.145**	0.146**
	(0.0749)	(0.0574)	(0.0572)	(0.0819)	(0.0613)	(0.0616)	(0.0819)	(0.0613)	(0.0616)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	9.817***			10.93***	0.0319		9.304***		
	(1.063)			(1.626)	(0.0508)		(1.946)		
Rho		0.146***	0.167			0.0444		0.0319	0.0444
		(0.0470)	(0.163)			(0.147)		(0.0508)	(0.147)
Lambda			-0.0274			-0.0155			-0.0155
			(0.207)			(0.171)			(0.171)
Sigma2_e		0.0867***	0.130***		0.0751***	0.113***		0.0751***	0.113***
		(0.00593)	(0.00646)		(0.00511)	(0.00514)		(0.00511)	(0.00514)
Observations	432	432	432	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144	144	144	144
R-squared (within)	0.345	0.145	0.147	0.541	0.280	0.280	0.541	0.280	0.280

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.20: Household-to-Firm — Robustness Test n.2 — Main Results Food Consumption

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	SAR	SAC	FE	SAR	SAC	FE	SAR	SAC
Distance	-1.476	-1.641**	-1.652**	-4.119***	-3.172***	-2.767***	-4.119***	-3.172***	-3.106***
	(1.052)	(0.717)	(0.752)	(0.711)	(0.822)	(0.704)	(0.711)	(0.822)	(0.799)
Female Head	-0.0496	-0.00005	-0.000154	0.0248	-0.00131	-0.0158	0.0248	-0.00131	-0.0182
	(0.137)	(0.113)	(0.113)	(0.135)	(0.110)	(0.0903)	(0.135)	(0.110)	(0.104)
Household Labor	-0.106***	-0.0914***	-0.0913***	-0.0673*	-0.0644**	-0.0512**	-0.0673*	-0.0644**	-0.0587**
	(0.0353)	(0.0270)	(0.0271)	(0.0386)	(0.0273)	(0.0224)	(0.0386)	(0.0273)	(0.0258)
Household Size	0.0122	0.00990	0.00993	0.0342	0.0105	0.0143	0.0342	0.0105	0.0122
	(0.0298)	(0.0241)	(0.0241)	(0.0370)	(0.0257)	(0.0211)	(0.0370)	(0.0257)	(0.0241)
Education Adults	-0.0100	-0.00730	-0.00711	0.00756	-0.00136	0.00543	0.00756	-0.00136	0.00419
	(0.0262)	(0.0190)	(0.0194)	(0.0214)	(0.0188)	(0.0150)	(0.0214)	(0.0188)	(0.0174)
N. of Child	-0.0849***	-0.0833***	-0.0836***	-0.0913***	-0.0665**	-0.0754***	-0.0913***	-0.0665**	-0.0754***
	(0.0309)	(0.0275)	(0.0279)	(0.0333)	(0.0274)	(0.0224)	(0.0333)	(0.0274)	(0.0257)
N. of Infants	0.0995*	0.0870**	0.0870**	0.0626	0.0758*	0.0693**	0.0626	0.0758*	0.0763*
	(0.0525)	(0.0441)	(0.0441)	(0.0456)	(0.0434)	(0.0348)	(0.0456)	(0.0434)	(0.0403)
Free Seed	0.0887	0.0553	0.0542	-0.153	-0.0344	-0.0835	-0.153	-0.0344	-0.0689
	(0.111)	(0.0868)	(0.0903)	(0.129)	(0.0926)	(0.0910)	(0.129)	(0.0926)	(0.0986)
Seed Purchase	0.102	0.0793	0.0795	0.209	0.144	0.168**	0.209	0.144	0.148*
	(0.139)	(0.0916)	(0.0917)	(0.163)	(0.0895)	(0.0774)	(0.163)	(0.0895)	(0.0863)
Fertilizer Use	0.0850	0.0859+	0.0860+	0.121*	0.0813+	0.0766*	0.121*	0.0813+	0.0868*
	(0.0637)	(0.0529)	(0.0530)	(0.0701)	(0.0540)	(0.0451)	(0.0701)	(0.0540)	(0.0509)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	16.81***			31.48***			33.46***		
	(6.401)			(4.168)			(4.545)		
Rho		0.00105***	0.00104***		0.000220	-0.00369***		0.000220	-0.00144*
		(0.000141)	(0.000358)		(0.000203)	(0.000376)		(0.000203)	(0.000789)
Lambda			0.00004			0.00229***			0.00138***
			(0.000648)			(0.00004)			(0.000378)
Sigma2_e		0.117***	0.176***		0.103***	0.114***		0.103***	0.144***
		(0.00637)	(0.00662)		(0.00556)	(0.00459)		(0.00556)	(0.00743)
Observations	687	687	687	687	687	687	687	687	687
Number of HH_id	229	229	229	229	229	229	229	229	229
R-squared (within)	0.198	0.210	0.210	0.468	0.353	0.289	0.468	0.353	0.349

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.21: Household-to-Firm –- Robustness Test n.2 –- Main Results Total Consumption

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	SAR	SAC	FE	SAR	SAC	FE	SAR	SAC
Distance	-1.412**	-1.415**	-1.383**	-2.941***	-2.171***	-2.214***	-2.941***	-2.171***	-2.214***
	(0.663)	(0.623)	(0.613)	(0.610)	(0.719)	(0.712)	(0.610)	(0.719)	(0.712)
Female Head	-0.0561	-0.0114	-0.0113	0.0263	0.00115	-0.0108	0.0263	0.00115	-0.0108
	(0.130)	(0.0985)	(0.0981)	(0.118)	(0.0962)	(0.0945)	(0.118)	(0.0962)	(0.0945)
Household Labor	-0.0885***	-0.0782***	-0.0785***	-0.0590*	-0.0565**	-0.0547**	-0.0590*	-0.0565**	-0.0547**
	(0.0301)	(0.0235)	(0.0234)	(0.0346)	(0.0238)	(0.0234)	(0.0346)	(0.0238)	(0.0234)
Household Size	0.0208	0.0188	0.0178	0.0436	0.0278	0.0288	0.0436	0.0278	0.0288
	(0.0259)	(0.0210)	(0.0209)	(0.0329)	(0.0224)	(0.0219)	(0.0329)	(0.0224)	(0.0219)
Education Adults	-0.00315	-0.00167	-0.00303	0.00993	0.00107	0.00406	0.00993	0.00107	0.00406
	(0.0229)	(0.0165)	(0.0168)	(0.0205)	(0.0164)	(0.0160)	(0.0205)	(0.0164)	(0.0160)
N. of Child	-0.0882***	-0.0875***	-0.0855***	-0.0968***	-0.0781***	-0.0839***	-0.0968***	-0.0781***	-0.0839***
	(0.0276)	(0.0239)	(0.0242)	(0.0314)	(0.0240)	(0.0236)	(0.0314)	(0.0240)	(0.0236)
N. of Infants	0.0771*	0.0678*	0.0676*	0.0566	0.0663*	0.0660*	0.0566	0.0663*	0.0660*
	(0.0443)	(0.0383)	(0.0382)	(0.0391)	(0.0379)	(0.0369)	(0.0391)	(0.0379)	(0.0369)
Free Seed	0.0927	0.0632	0.0696	-0.0833	0.0115	-0.00873	-0.0833	0.0115	-0.00873
	(0.0985)	(0.0755)	(0.0738)	(0.116)	(0.0809)	(0.0864)	(0.116)	(0.0809)	(0.0864)
Seed Purchase	0.0385	0.0111	0.0125	0.0609	0.0450	0.0450	0.0609	0.0450	0.0450
	(0.113)	(0.0797)	(0.0795)	(0.133)	(0.0783)	(0.0774)	(0.133)	(0.0783)	(0.0774)
Fertilizer Use	0.0804	0.0873*	0.0864*	0.135**	0.103**	0.103**	0.135**	0.103**	0.103**
	(0.0520)	(0.0460)	(0.0455)	(0.0580)	(0.0472)	(0.0462)	(0.0580)	(0.0472)	(0.0462)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	16.63***			24.35***			26.82***		
	(4.038)			(3.598)			(3.905)		
Rho		0.000893***	0.00100***		0.000146	-0.000526		0.000146	-0.000526
		(0.000141)	(0.000256)		(0.000200)	(0.000666)		(0.000200)	(0.000666)
Lambda			-0.000239			0.000720			0.000720
			(0.000519)			(0.000533)			(0.000533)
Sigma2_e		0.0886***	0.132***		0.0787***	0.116***		0.0787***	0.116***
		(0.00481)	(0.00499)		(0.00425)	(0.00472)		(0.00425)	(0.00472)
Observations	687	687	687	687	687	687	687	687	687
Number of HH_id	229	229	229	229	229	229	229	229	229
R-squared (within)	0.223	0.236	0.241	0.461	0.353	0.353	0.461	0.353	0.353

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.22: Household-to-Firm –– Robustness Test n.2 –– Main Results Food Consumption with Downstreamness*Inverse-Distance

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	**SAR**	**SAC**	**FE**	**SAR**	**SAC**	**FE**	**SAR**	**SAC**
Down.*Inv. Dist.	0.231***	0.236***	0.195***	0.289***	0.340***	0.340***	0.289***	0.340***	0.185***
	(0.0771)	(0.0720)	(0.0675)	(0.0929)	(0.0727)	(0.0747)	(0.0929)	(0.0727)	(0.0588)
Female Head	-0.0361	-0.00981	-0.0939	0.152	-0.0326	-0.0498	0.152	-0.0326	0.0299
	(0.162)	(0.124)	(0.119)	(0.144)	(0.119)	(0.118)	(0.144)	(0.119)	(0.0989)
Household Labor	-0.0906**	-0.0786**	-0.0784**	-0.0344	-0.0384	-0.0149	-0.0344	-0.0384	-0.0370
	(0.0436)	(0.0336)	(0.0307)	(0.0449)	(0.0336)	(0.0325)	(0.0449)	(0.0336)	(0.0274)
Household Size	0.0592+	0.0525*	0.0416+	0.0629	0.0395	0.0351	0.0629	0.0395	0.0233
	(0.0365)	(0.0314)	(0.0282)	(0.0511)	(0.0334)	(0.0330)	(0.0511)	(0.0334)	(0.0270)
Education Adults	-0.0402	-0.0413*	-0.0547**	-0.0312	-0.0331+	-0.0508**	-0.0312	-0.0331+	-0.0281+
	(0.0314)	(0.0225)	(0.0215)	(0.0272)	(0.0225)	(0.0241)	(0.0272)	(0.0225)	(0.0172)
N. of Child	-0.121***	-0.113***	-0.0979***	-0.0935**	-0.0789**	-0.0419	-0.0935**	-0.0789**	-0.0776***
	(0.0398)	(0.0345)	(0.0314)	(0.0431)	(0.0352)	(0.0359)	(0.0431)	(0.0352)	(0.0281)
N. of Infants	0.0633	0.0552	0.0447	0.0193	0.0249	-0.0387	0.0193	0.0249	0.0602
	(0.0682)	(0.0559)	(0.0513)	(0.0693)	(0.0555)	(0.0565)	(0.0693)	(0.0555)	(0.0437)
Free Seed	0.318**	0.240**	0.231**	-0.234	0.137	0.203*	-0.234	0.137	0.0138
	(0.155)	(0.117)	(0.0909)	(0.221)	(0.129)	(0.108)	(0.221)	(0.129)	(0.116)
Seed Purchase	0.0699	0.0457	0.0289	-0.000321	0.0811	0.0745	-0.000321	0.0811	0.111
	(0.183)	(0.112)	(0.105)	(0.244)	(0.112)	(0.107)	(0.244)	(0.112)	(0.0951)
Fertilizer Use	0.130+	0.129*	0.0859+	0.171*	0.123*	0.135*	0.171*	0.123*	0.129**
	(0.0897)	(0.0683)	(0.0590)	(0.0931)	(0.0715)	(0.0716)	(0.0931)	(0.0715)	(0.0571)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	11.07***			11.83***			11.78***		
	(1.195)			(1.888)			(1.771)		
Rho		0.000951***	0.00183***		-0.000569	0.00112***		-0.000569	-0.00507***
		(0.000249)	(0.000222)		(0.000362)	(0.000327)		(0.000362)	(0.000498)
Lambda			-0.00271***			-0.00407***			0.00326***
			(0.000749)			(0.000775)			(0. 00004)
Sigma2_e		0.117***	0.156***		0.0981***	0.121***		0.0981***	0.107***
		(0.00809)	(0.00837)		(0.00675)	(0.00693)		(0.00675)	(0.00544)
Observations	423	423	423	423	423	423	423	423	423
Number of HH_id	141	141	141	141	141	141	141	141	141
R-squared (within)	0.286	0.299	0.331	0.534	0.416	0.423	0.534	0.416	0.237

The null hypothesis of Moran’s I is rejected for the dependent variable at alpha = 0.10
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.23: Household-to-Firm — Robustness Test n.2 — Main Results Total Consumption with Downstreamness*Inverse-Distance

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	SAR	SAC	FE	SAR	SAC	FE	SAR	SAC
Down.*Inv. Dist.e	0.182***	0.182***	0.161***	0.226***	0.268***	0.295***	0.226***	0.268***	0.295***
	(0.0673)	(0.0622)	(0.0570)	(0.0843)	(0.0633)	(0.0647)	(0.0843)	(0.0633)	(0.0647)
Female Head	-0.0433	-0.0253	-0.106	0.0977	-0.0464	-0.0852	0.0977	-0.0464	-0.0852
	(0.157)	(0.107)	(0.102)	(0.133)	(0.104)	(0.102)	(0.133)	(0.104)	(0.102)
Household Labor	-0.0685*	-0.0601**	-0.0552**	-0.0269	-0.0256	-0.000177	-0.0269	-0.0256	-0.000177
	(0.0353)	(0.0290)	(0.0262)	(0.0392)	(0.0292)	(0.0280)	(0.0392)	(0.0292)	(0.0280)
Household Size	0.0582*	0.0544**	0.0339	0.0718+	0.0548*	0.0475*	0.0718+	0.0548*	0.0475*
	(0.0331)	(0.0271)	(0.0244)	(0.0458)	(0.0291)	(0.0285)	(0.0458)	(0.0291)	(0.0285)
Education Adults	-0.0306	-0.0317+	-0.0476**	-0.0232	-0.0276	-0.0437**	-0.0232	-0.0276	-0.0437**
	(0.0266)	(0.0195)	(0.0186)	(0.0248)	(0.0195)	(0.0209)	(0.0248)	(0.0195)	(0.0209)
N. of Child	-0.129***	-0.127***	-0.0980***	-0.117***	-0.107***	-0.0655**	-0.117***	-0.107***	-0.0655**
	(0.0343)	(0.0298)	(0.0272)	(0.0410)	(0.0307)	(0.0312)	(0.0410)	(0.0307)	(0.0312)
N. of Infants	0.0505	0.0482	0.0271	0.0395	0.0429	-0.0114	0.0395	0.0429	-0.0114
	(0.0554)	(0.0483)	(0.0437)	(0.0571)	(0.0483)	(0.0484)	(0.0571)	(0.0483)	(0.0484)
Free Seed	0.292**	0.233**	0.213***	-0.0818	0.159	0.237**	-0.0818	0.159	0.237**
	(0.142)	(0.102)	(0.0768)	(0.206)	(0.112)	(0.0930)	(0.206)	(0.112)	(0.0930)
Seed Purchase	0.0222	-0.00146	-0.0193	-0.110	0.0234	0.0406	-0.110	0.0234	0.0406
	(0.148)	(0.0971)	(0.0901)	(0.189)	(0.0974)	(0.0925)	(0.189)	(0.0974)	(0.0925)
Fertilizer Use	0.112	0.112*	0.0636	0.169**	0.131**	0.146**	0.169**	0.131**	0.146**
	(0.0731)	(0.0590)	(0.0499)	(0.0829)	(0.0622)	(0.0620)	(0.0829)	(0.0622)	(0.0620)
Seed Type Dummy*	-	-	-	-	-	-	-	-	-
Urea Seller Dummy*	-	-	-	-	-	-	-	-	-
Constant	10.57***			11.16***			10.52***		
	(1.063)			(1.712)			(1.635)		
Rho		0.000777***	0.00166***		-0.000595*	0.000943***		-0.000595*	0.000943***
		(0.000240)	(0.000205)		(0.000342)	(0.000302)		(0.000342)	(0.000302)
Lambda			-0.00285***			-0.00404***			-0.00404***
			(0.000704)			(0.000683)			(0.000683)
Sigma2_e		0.0876***	0.114***		0.0743***	0.0898***		0.0743***	0.0898***
		(0.00604)	(0.00621)		(0.00512)	(0.00505)		(0.00512)	(0.00505)
Observations	423	330	330	423	330	330	423	330	330
Number of HH_id	141	110	110	141	110	110	141	110	110
R-squared (within)	0.318	0.323	0.356	0.534	0.453	0.432	0.534	0.453	0.432

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.10

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.24: Firm-to-Household – Main Results Total Sales Value

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	SAR	SAC	FE	SAR	SAC	FE	SAR	SAC
Distance	-0.398*	-0.390**	-0.371**	-0.333*	-0.335*	-0.410	-0.333*	-0.339***	-0.410
	(0.232)	(0.172)	(0.172)	(0.188)	(0.172)	(0)	(0.188)	(0.116)	(0)
Male Owners	0.0293	0.0346	0.0387	-0.152	-0.0399	-0.0000007	-0.152	-0.0360	-0.0000007
	(0.0993)	(0.151)	(0.152)	(0.162)	(0.143)	(0.187)	(0.162)	(0.0958)	(0.128)
Employees	0.00109***	0.00111*	0.00112*	0.00127***	0.00159**	0.000305	0.00127***	0.00157***	0.000303
	(0.000229)	(0.000653)	(0.000654)	(0.000373)	(0.000651)	(0.0243)	(0.000373)	(0.000435)	(0.00829)
Initial Paid-Up Capital	-0.000000004	-0.000000004	-0. 00000002	-0. 00000004	-0. 00000002	0. 00000003	-0. 00000004	-0. 00000002	0. 00000003
	(0. 00000001)	(0. 00000003)	(0. 00000003)	(0. 00000003)	0. 00000004)	0. 0000005)	(0. 00000003)	(0. 00000003)	(0. 0000002)
Export Value	0. 00000001	0. 00000001	0. 000000001	0. 00000001	0. 00000001	0. 000000007	0. 00000001	0. 00000002	0. 000000007
	(0. 000000008)	(0. 00000002)	(0. 00000002)	(0. 00000001)	0. 00000001)	(0. 00000003)	(0. 00000001)	(0. 00000001)	(0. 00000001)
Raw Material Dummy*	-	-	-	-	-	-	-	-	-
Keeping Accounting Books Dummy*	-	-	-	-	-	-	-	-	-
Constant	17.74***			18.57***			18.78***		
	(1.073)			(2.091)			(2.693)		
Rho		-0.00004	-0. 00002		-0.00005	0.00006		-0.00007	0.00006
		(0. 00006)	(0.00006)		(0.00006)	(0.00251)		(0.00005)	(0.000816)
Lambda			-0.00004			-0.000221			-0.000222
			(0.00009)			(0.00929)			(0.00343)
Sigma2_e		1.676***	2.511***		1.307***	1.500***		0.585***	1.500***
		(0.114)	(0.114)		(0.0890)	(0.524)		(0.0214)	(0.223)
Observations	432	432	432	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144	144	144	144
R-squared (within)	0.207	0.207	0.207	0.632	0.381	0.0007	0.632	0.377	0.0007

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.05

Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.25: Firm-to-Household – Main Results Productivity

	Wave Fixed Effects			Region/Zone-Wave Fixed Effects			Wave Fixed Effects HH Trends		
	FE	**SAR**	**SAC**	**FE**	**SAR**	**SAC**	**FE**	**SAR**	**SAC**
Distance	-0.486**	-0.489***	-0.542***	-0.344**	-0.341**	-0.318	-0.344**	-0.217*	-0.327
	(0.235)	(0.175)	(0.180)	(0.152)	(0.173)	(0.236)	(0.152)	(0.112)	(0.821)
Male Owners	0.200**	0.224+	0.211	0.154*	0.153	0.139	0.154*	0.223**	0.151
	(0.0885)	(0.154)	(0.153)	(0.0901)	(0.144)	(0.147)	(0.0901)	(0.0939)	(0.108)
Employees	-0.000118	-0.000118	-0.000177	0.000575+	0.000611	0.000709	0.000575+	0.000708*	0.000700
	(0.000248)	(0.000665)	(0.000658)	(0.000382)	(0.000654)	(0.000677)	(0.000382)	(0.000426)	(0.000840)
Initial Paid-Up Capital	0.000000007	0.000000007	0.000000005	0.00000001	1.670.0000000	0.00000003	1.470.0000000	1.370.0000000	2.750.0000000
	(0.00000001)	(0.00000003)	(0.00000003)	(0.00000002)	(0.00000004)	(0.00000004)	(0.00000002)	(0.00000002)	(0.00000003)
Export Value	0.000000001	0.000000002	0.000000002	0.000000002	0.000000004	0.000000007	0.000000002	0.000000005	0.000000004
	(0.000000004)	(0.00000002)	(0.00000002)	(0.000000005)	(0.00000002)	(0.00000002)	(0.000000006)	(0.00000001)	(0.000000009)
Raw Material Dummy*	-	-	-	-	-	-	-	-	-
Keeping Accounting Books Dummy*	-	-	-	-	-	-	-	-	-
Constant	2.770**			1.434			3.674*		
	(1.328)			(1.214)			(1.942)		
Rho		-0.00492**	-0.0112***		-0.00469	-0.00393		-0.00757***	-0.00392
		(0.00212)	(0.00334)		(0.00292)	(0.00490)		(0.00206)	(0.0142)
Lambda			0.00633***			-0.0113			-0.00885
			(0.00204)			(0.0229)			(0.0804)
Sigma2_e		1.740***	2.575***		1.323***	1.955***		0.561***	1.142***
		(0.118)	(0.119)		(0.0901)	(0.110)		(0.0198)	(0.0764)
Observations	432	432	432	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144	144	144	144
R-squared (within)	0.277	0.270	0.265	0.454	0.454	0.441	0.454	0.449	0.447

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.05
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.26: Firm-to-Household – Main Results Total Sales Value with Different Weights

	Wave Fixed Effects		Region/Zone-Wave Fixed Effects		Wave Fixed Effects HH Trends	
	SAR	SAC	SAR	SAC	SAR	SAC
Distance	-0.397**	-0.406**	-0.357**	-0.376**	-0.362***	-0.397***
	(0.173)	(0.173)	(0.172)	(0.172)	(0.117)	(0.116)
Male Owners	0.0333	0.0279	-0.0446	-0.0493	-0.0405	-0.0477
	(0.152)	(0.151)	(0.143)	(0.143)	(0.0973)	(0.0971)
Employees	0.000949	0.00109*	0.00156**	0.00158**	0.00155***	0.00156***
	(0.000795)	(0.000653)	(0.000651)	(0.000651)	(0.000441)	(0.000442)
Initial Paid-Up Capital	0. 000000003	-0.000000003	-0.00000002	-0.00000001	-1.510.0000000	-0.0000001
	(0. 00000002)	(0.00000003)	(0.00000004)	(0.00000004)	(0.00000003)	(0.00000003)
Export Value	0. 000000007	0.00000002	0.00000002	0.00000001	0.00000001	0.00000001
	(0. 00000001)	(0.00000002)	(0.00000002)	(0.00000002)	(0.00000001)	(0.00000001)
Raw Material Dummy*	-	-	-	-	-	-
Keeping Accounting Books Dummy*	-	-	-	-	-	-
Constant			-0.000236			
			(0.000430)			
Rho	-0.000112	-0.00008		-0.00005	-0.000381	0.000185
	(0.000433)	(0.000463)		(0.000453)	(0.000374)	(0.000405)
Lambda		-0.00007		-0.000521		-0.00104**
		(0.000484)		(0.000552)		(0.000527)
Sigma2_e	1.679***	2.517***	1.309***	1.956***	0.603***	0.893***
	(0.114)	(0.114)	(0.0891)	(0.0890)	(0.0224)	(0.0222)
Observations	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144
R-squared (within)	0.207	0.207	0.380	0.380	0.376	0.376

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.05
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1

Table A.27: Firm-to-Household – Main Results Productivity with Different Weights

	Wave Fixed Effects		**Region/Zone-Wave Fixed Effects**		**Wave Fixed Effects HH Trends**	
	SAR	**SAC**	**SAR**	**SAC**	**SAR**	**SAC**
Distance	-0.487***	-0.487***	-0.346**	-0.350**	-0.231**	-0.234**
	(0.176)	(0.176)	(0.174)	(0.173)	(0.114)	(0.116)
Male Owners	0.200	0.201	0.154	0.157	0.222**	0.222**
	(0.155)	(0.155)	(0.145)	(0.145)	(0.0950)	(0.0980)
Employees	-0.000119	-0.000120	0.000575	0.000582	0.000693+	0.000751*
	(0.000670)	(0.000670)	(0.000657)	(0.000657)	(0.000431)	(0.000445)
Initial Paid-Up Capital	0.000000007	0.000000008	0.00000002	0.00000002	0.00000001	0.00000001
	(0.00000003)	(0.00000004)	(0.00000004)	(3.740.0000000)	(0.00000002)	(0.00000003)
Export Value	0.000000001	0.000000001	0.000000002	0.000000002	0.000000003	0.000000003
	(0.00000002)	(0.00000002)	(0.00000002)	(0.00000002)	(0.00000001)	(0.00000001)
Raw Material Dummy*	-	-	-	-	-	-
Keeping Accounting Books Dummy*	-	-	-	-	-	-
Constant			-0.00009			
			(0.000437)			
Rho	-0.000005	0.000009		0.00002	-0.000145	0.000305
	(0.000437)	(0.000456)		(0.000465)	(0.000383)	(0.000398)
Lambda		-0.00005		-0.000343		-0.000995*
		(0.000460)		(0.000594)		(0.000565)
Sigma2_e	1.767***	2.650***	1.334***	1.997***	0.575***	0.906***
	(0.120)	(0.120)	(0.0908)	(0.0908)	(0.0205)	(0.0225)
Observations	432	432	432	432	432	432
Number of HH_id	144	144	144	144	144	144
R-squared (within)	0.277	0.277	0.453	0.453	0.450	0.450

The null hypothesis of Moran's I is rejected for the dependent variable at alpha = 0.05
Robust standard errors in parentheses: +p<0.15, *** p<0.01, ** p<0.05, * p<0.1