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Microcredit and Agricultural Technology Adoptions:

Evidence from Ethiopia

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Abstract

In Ethiopia, women and female headed households make up significant share of farm households who are also extremely poor. In this thesis I provide evidence for the need to move beyond microcredit and promote a broader financial inclusion to affect a majority of farm households' livelihood strategies, particularly technology adoptions. I use large and nationally representative panel of households obtained from rural Ethiopia as part of the World Bank's LSMS-ISA to 1) understand constraints to technology adoption, highlighting credit 2) assess whether microcredit is positioned to work for a majority of them. To the latter's effect, I investigate decisions to participate in the credit markets and use a particular credit type; explore the relationship between formal and informal lenders - whether they serve as substitutes or complements. The last two decades has witnessed a dramatic expansion in the physical access to microcredit in poor, risky agrarian settings. There is limited penetration of banks and many households, especially small and marginal farmers rely on informal finance. For many, microcredit is introduced to rescue poor borrowers by reducing institutional credit constraints and their reliance on informal finance. So one expects that the information technology and contract enforcement mechanisms of microcredit lenders to lie between the two extremes. I employ state-of-the-art and complex econometric methodologies which allow to obtain more reliable results and, hence, more specific contributions to research and practice.

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List of Acronyms and Abbreviations

AgSS - Annual Agricultural Sample Survey

AIDB - Agricultural and Industrial Development Bank

AISE - Agricultural Inputs Supply Enterprise, Ethiopia

CSA - Central Statistics Agency, Ethiopia

EA - Enumeration Area

ECX - Ethiopian Commodity Exchange

EPAR - Evans School Policy Analysis and Research Group

ESS - Ethiopian Socioeconomic Survey

ETB - Ethiopian Birr

GDP - Gross Domestic Product

GGDC - Groningen Growth and Development Centre

GTP - Growth and Transformation Plan

IFC - International Financial Corporation

IIA - Independence of Irrelevant Alternatives

IMF - International Monetary Fund

LIFT - Land Investment for Transformation

LSMS-ISA - Living Standard Measurement Study-Integrated Survey on Agriculture

MFIs - Microfinance Institutions

MNL - Multinomial Logit

MNP - Multinomial Probit

NBE - National Bank of Ethiopia

NGOs - Non-Governmental Organizations

PASDEP - Plan for Accelerated and Sustained Development to End Poverty

PRSP - Poverty Reduction Strategy Papers

RHS - Right Hand Side

SACCOs - Saving and Credit Cooperatives

SDPRP - Sustainable Development and Poverty Reduction Program

SNNP - Southern Nations Nationalities People region of Ethiopia

SSA - Sub-Saharan Africa

WB - World Bank Group

Introduction

The past two decades has seen the proliferation of microcredit in low-income food deficit countries. The introduction of microcredit technologies is viewed by many as one important innovation to enrich rural financial intermediation and enable the poor to make their way out of poverty via investments and savings. In subsistence agriculture-based countries - where banks have not expanded much into agricultural finance, most farm households rely on informal finance. There is a widely held belief that these alternative sources of finance are generally unproductive and some of them are also highly exploitive. At least at the beginning, many expected that microcredit will change the credit landscape in these settings considerably.

The new lending technique has the potential to reduce formal sector credit constraints and reliance on informal finance. The main dividing line between formal and informal lenders is the mechanisms they rely on to deal with challenges posed by asymmetric information and contract enforcements. Conceptually, microcredit providers are in a better position than banks to share superior informational advantages informal lenders used to enjoy exclusively. They are also able to substitute binding collateral requirements with heavy screening, monitoring and enforcement of contracts thanks to their group-liability mechanisms (Conning & Udry, 2007). Credit constraint has traditionally mired technology adoptions (de Janvry et al., 2016; Magruder, 2018), contributing to low and stagnant yield growth in SSA.

In this thesis I provide wide-ranging evidence on constraints to adoption underscoring credit and whether microcredit is effective enough to induce/enable smallholders to uptake credit/ invest in a relatively risky, but potentially productivity enhancing technology in Ethiopia. My analysis of household technology adoption decisions focuses on inorganic fertilizer (henceforth fertilizer, unless stated otherwise). Credit availability may improve up on the investment levels of farm households, but it is not a panacea. Moreover, credit facilities may have to be fused with other services that the rural poor

needs such as: savings, insurance and efficient transfer services. Until recently, many people had the impression that MFIs have done significant steps forward in responding to their needs and that they are 'on the right track.' Yet, after reports of borrowers trapped into a vicious circle (for example, in the Indian state of Andhra Pradesh), a growing number of studies are criticizing a rosy view about microfinance and questioning whether microcredit can address severe institutional finance gap and effective enough in spurring technology adoptions. Limited uptake of microcredit and its limited impact is widely documented in various contexts of low income countries (Banerjee et al., 2015).

I take advantage of large and nationally representative panel of households obtained from rural Ethiopia as part of the World Bank's LSMS-ISA in 2011/12, 2013/14 and 2015/16. Unlike many surveys implemented in the past in Africa, the LSMS-ISA contains a separate credit section with detailed questionnaires about loan applications and the resulting credit market equilibrium outcomes for each sample respondent. It was designed in such a way that enables one elicit farmers' credit constraint status and hence allows for the best one can do with observational data. The approach I follow in this thesis - direct elicitation methodology (after Boucher et al., 2009) - relies on borrowing incidence to identify non-price credit rationing status. The available data is not only large, but also rich in that it provides detailed and harmonized information on households and their farm, community level and location-specific characteristics including credits and inputs use. Thus, it provides a unique opportunity to rigorously examine the dynamics of technology adoptions and uptake of credit decisions while addressing major econometric challenges.

Descriptive statistics shows that of sample households which are engaged in crop production about 50.5% are non-users of fertilizer. Only about 23% of households have access to credit, of which only about 30% obtain loans from formal sources. In other words, significant share of rural poor still rely on informal finance some of which are

highly exploitive. About 54% of sample households reported to face some kind of credit rationing. Of this transaction costs and risk rationing accounts for about 15% and 57% respectively. While only 17% of non-users reported to face quantity rationing this share increases to 60% if a broader definition of credit constraints is considered. The corresponding share is only 12% and 46% among fertilizer users. Some research questions need to be asked: Why borrowing households increasingly rely on informal finance while microcredit supply is expanding? Is this rationing leading to more demand of informal finance and/or expanding access to microcredit is also growing the importance of informal finance? How do households sort themselves into different credit contracts and what are the factors at play in influencing their decisions to use varied credits? Is this rationing affecting the technology adoption decisions of Ethiopian farmers? In this thesis I try to address these questions.

I specify panel selection model to examine causal effects of credit constraints on both the dichotomous adoption and the continuous conditional intensification decisions. To the best of my knowledge, this is one of the first studies that attempt to tackle self-selection into adoptions and potential endogeneity of credit constraints while controlling for unobserved heterogeneity in both the selection and main equations. As for the second topic, unlike Abate et al. (2016), I analyze the role of microcredit in comparison to semi-formal and informal sources of finance with a special focus to the latter. I employ a random-utility maximizing discrete choice model and Heckman selection model to investigate the interactions between formal and informal finance and decisions to demand, apply for and use varied credits. Results reveal a negative association between measures of credit constraints status and adoption variables. The effect is stronger when the demand-side credit rationing is accounted for and when within household variation in credit constraint status is considered as opposed to across constrained and unconstrained households. Majority of farmers are not able take advantage of micro-

credit in part due to difficulty to reach, approach or use. Results also shed some light on access to productive inputs dimension of gender inequality.

This thesis brings two distinct strands of literature together: an emerging literature that scrutinizes the role of microfinance from outreach and credit access perspectives and fairly well-established literature on technology adoptions in low-income countries (Feder et al., 1985 and followers). Some of the studies that closely relate to the first issue I analyze in this thesis are: Menkhoff and Rungruxsirivom (2011) on village funds in rural Thailand, Khoiet et al. (2013) on Vietnamese rural finance and Islam et al. (2015) on microfinance institutions in Bangladesh. My approach to the analysis of the interactions between formal and informal finance is different from them. It is rather closer to an approach by Allen et al. (2019) albeit in a very distinct context - they study the role of informal finance in firm growth in China. The way I drive a variable capturing formal credit market development and the estimation strategy employed in this particular case make the current study different also from the latter. Moreover, the main source of formal finance in their study is traditional banks.

Africa's second most populous nation, yet one of the poorest in the world; Ethiopia provides an interesting empirical context to study these issues. The agricultural sector is very large, accounting for nation's significant share of output, employment and foreign exchange earnings, among others. Albeit notable policy attentions, it performed poorly over a long period. Technology adoption is often suggested as a promising way to raise productivity of smallholder farmers. Farmers are highly encouraged to utilize modern technologies, especially fertilizer.[1] Therefore, focusing on this particular input/technology seems interesting in its own right. Beyond that, it could also provide some insight into the role of microcredit in facilitating adoptions of other - relatively risky, but productivity enhancing - technologies in rural Ethiopia. The government

[1] The government sets (and subsidizes) fertilizer prices, but does not consider it a formal subsidy programme (Rashid et al., 2013)

considers microcredit as a key policy instrument in combating poverty, especially among the poorer, but productive farm households (Amha, 2003; 2011). Recently there is a trend of commercializing microfinance - some prominent MFIs have already taken the initiative to graduate to rural banks.

The remainder of this thesis is structured as follows: chapter one revisits historical relationship between finance and smallholder growth in Ethiopia. Chapter two describes the LSMS-ISA data and provides credit constraints status identification procedures and some descriptive evidence. In chapter three I investigate the decisions to demand, apply for and use varied credits and the interactions between formal and informal finance. This is followed by the examination of the effects of credit constraints on technology adoptions and intensity of use decisions in chapter four. Chapter five concludes the thesis.

Chapter One

1. Finance and Smallholder Agriculture in Ethiopia

Like in most developing nations, Ethiopian governments under different regimes responded to poorly performing rural credit markets by establishing various institutions. The establishment of agricultural bank of Ethiopia in 1945 is believed to be a pioneer. Although it was established in a quite distinct context, the imperial regime's intention was to accelerate agricultural development via advancing loans to smallholders for the purpose of, among others, purchasing seeds, livestock and implements (Assefa, 1987). An attempt was made to transform subsistence-oriented agricultural production to market-oriented surplus production. To this effect, the imperial regime underscored the importance of introducing improved tools and implements, modern techniques, and better seeds backed by facilitating credits, price and tax policies as well as land reform and agricultural services (Assefa, 2004).

While commercial farms were able to directly obtain credits from the banks, farmers' cooperatives took the leading role of linking development bank (primary lender) to smallholder farmers in a two tier system. They receive credit funds from the bank; buy farm inputs and supply them to farmers on credits. Thus, they determine who should benefit first from the limited funds available for credits to the sector. Due to a number of reasons - chiefly collateral requirements of as high as 200% of the loans - farmers' thirsty for finance failed to be satisfied. Agriculture received, on average, only 42% of total loans disbursed by the development bank during the 1951-69 of which smallholder farmers managed to receive only 7.5% (Assefa, 2004).[2] More striking is that, the bulk of the loans meant to stimulate smallholder growth went to "absentee landlords, merchants, town dwellers, government officials and other non-agriculturalists, which were mainly spent on house building, shops, cars, weeding, et cetera" (Assefa, 1987; Assefa,

[2] The main task of the development bank of Ethiopia at the time was to handle long-term credits (Assefa, 2004).

2004, p.7). This trend lasted until the 1974 revolution that eliminated the imperial regime and brought in the socialist regime. Subsistence farming dominated agriculture contributed more than 70% to total output and more than 90% to total employment during most of this period (table 1.3). However, agricultural output grew, on average, by only two percent. Labour productivity in the sector and hence welfare of most farm households deteriorated around the end of the imperial regime (table 1.1 and table 1.2).

Table 1.1
Value added based output growth (at constant 2005 national prices)

(Average, in Percentage)

	1960s	1970-73	1974-79	1980s	1990-94	1995-99	2000s	2010-12
GDP	3.7	3.0	0.8	1.9	1.6	3.8	8.0	10.0
By sectors								
Agriculture	2.0	2.2	0.3	1.0	0.1	0.9	6.5	7.2
Mining	13.4	9.9	-7.7	6.5	29.3	6.4	6.3	38.2
Manufacturing	9.2	6.9	2.4	3.9	3.6	6.1	7.1	12.5
Utilities	14.9	8.2	3.4	6.8	2.9	3.6	6.9	13.3
Construction	12.0	0.6	-1.9	3.0	-1.7	8.6	11.2	12.0
Trade, restaurants & hotels	14.2	5.6	1.0	2.9	3.1	5.5	10.4	11.7
Transport, storage, communication	11.8	9.7	2.6	5.9	3.7	5.5	10.3	12.1
Finance, insurance, real estate	9.5	10.7	13.4	4.9	8.1	7.0	12.3	16.5
Government services	3.5	7.3	8.5	4.7	11.6	13.5	8.8	10.2
Community, social/personal service	9.1	7.1	2.7	4.3	10.1	8.5	6.2	6.3

Source: Own computation based on GGDC 10-Sector Database

For much of the 1970s till the end of the 1980s the country was under heavy central planning influenced by soviet-style socialist ideology. Broader policy measures from the central planning organ included, but were not limited to controls on exchange rates, deposits and lending rates as well as credit allocations. Credit policy gave absolute priority to the socialized sector at the cost of private sector development including smallholder farmers. Private sector and cooperatives respectively absorbed, on average, only 4.7% and 1.1% of total outstanding domestic credit during the 1986-90 (WB, 1991). Of the total agricultural loans provided by the then AIDB during the same period, more

than 89% channeled to state farms and the remaining to cooperatives, leaving private peasant sector isolated(Assefa, 2004).

Table 1.2
Value-added based labour productivity growth (constant 2005 national prices)

(Average, in percent)

	1960s	1970-73	1974-79	1980s	1990-94	1995-99	2000s	2010-11
GDP	1.2	0.0	-2.1	-1.8	0.3	0.4	4.6	5.6
By sectors								
Agriculture	0.0	-0.5	-2.2	-2.6	-1.3	-2.1	4.6	6.5
Mining	0.0	-14.5	-14.5	-7.2	-1.5	-1.5	-1.5	-1.5
Manufacturing	2.0	2.0	2.0	-0.8	-3.1	-3.1	-3.1	-3.1
Utilities	-1.1	-1.1	-1.1	-0.1	0.7	0.7	0.7	0.7
Construction	0.2	0.2	0.2	-3.0	-5.6	-5.6	-5.6	-5.6
Trade, restaurants & hotels	-3.5	-3.5	-3.5	-2.0	-0.8	-0.8	-0.8	-0.8
Transport, storage, communication	-0.1	-0.1	-0.1	1.9	3.5	3.5	3.5	3.5
Finance, insurance, real estate, others	10.3	7.1	10.2	1.1	4.7	-1.9	-2.1	-1.3
Government services	-2.8	-2.8	-2.8	2.3	6.4	6.4	6.4	6.4
Community, social/personal services	-4.8	-4.8	-4.8	0.1	4.0	4.0	4.0	4.0

Source: Own computation based on GGDC 10-Sector Database

Table 1.3
Sectoral output (O) and employment (E) share(S)

(Average, Percentage)

	1960s		1970-73		1974-79		1980s		1990-94		1995-99		2000s		2010-11	
	OS	ES	OS	ES	OS	ES	OS	ES	OS	ES	OS	ES	OS	ES	OS	ES
GDP	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
By sectors																
Agriculture	80.5	94.7	72.8	91.9	70.8	90.7	65.0	88.9	62.5	89.3	54.2	86.3	46.9	82.5	41.4	74.3
Mining	0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.1	0.5	0.2	0.5	0.2	0.5	0.3	0.7	0.6
Manufacturing	2.6	1.5	3.4	1.9	3.5	1.6	4.5	1.7	4.3	1.8	5.3	2.6	5.4	4.1	5.3	6.6
Utilities	0.7	0.0	1.0	0.0	1.2	0.1	1.7	0.1	2.2	0.1	2.1	0.1	2.2	0.1	2.0	0.1
Construction	3.6	0.2	4.6	0.3	4.0	0.2	4.5	0.3	3.2	0.2	3.7	0.4	5.2	1.1	5.8	2.2
Trade, restaurants and hotels	7.5	1.4	11.8	2.8	12.2	3.2	13.0	3.7	12.4	3.5	14.5	4.5	15.9	6.3	18.9	10.5
Transport, storage, commun.	1.3	0.2	2.1	0.4	2.3	0.4	3.2	0.4	3.8	0.4	4.3	0.4	5.3	0.4	5.7	0.5
Finance, insurance, real s.	0.6	0.1	0.9	0.1	1.7	0.1	2.4	0.1	3.3	0.1	3.9	0.1	5.0	0.2	6.7	0.5
Government services	1.9	1.0	1.8	1.2	2.7	1.9	3.6	2.4	5.4	2.2	8.1	2.5	10.4	2.5	10.8	2.4
Community, social/personal	1.0	0.7	1.2	1.3	1.5	1.7	1.8	2.4	2.4	2.4	3.3	2.8	3.2	2.5	2.7	2.3

Source: Own computation based on GGDC 10-Sector Database

A critical review of NBE's directives shows that discrimination rule applied to lending rate over the period was discouraging for private sector development. Thus, the socialist regime as well largely failed to ensure smallholders' adequate access to financial ser-

vices. Instead, credit policy during the regime created a fertile ground for well connected and influential or to ideologically favoured groups to absorb the bulk of credits (Assefa, 2004). Overall economic performance as well as that of the agricultural sector was very disappointing during the socialist regime: 1974-91. The contribution of agriculture to total output and employment remained quite significant showing little sign of structural shift (Table 1.3). A little sign of gains in terms of agricultural output expansion observed during the previous regime vanished and labour productivity further deteriorated (table 1.1 and table 1.2).

Post-1991 can be considered as a marked policy departure in Ethiopia. The new regime openly adopted a market-oriented economic policy.[3] The issue of credit allocation left to the forces of market with a minimum control on lending rate still lingered. Consequently, the private sector received the lion's share of total institutional credits. As far as rural credit is concerned, banks attempted to reach households in a two tier system via cooperatives and peasant associations. Nevertheless, huge gap in rural finance persisted even after the reform due to seemingly unavoidable constraints - market failures - and smallholder agriculture continued to suffer. The limited loans disbursed to smallholder agriculture from the banking system kept falling short of the amount and kind of loans needed to make the necessary investment to intensify the sector. For most farm households informal sources of finance such as Eqqub, money lenders and friends remained a last resort in case they wish to finance their economic activities out of borrowing (NBE, 1996).

The nation issued its first microfinance legislation in 1996 for the establishment of deposit taking MFIs to provide the poor with sustainable financial service alternatives. It has also tried to create an environment conducive for the emergence and proliferation of financial cooperatives via proclamation in 1998 (Amha, 2011). These two institu-

[3] Although it was not a full blown ones, several policy, legal, regulatory, supervisory and institutional reforms were undertaken (for details: Assefa, 2004; Geda, 2006)

tions have been exerting commendable efforts to satisfy farmers' unmet credit demand albeit limited ability to do so. Currently, Ethiopia has one of the strongest MFIs sector in SSA, with significant outreach serving millions of customers (Amha & Peck, 2010). There were around 14,453 SACCOs in 2014, which focused on delivering financial services (Tesfamariam, 2015). Nevertheless, recently available evidence shows that informal sources are by far important in rural credit market.

Over the last decade the Ethiopian government pursued a series of development strategies that focused on reducing multidimensional poverty in rural areas. Special attention was given to increasing agricultural productivity and thereby raising the purchasing power of small and marginal farmers. Supported by exceptionally high public infrastructure investments, the nation managed to achieve some remarkable economic progress albeit from a low base (WB, 2016). Total output expanded, on average, by more than eight percent per annum. This was made possible thanks to expansion in the agricultural sector, which still accounted for a significant share of total employment, but also total output (table 1.1). The largest part of expansion was driven by productivity surge and the remaining by increased cultivated land (WB, 2016). According to the bank, this expansion in agricultural output was accompanied by multidimensional wellbeing improvement including poverty rate. This is also evident from agricultural labour productivity growth in table 1.2 above.

Yet, the observed growth was flimsy in that it was not accompanied by structural changes observed in other parts of the world (Rodrik, 2014). The service sector (mostly informal) took the leading role of absorbing the marginal amount of labour leaving agricultural sector (table 1.3). More importantly, agricultural land and labour productivity was still among the lowest even by African standard. For instance, cereal subsector is estimated to account for roughly 60% of rural employment, 80% of total cultivated land, more than 40% of a typical household's food expenditure, more than 60% of the calorie consumption and for nearly 30% of national income (Rashid, 2010). However,

cereal yield in Ethiopia was less than fifth of the level in Egypt, less than a third of that in China and Vietnam (Alemayehu Seyoum, 2009). This wide gap in cereal productivity can significantly be explained by limited adoptions and low intensity of modern technology use (Minot & Benson, 2009; Rashid et al., 2013). Sheahan and Barrett (2017) document that many farmers in selected countries in SSA - including Ethiopia - use fertilizer than is often acknowledged in earlier literature.[4] Yet, there is immense variation across households in terms of intensity of use, even among those with similar biophysical endowments.

Descriptive evidence in table 1.4 is computed based on the LSMS-ISA dataset and includes rural and rural town households which are engaged in crop production during the last three waves of the survey. An increasing number of households reported to use any amount of fertilizer on their plots albeit from a low base and at a decreasing rate: around 46%, 50% and 52% in 2012, 2014 and 2016 respectively. This is consistent with evidence provided in Sheahan and Barrett (2017). On average, the rate of application for the entire households - including non-users - stood at 43kg/ha in 2012 and 55kg/ha in 2014. These correspond to 65kg/ha and 72kg/ha among users only during the same period.

Despite winsorization of extreme values, reported average for 2016 still suffers from outliers and is not reliable. Yet, it is evident that application rate has increased tremendously in 2016 not only among users, but also across the entire households. The first 25 percentile and median application rates, among users, was 124kg/ha and 298kg/ha. This is comparable to the level observed in Malawi and Nigeria in 2011; the other nations in SSA at the forefront - with similar efforts to the Ethiopia government - promoting increased use of fertilizer.[5] But, one can hardly understand from table 1.4 who is using fertilizer and who is not, an issue that deserves further investigation. If

[4] They also use LSMS-ISA dataset - but, a cross-section of households from selected countries in SSA. Data on Ethiopian sample is obtained from the first wave of the survey.

[5] For details, see in Sheahan and Barrett (2017).

Ethiopia has to achieve robust structural transformation and thereby noticeably reduce rural poverty and ensure food security, constraints to adoptions and optimal utilization of improved technologies especially in the cereal subsector needs to be addressed.

Table 1.4
Intensity of fertilizer use

Variables	2011-12	2013-14	2015-16
Inorganic fertilizer application rate (kg/ha)			
Mean	43.4	55.6	884.6
Std. Dev.	60.5	71.9	3975.0
Min	0.0	0.0	0.0
p25	0.0	0.1	0.0
Median	20.6	25.4	129.9
p75	66.1	89.7	468.5
Max	741.9	395.4	60644.2
Total Obs.	2642	2883	2792
Inorganic fertilizer application rate, among users (kg/ha)			
Mean	65.2	72.2	1300.8
Std. Dev.	63.9	74.3	4764.6
Min	0.0	0.1	2.1
p25	20.6	12.3	124.4
Median	48.6	52.4	298.5
p75	92.9	103.3	603.0
Max	741.9	395.4	60644.2
Total Obs.	1235	1461	1460

Source: EPAR, Washington University

Note: That winsorization is applied to both variables: Total area planted is winsorized at top 1% and bottom 1% (of non-zero values) and the result is used to construct an indicator for use in area-weight (area planted*household weight). Then final indicator is winsorized at top 1%.

Summing Up

The agricultural sector is very large, accounting for nation's significant share of output and employment. Albeit notable policy attentions, it performed poorly over a long period. For Ethiopia to embark on a successful transition from subsistence farming to a state of higher agricultural productivity; acceptable level of farmers need to adopt and optimally use improved technologies. Accumulated knowledge from the development paths of the nation reveals that significant reduction in the poverty and food insecurity rates hinges on substantial productivity gains in the sector. However, for the majority of rural poor to benefit from the advantages of improved technologies, the use of these technologies necessitates that it be financed.

Ensuring adequate and timely flow of institutional credit to rural areas, particularly which tailored to the needs of small and marginal farmers, however remained largely challenging in Ethiopia. Like in many other developing economies, the Ethiopian government (under different regimes) responded to this problem by establishing various credit institutions. Yet, this one as well proved inadequate for a number of reasons. Financial providers' activity, the institutional environment as well as farm households and their farm characteristics jointly makes accessibility to formal sector credits almost impossible for most resource poor farmers.

I find conclusions by Hayami and Kikuchi (1981) and Sarap (1991) important in the Ethiopian context. In an environment characterized by poor legal institutions, larger farmers and rural elites use their economic, social and political positions and connections to absorb the bulk of institutional credits. Resource poor farmers have limited assets to use it as collateral and demand small loans at a time making them risky and costly from lenders' perspectives. In case they manage to get access to institutional credits they do so usually after much delay compared to their larger counterparts. Their lower bargaining power, bureaucratic and procedural formalities required; pat-

ronage, arbitrariness and corrupt practices of lenders and officials especially in the co-operatives being the main factors behind substantial delay in getting institutional credits.

More recently, there are considerable efforts by microcredit providers - MFIs and rural financial cooperatives - to improve upon rural credit markets. Fertilizer adoption rates remained low and recent improvements is accompanied by tremendous variation in the intensity of use even across households with similar biophysical endowments.

Chapter Two

2. Data

The ESS, which is part of the World Bank's LSMS-ISA project in SSA, is a multi-topic, nationally representative panel household survey with a focus on agriculture. The sample is also representative at the regional level for the most populous regions: Tigray, Amhara, Oromia and the SNNP. Region-specific estimates are possible for a group of smaller regions: Afar, Benishangul Gumuz, Diredawa, Gambella, Harari and Afar. The ESS contains detailed post-planting information on the type of landholdings, irrigation, inputs use (including fertilizer), crop conditions, cropland areas of all fields under major crops; information on livestock holdings; post-harvest information on agricultural practices as well as crop and livestock product utilization information; information on socio-economic variables - sex, age, literacy and education, employment, shocks, consumption expenditures, sources of income (on-farm and off-farm), credits, and asset ownership. Community-level information on access to infrastructure and institutions and location-specific variables are also collected.

Households in the survey were visited three rounds so far: first in 2011/12 and then a follow-up survey in 2013/14 and 2015/16. The survey uses a two-stage probability sampling. In the first stage the EAs - primary sampling units - are selected for the rural, small and large town areas samples. This is followed by the selection of households included in the survey from each EA in the second stage. For the rural samples, 290 EAs were selected based on probability proportional to size of the total EAs in each regional state. A total of 12 households were sampled in each EA (without replacement) of which 10 were randomly selected out of the total households engaged in farming and/or livestock rearing activities and the other two out of the remaining households, that is, those which are not engaged in either activity. In case there were less than two households from the latter category, more households from the former cate-

gory were surveyed. For a small town samples, a total of 43 EAs were selected in the first stage. In the second stage, 12 households - irrespective of their agricultural activities - were selected randomly from a list of each EA without replacement. Accordingly, a total of 3969 households were visited during the first round with a response rate of 99.3%.[6] Similarly, a total of 5262 and 4954 households were visited respectively during the second and third rounds with a response rate of 96.2% and 85%.[7]

EPAR (2019) uses raw LSMS-ISA data to construct a set of agricultural development indicators, with an aim to facilitate analyses of this dataset and to make estimates of relevant indicators available to a broader audience of potential users. To this effect, Stata do files are developed - creating three final datasets at the household, individual and plot levels with labeled variables and construction decisions for each indicator across survey instruments. In the process of final indicator construction, the team at EPAR further cleans any illogical entries that surface, deals with potential outlier observations across all indicators and then winsorize values. Both winsorized and unwinsorized versions of the variables are included in the Stata do files. There is also a specific winsorization decisions for each indicator. The same cleaning and winsorization procedure is followed across indicators and survey instruments. Moreover, household weights, individual weights, area weights and animal weights are applied where necessary to obtain representative estimates for household, individual, hectare and animal respectively. Besides the main LSMS-ISA dataset, I use some variables constructed by the EPAR team. Accordingly, with the exceptions of dummies that capture credit constraints status, rain perceptions, education of household head, remittance and wealth effects, as well as age of household head, all variables I use in this thesis are compiled by the EPAR team.

[6] The first round was designed in such a way that it represents rural and small town areas of Ethiopia. Thus, it excludes samples from major urban areas.

[7] Attrition in major urban areas was 15% due to consent refusal and inability to trace the whereabouts of sample respondents during the third wave.

Unlike most surveys implemented in the past, especially in SSA, the LSMS-ISA contains a separate credit module with detailed questionnaires for sample respondents pertaining to their participation in the credit markets. Responses obtained allow for relatively better proxy of the extent and forms of credit constraints in the rural areas of low-income countries like Ethiopia. This is especially crucial when it comes to understanding and quantifying the effects of incomplete credit markets on farm households' decisions including technology adoptions. Yet, it is far from being perfect. One important shortcoming I came across of this survey is that it is challenging to exhaustively classify sources of rural finance into: formal, semi-formal and informal due to a vague response "others." It is possible that "others" includes Iqqub, Iddir and other local financiers; even formal and informal sources. My impression is that the incidence of the latter two is low and this classification does not pose a serious threat in the econometric exercises. This classification matters only in the analysis of decisions to use varied credits. Even in that case the main interest is in the interactions between formal and informal credits.

The other is that, it is very likely that farm households obtain credits from multiple sources. Evidence for this is response obtained from the first round of the survey. Yet, the focus seems to be on obtaining only the first main source of credits during the latest two rounds. Thus, I am not able, for example, to include the alternative "both formal and informal credits" in the choice set from which the household selects.[8] Available information is adequate to identify the incidence of credit constraints, but not necessarily its level. The dividing line is that not all households which reported credit constrained are necessarily creditworthy clients from lenders' perspectives. Yet, the incidence of credit constraints provides an upper-bound measure of the extent of true credit constraints (Sanchez & Love, 2009).

[8] In case multiple loan contracts are reported by a single household in the first round of the survey, then only the one made by the household head is considered.

For the current purpose I consider only samples from rural and rural town areas, extracting an unbalanced panel of farm households which are engaged in crop production. In cases where the panel dimension of data is important, all households observed at least twice and for which I am able to identify their credit constraint status, based on information available to me, are included in the sample of data used in the econometric exercises. Only limited households are dropped due to missing information on other important variables included in the estimations. Borrowing households with no clear information concerning the sources and purpose of loans as well as no information on the amount of loans and an amount of loans obtained below 150 Ethiopian birr are dropped.

2.1. The Rural Credit Market in Ethiopia: Evidence from the LSMS-ISA

In this section I examine financing arrangements in rural Ethiopia over a medium term horizon highlighting the relative importance of formal and informal sources of finance. In this thesis informal finance providers are relatives, neighbors, local merchants/grocery, employers and religious institutions and money lenders. Semi-formal sources of finance are cooperatives, the government, NGOs and "others." formal finance providers are MFIs and traditional banks. The rationale behind their classification becomes clearer in chapter three of this thesis.

There is a growing importance of informal finance despite the unprecedented efforts to reduce its role via institutional credits supply - mainly microcredit. Substantial amount of loans - nearly one third of total credit supplied - originated from informal sources during the period from 2012-16. Albeit high interest paid on some of these loans, even relatively better-off households opt for informal lenders. Where the role of formal sources of finance is quite limited, farm households rely mainly on informal sources. While informal sources account for the lion's share of credits used to smooth consumption, especially in low potential areas of the country, substantial part of it also used for productive purposes.

Compared to formal sources, mainly MFIs, informal and semi-formal sources allow for more flexible terms of repayment. Smaller-size, shorter-term better defines loans obtained from informal sources. Interest charged on loans from informal sources, with the exception of selected lenders, is much higher than loans from formal sources. Interest charged on loans from NGOs and money lenders is extremely high - evidence that brace existing views of informal finance providers. Some informal lenders tend to exploit poorer borrowers taking advantage of their positions. Contrary to existing beliefs, careful inspection of available data reveals that not every loan from relatives, neighbors and religious institutions is interest free - some borrowers pay substantial interest. Some interesting relationship between formal and informal loans can also be established depending on households' timing of borrowing (figure 2.1).

a. Access to Finance

On average, about 23% of households were able to access credits over the period from 2012-16. This is in sharp contrast with existing evidence that about 56% of smallholder farmers had access to credits - cash or in kind - from various sources in 2008 (Amha, 2011). This could be due to a decline in agricultural inputs credits, which around 47% of farmers managed to access in the same period. Considerable heterogeneity across regions in access to credits is evident from data in table 2.1. Credits provided by the government and donors as part of the Ethiopia's extensive food security programmes for chronically food-insecure households partly explains the observed heterogeneity (Amha, 2011) (see also table 2.3). While, on average, about 24% of rural households borrowed from different sources this number stood at 17% in rural towns. Farm households in Tigray and Amhara had better access to credits followed by those in Oromia and the SNNP. Those in a group of smaller regional states of Ethiopia - regionO - had limited access to credits.

Table 2.1

Households' response in access to finance from any source over 12 months preceding the survey

	Yes		No	
	Sample respondents	Percentage share	Sample respondents	Percentage share
Period				
2012	863	22.6	2959	77.4
2014	885	24.3	2758	75.7
2016	830	22.7	2831	77.3
Total/Average	2578	23.2	8548	76.8
Location				
Rural	2347	24.0	7448	76.0
Rural town	231	17.4	1100	82.6
Regions				
Tigray	367	32.4	767	67.6
Amhara	720	29.5	1722	70.5
Oromia	502	22.7	1705	77.3
SNNP	577	20.4	2258	79.6
RegionO	412	16.4	2096	83.6

Source: Own computation based on LSMS-ISA dataset

RegionO includes Afar, Benishangul Gumuz, Gambella, Harari and Somalie regional states as well as Diredawa

b. Sources of Finance

Formal sources of finance account for only about 30% of total loans farm households received over the period from 2012-16 (table 2.2). Despite the unprecedented government efforts to limit the role of NGOs and informal lenders via institutional credit interventions, the informal sector share in total credits stood at about 68% in 2016, with its role significantly increasing over time. Relatives, neighbors and local merchants were the main sources of finance for smallholder farmers with about 42%, 12.4% and 9.5% share in total credits respectively. Evidently, households obtain loans from more than one source, combining not only multiple informal sources, but also informal and formal ones (table 2.2). For instance, there were households which obtained loans from three different sources and for that matter combining loans from MFIs with informal lenders such as money lenders. The coexistence of formal and informal sources of finance and households borrowing from both sources at the same time is not an observation specific to the rural Ethiopian setting. There are some theoretical explanations for this, an issue I will return to in chapter three of this thesis.

Formal sources account for as high as 45% of total credits in Amhara followed by 37% in Tigray while it is only slightly higher than four percent in regionO (table 2.3). The role of informal sources in Tigray seems to be underestimated and that of semi-formal sources inflated perhaps due to a vague "Others" grouping. Yet, it is reasonable to expect relatively higher roles of semi-formal loans in Tigray. The government and donors allocate large sum of funds every year mainly in the form of production credits to build assets of chronically food insecure households. Households in more vulnerable regions are expected to benefit the most.

Table 2.2
Borrowing households' main sources of loans

Source (Incidence, % share)	2012	2014	2016	Total
Formal	32.0	32.2	25.5	30.0
Commercial banks	0.5	0.3	0.4	0.4
Microfinance institutions	31.5	31.9	25.2	29.6
Semi-formal	17.0	10.1	6.4	11.2
NGOs	3.1	0.0	1.4	1.5
Others	13.9	10.1	4.9	9.7
Of which: Cooperatives		46.1		
Government		32.6		
Informal	51.0	57.7	68.1	58.8
Relative	29.9	34.4	42.0	35.3
Grocery/Local merchant	5.1	5.5	9.5	6.7
Employer	0.9	0.3	0.2	0.5
Money lender	4.2	5.0	2.3	3.8
Neighbors	9.4	11.2	12.4	11.0
Religious institutions	1.5	1.4	1.6	1.5

Of which multiple sources in 2012 only	Sample respondents
Three different informal sources	1
Two different informal sources	10
Informal and formal sources	12
Two different informal sources and one formal sources	1
Informal, semi-formal and formal sources	1
Semi-formal and formal sources	3
Semi-formal and informal sources	10

Source: Own computations based on LSMS-ISA dataset

Note: This classification into formal, semi-formal and informal is not mutually exclusive. "Others" grouping likely includes sources such as Eqqub, Iddir and some cases of formal and informal sources. For instance, in 2014 for which I have relatively a precise data, cooperatives and the government account for only 78.7% of "Others." The survey provides information on multiple sources only for the first wave, 2012.

Despite better agricultural potential in most parts of the central and southern regions of the country - Oromia and the SNNP - compared to their northern counterparts - Tigray and Amhara, formal finance providers are less active, particularly in the SNNP (table 2.3). While relatives are the dominant informal source of finance for farm households across all regions money lenders are more active in Amhara and the SNNP. In low agricultural potential areas of the country where the role of formal sources of finance is quite limited households rely mainly on relatives, local merchants and neighbors. Credits extended by MFIs accounts for the lion's share of total credits supplied (table 2.4). While the number of beneficiaries remained the same average loan size significantly declined over the period 2012-14 leading to a sharp drop in credits supplied by MFIs.

Table 2.3
Borrowing households' main sources of loans by regions: 2012-16

Sources (Incidence, % share)	Tigray	Amhara	Oromia	SNNP	RegionO
Formal	37.3	44.9	32.7	22.7	4.4
Commercial banks	0.5	0.4	1.0	0.0	0.0
Microfinance institutions	36.8	44.4	31.7	22.7	4.4
Semi-formal	31.6	6.4	11.8	9.2	3.6
NGOs	1.6	1.1	3.0	1.2	0.7
Others	30.0	5.3	8.8	8.0	2.9
Of which:					
Cooperatives	51.2	17.1	26.8	2.4	2.4
Government	93.1	0.0	0.0	3.4	3.4
Informal	31.1	48.8	55.6	68.1	92.0
Relative	21.3	32.5	35.3	40.2	46.1
Grocery/Local merchant	3.0	1.7	5.6	4.9	22.6
Employer	0.3	0.1	0.6	0.0	1.9
Money lender	0.0	6.5	2.2	5.5	2.2
Neighbors	6.3	4.2	11.6	16.3	18.9
Religious institutions	0.3	3.8	0.4	1.2	0.2

Source: Own computations based on LSMS-ISA dataset
Note: Percentage share on cooperatives and the government here corresponds to their total contribution as a source of finance only in 2014's "Others" and not for the period from 2012-16. So for instance, under Tigray about 51.2% of "Others" in 2014 (which is 10.1%, table 2.2) was taken by cooperatives in Tigray, the remaining by cooperatives in other regions.

Interestingly, the gap is filled by informal lenders, particularly relatives. Loans provided by relatives account for over 31% in 2014 up from about 17% in 2012. Average loan

size grew by more than the growth in the number of households which obtained the loans (1.3 times vis-a-vis 1.2 times) over the same period. Religious institutions' average loan size jumped enormously while the number of households which obtained the loans remained roughly the same over the period 2012-16. It jumped by threefold and over fivefold on a two (2014-16) and four (2012-16) years basis albeit its trivial share in total credit supply. Overall, substantial amount of loans (nearly one third of total credit supplied) originated from informal sources during 2012-16 (table 2.4).

Table 2.4
Loans volume by main sources

Source	Loan volume (in Millions Birr)			% share (of total)		
	2012	2014	2016	2012	2014	2016
Formal	1.86	1.21	1.81	64.9	51.2	63.1
Commercial Banks	0.02	0.01	0.02	0.8	0.6	0.7
Microfinance Institutions	1.84	1.19	1.79	64.1	50.6	62.4
Semi-formal	0.24	0.18	0.13	8.4	7.7	4.4
NGOs	0.05	0.00	0.05	1.7	0.0	1.8
Others	0.19	0.18	0.07	6.7	7.7	2.6
Informal	0.76	0.97	0.93	26.7	41.1	32.5
Relative	0.48	0.73	0.65	16.9	31.1	22.6
Neighbor	0.07	0.08	0.10	2.3	3.4	3.4
Grocery/Local Merchant	0.13	0.07	0.12	4.5	3.0	4.1
Money Lender	0.07	0.06	0.02	2.3	2.7	0.6
Employer	0.01	0.00	0.00	0.4	0.2	0.0
Religious Institution	0.01	0.02	0.05	0.3	0.7	1.8
Source	Average loan size growth (ratio)			Sample respondents growth (ratio)		
	2012-14	2014-16	2012-16	2012-14	2014-16	2012-16
Formal	0.7	1.7	1.2	1.0	0.7	0.8
Commercial Banks	0.8	1.5	1.2	0.8	1.0	0.8
Microfinance Institutions	0.6	2.0	1.3	1.0	0.7	0.8
Semi-formal	0.6	3.0	1.7	0.6	0.6	0.4
NGOs	0.0	0.0	2.3	0.0	0.0	0.5
Others	1.3	0.9	1.1	0.7	0.5	0.3
Informal	0.9	1.1	1.0	1.2	1.1	1.3
Relative	1.3	0.8	1.0	1.2	1.1	1.4
Neighbor	1.0	1.2	1.1	1.3	1.0	1.3
Grocery/Local Merchant	0.5	1.0	0.5	1.2	1.6	2.0
Money Lender	0.8	0.6	0.5	1.2	0.4	0.5
Employer	0.9	0.5	0.5	0.4	0.7	0.3
Religious Institution	1.7	3.0	5.1	0.9	1.1	1.0

Source: Own computations based on LSMS-ISA dataset

c. Income Status and Loans Characteristics

With the exceptions of households in the SNNP, most rural households which obtained loans from informal sources, particularly relatives and local merchants in Tigray; relatives, local merchants, money lenders and Neighbors in regionO; local merchants and religious institutions in Amhara; relatives, local merchants and Neighbors in Oromia, could have accessed credit from MFIs had their income status alone mattered (table 2.5). In some regions, specifically Oromia, NGOs focused more on serving relatively better-off households which were more likely to have got even bank credits. Obviously, not all households which resort to informal lenders for finance are equally asset or resource poor. Some households can provide sufficient assets to pledge to access formal sector credits, but poor collateral laws make writing and enforcing contracts with most of their assets difficult if not impossible. Moreover, for a number of fundamental reasons to be discussed in detail in chapter three of this thesis, some households find it more convenient to approach informal lenders.

Table 2.5
Borrowing households' consumption quintile by source of loans: 2012-16

Source	Mean					Mean	Freq.
	Tigray	Amhara	Oromia	SNNP	RegionO	Total	
Commercial banks	3.0	3.7	4.0	0.0	0.0	2.1	10
Microfinance institutions	3.9	2.6	3.3	3.0	3.5	3.3	726
NGOs	3.3	2.4	3.6	2.4	4.0	3.1	36
Others	3.4	2.3	2.9	2.2	2.6	2.7	238
Relative	3.5	2.6	3.3	2.6	3.6	3.1	868
Grocery/Local merchant	4.2	3.3	3.5	3.1	3.5	3.5	157
Employer	4.0	3.0	3.0	0.0	2.8	2.6	12
Money lender	0.0	2.5	3.1	2.8	3.4	2.3	96
Neighbors	3.1	2.5	3.4	2.1	3.9	3.0	268
Religious institutions	2.0	2.9	3.0	2.3	2.0	2.4	36

Source: Own computations based on LSMS-ISA dataset
Note: that consumption quintile is constructed based on total nominal consumption expenditure that is adjusted for spatial prices. Consumption quintiles are constructed by the LSMS-ISA team.

Compared to formal sources, particularly MFIs, informal and semi-formal sources of finance allow for more flexible terms of repayment (table 2.6). Small-size, short term working capital is usually what matters a lot for most farm households and credit from

informal sources seems to be better tailored to this needs. With the exceptions of loans obtained from local merchants, average loan from formal sources is larger than the one obtained from informal sources. Borrowed loans from informal sources and MFIs respectively lasts, on average, less than 10 months and well over 14 months before full repayment is made. Conversely, MFIs allow for the shortest frequency of repayment, which implies that, given their relatively larger loan size, poor borrowers are forced to make larger periodic repayments. Interest charged on loans from informal sources, with the exception of selected lenders, is much higher than loans from formal sources. Interest charged on loans from NGOs and money lenders is extremely high - evidence that brace existing views of informal finance providers. Contrary to existing beliefs, careful inspection of available data reveals that not every loan from relatives, neighbors and religious institutions is interest-free - some borrowers pay significant interest.

Table 2.6
Loans characteristics by source in 2016*

Source	Mean	Freq.	Mean	Freq.	Mean	Freq.	Mean	Freq.
	Loan size (In Birr)		Annual interest		Loan duration (In months)		Freq. of repayment	
Commercial banks	5,752.7	10	14.8	3	15.3	3	4.8	4
MFIs	6,319.9	763	19.9	174	14.7	178	5.4	210
NGOs	2,657.3	39	25.1	7	10.6	8	6.3	12
Others	1,813.3	250	15.6	30	10.0	30	6.0	41
Relative	2,055.6	911	7.7	161	8.3	164	6.3	350
Local merchant	3,191.4	172	19.9	35	6.4	36	5.6	79
Employer	1,253.8	13	0.0	2	0.0	0	7.0	2
Money lender	1,479.7	99	81.1	11	9.5	11	5.9	19
Neighbors	871.3	283	24.5	51	7.5	54	6.9	103
Religious inst.	1,992.7	38	26.2	4	8.5	4	6.8	13

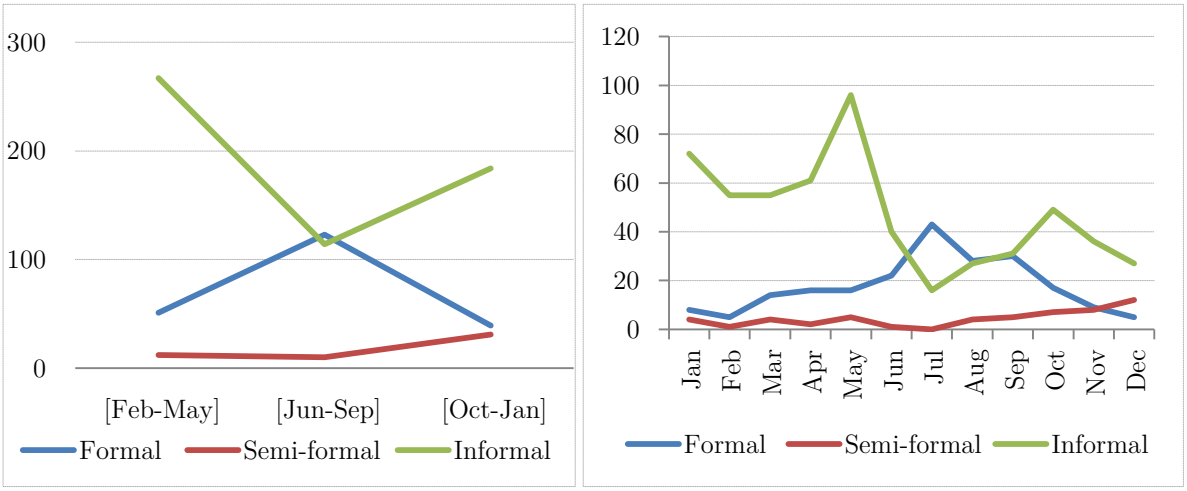
Source: Own computations based on LSMS-ISA dataset
Note: that except for loan size, information contained in table 1.6 is available only for the latest wave of the survey. *loan size is average for 2012-16. Freq. - frequency

Some interesting relationship between formal and informal loans can also be established depending on households' timing of borrowing (figure 2.1).[9] As expected, bor-

[9] Note that timing of borrowing as used here does not necessarily correspond to a period during which a new loan contract is initiated. It is rather a period during which borrowing households manage to secure the loans they have requested some time ago.

rowing from formal sources picks during the main planting season, specifically in the month of July. This is a critical time for most farm households to purchase the necessary inputs such as fertilizer, improved seeds and agrochemicals. Borrowing from formal sources declines following the onset of the main harvest season well through the short rain season. This is also natural given that most households hold some cash on hand (in kind) in these periods. Conventionally most farmers in low income settings sell their produce immediately following harvest. Incomplete credit market provokes a "sell low, buy high" phenomenon in which case farmers sell their produce when the price is too low immediately after harvest and buy similar products when the price is much higher during the lean seasons. They do so usually to fulfill their financial obligations, including debt from formal sources that is relatively more rigid. Some households may even borrow from informal sources to meet those obligations. This is evident in figure 2.1 that borrowing from informal sources plummets within the same period borrowing from formal sources picks and then raise during the main harvest season well through the short rain season.

Figure 2.1
Households' timing of borrowing by source: 2016



Source: Own computations based on LSMS-ISA dataset. The Y-axis indicates sample respondents
Note: Separation of months in which households obtained loans into three interlocked time periods correspond to important agricultural seasons in Ethiopia. There are two main crop seasons: the belg season (short rain season running approximately from February through May) and the Meher season (from June to September for planting and from end of September to February for harvest). The latter is very important accounting for 90-95% of the nation's total cereals output (Yigezu & Zekaria, 2010).

Interestingly, there are two picks for loans from informal sources: the lower pick is in the main harvest season (in October) and the higher pick occurs in the short rain season (in May). This is in line with the extent of households' liquidity constraints from the harvest to lean seasons. The other possible explanation is that formal credit denied households when it is most needed during the main planting phase redirect their request to informal lenders. Most farmers learn the outcome of their loan applications usually after much delay in the case of formal credits. This implies that they have to wait till the end of July after which desperate households resort to informal lenders who process their request swiftly. It is evident from the same figure that loans from informal sources bounce back from July.

d. Purpose of Loans

Farm households borrow mainly to purchase agricultural inputs, which accounted, on average, for about 46% of total credits over the review period, followed by consumption smoothing (table 2.7). This general trend holds at regional level as well with the exception in two regions. As expected, households in low agricultural potential areas of the country - regionO - use large share of borrowed funds for consumption smoothing. In Amhara region, borrowing for rural non-farm enterprises is relatively more active lead by farm loans. This may come to one's surprise given that the rate of participation in non-farm enterprises is the lowest in Amhara than in other regions of Ethiopia. Loening et al. (2008) document the proportion of farm households participating in the non-farm enterprise to range from 0.19 in Amhara to 0.36 in the SNNP. Relatively more households in the latter region own and run non-farm enterprises, yet the subsector absorbs comparable share of borrowed funds in the two regions (nearly 26%).

Evidence contained in Loening et al. (2008) further reveals that access to finance is relatively less of a constraint to run non-farm enterprise in Amhara. Almost a quarter of households which run non-farm enterprise in the region manage to obtain credits mainly from MFIs and friends and relatives. In regions where there is relatively better

access to finance (table 2.1) and for that matter formal sector credits (table 2.3) households tend to use it more for productive purposes (table 2.7). This trend distinguishes the northern regions: Tigray and Amhara from that of central and southern regions: Oromia and the SNNP although the bulk of nation's total agricultural produce sources from the latter two combined.

Table 2.7
Households' main reason for obtaining loans: 2012-16

(Incidence, % share)	Farm	Non-farm	Personal
Period			
2012	47.7	20.6	31.7
2014	48.1	31.1	20.8
2016	43.3	19.3	37.5
Average	46.4	23.6	30.0
Region			
Tigray	56.2	21.1	22.7
Amhara	50.8	25.6	23.6
Oromia	48.6	21.4	30.0
SNNP	40.6	25.5	33.9
RegionO	35.5	23.6	40.9
Source			
Formal	38.1	34.3	14.2
Semi-formal	16.0	5.9	8.0
Informal	45.9	59.8	77.9

Source: Own computation based on LSMS-ISA
Note: Farm stands for loans used mainly to purchase agricultural inputs for food and other crops. Similarly, on-farm stands for loans used as a start-up capital for businesses; expand business and purchase non-farm inputs. Personal loans are mainly used for consumption smoothing.

2.2. Credit Constraints Status: Identification and Some Descriptive Figures

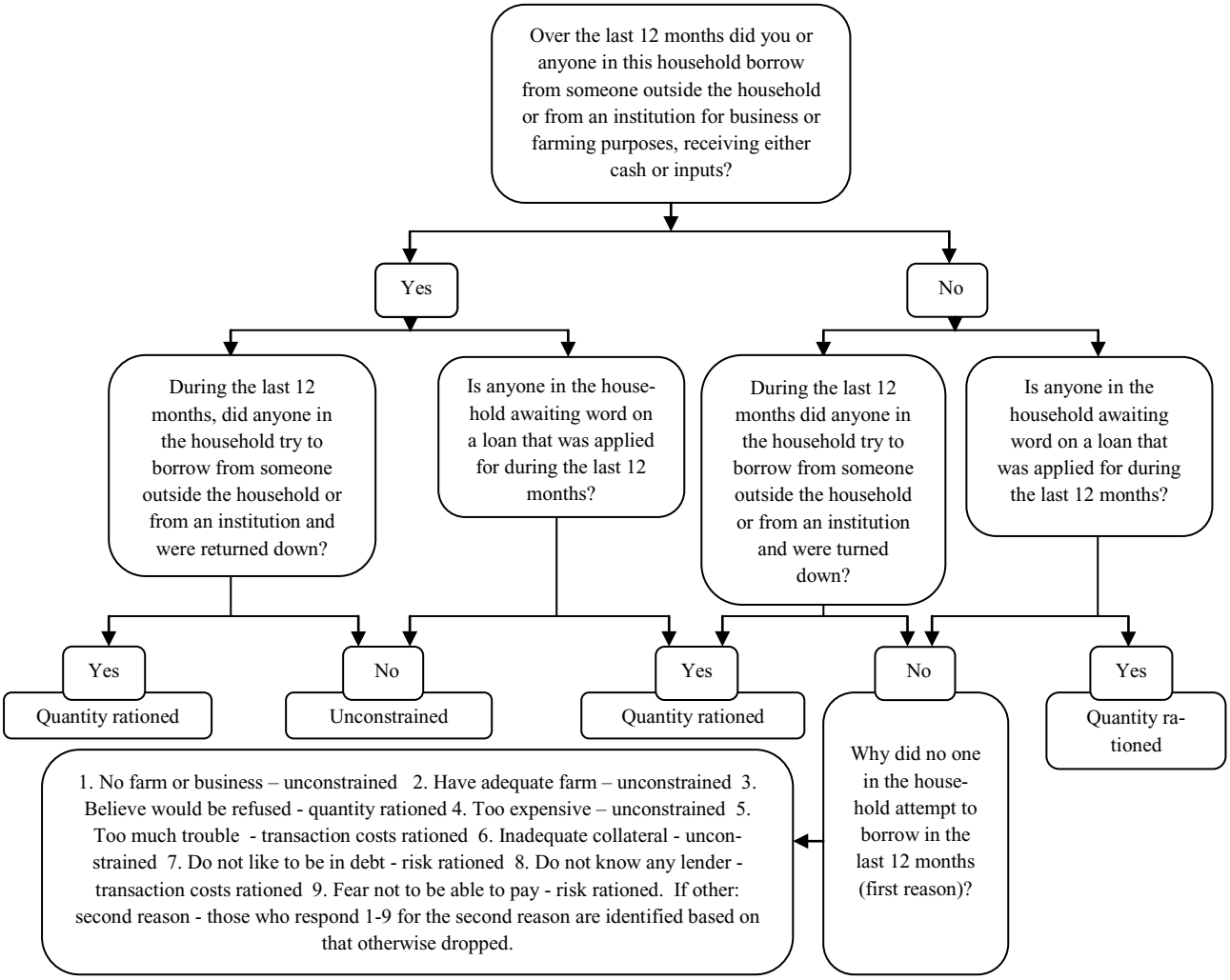
To identify non-price credit constraints status of the household I use direct elicitation methodology (Boucher et al., 2009) which relies on borrowing incidence. To make sense out of observed data, I follow the procedure described in figure 2.2. Accordingly, three separate groups can be identified.

i. Unconstrained households: this could be both borrowers and non-borrowers (non-applicants). Households in this category include those with large endowments of productive assets and liquidity as well as endowment-poor households with limited investment opportunities that require external finance. While some households have no demand for credit for the reasons just mentioned some others apply for loans and obtain the full amount requested (accessed).

ii. Supply-side constrained (quantity rationed) households: includes unsatisfied borrowers - receive loans, but the amount is less than their effective demand; applied, but rejected applicants - those with positive effective demand, but zero credit limit; certainly rejected non-applicants - this includes households which failed to apply for loans because based on past experience or their perceptions of the lenders supply rules, they were certain that their application would be rejected.

iii. Demand-side constrained (risk or transaction costs rationed) households: these are non-borrowers voluntarily withdraw from participating in the credit market due to either risk or transaction costs associated with application, access and use of credits. Even if they badly need external finance, some households forgo on applying due to higher transaction costs exacerbated by needless screening procedures, illiteracy, age and gender, et cetera. Some others prefer to protect their meager assets to borrowing which may increase the odds of exposure to risk.

Figure 2.1
Credit constraint status identification procedures



Source: Own construction, based on LSMS-ISA dataset

Non-borrowing households mentioned some reasons that I use to separate those which have no demand for credit from those which wish to borrow, but refrain from applying albeit they would not be denied access by the lenders. Households which do not demand any credit have adequate farm (enough liquidity of their own), own no farm/business, lack adequate collateral, and find available loans expensive at the prevailing interest rate (lack profitable projects). Certainly rejected non-applicants believe that their loans request would be refused. Transaction costs rationed households either do not know any lender or find it too much troubling to request one.[10] Finally, risk ra-

[10] This is important, particularly for MFIs. Some households reside in remote areas where these institutions hardly penetrate.

tioned households do not like to be in debt or fear not to be able to pay. However, for some households it is not straightforward to identify their loans status due to vague response for the first import reason not to borrow. Fortunately, there is a subsequent question in the survey which asks for the second important reason. I use responses to this last question to identify loans status for the remaining households.

Table 2.8 summarizes information on households' credit market participation decisions and the resulting equilibrium outcomes. Accordingly, on average, about 23% of sample respondents have no demand for credits and did not participate in the credit market during the period from 2012-16. There is, however, noticeable regional variation and an upward trend in the share of households which do not demand any credit. Contrary to one's expectation, partially accessed and rejected loan requests account for limited share (a little larger than two percent and four percent) of the total loans incidence. To put it another way, about 78% of households which applied for loans obtained the full amount requested with another more than eight percent obtaining partial amount. This indicates that supply side credit rationing is less concerning than emphasized in earlier studies (for example, Amha & Peck, 2010).

There is a downward trend and regional variation in the share of households which denied access to credit by lenders with above average rejection rate in Tigray and the SNNP. Significant share of households which requested informal lenders experienced partial or total rejection followed by those which directed their credit requests to formal lenders. Informal lenders account for more than 80% and 66% of overall unsatisfied and rejected cases reported in 2016. Interestingly, while informal lenders are rejecting additional loan requests formal lenders are easing their rejection rates over time. More than 51% of borrowing households reported to face demand-side credit rationing albeit substantial variation across regions. Risk rationing is more prevalent in the SNNP. As expected, transaction costs rationing is exceptionally high in regionO. It is well recognized that in most low income food insecure agrarian settings less-endowed households

prefer not to take loans and make an investment that may increase their exposure to risk. Thus, credit interventions which aim at stimulating smallholder growth may have to be fused with savings and insurance services to enable farmers build and protect their assets.

Table 2.8
Rural credit market participation decisions and outcomes for sample households

Incidence, % share	No demand	Accessed	Unsatisfied	Rejected	Certainly rejected	Transaction costs rationed	Risk rationed
Period							
2012	17.9	21.7	2.7	4.6	7.6	11.4	34.1
2014	23.9	23.7	3.1	4.0	8.8	8.1	28.4
2016	28.0	22.9	1.3	3.4	8.8	5.6	29.9
Average	23.3	22.8	2.4	4.0	8.4	8.4	30.8
Region							
Tigray	26.7	32.1	2.5	5.1	3.4	1.5	28.8
Amhara	25.1	29.6	2.4	2.5	6.4	2.1	31.8
Oromia	24.0	22.4	2.7	3.6	10.2	8.0	29.3
SNNP	22.8	18.5	2.9	5.0	8.7	4.0	38.0
RegionO	21.2	17.3	1.3	4.1	11.0	22.7	22.5

Incidence,	2012	2014	2016	2012	2014	2016	2012	2014	2016
% share	Accessed			Unsatisfied			Rejected applicant		
Formal	35.0	33.5	26.2	20.5	27.8	14.0	39.4	29.7	22.8
Semi-formal	18.6	10.8	6.7	12.3	9.3	4.7	17.2	4.4	10.9
Informal	46.4	55.7	67.1	67.1	62.9	81.4	43.4	65.9	66.3

Source: own computations based on LSMS-ISA dataset

Further assessment classifying by sources of loans is impossible for demand-side credit rationed households. The same holds true for certainly rejected households. Nevertheless, formal lenders penetration in regionO is expected to be low in part due to limited economic activities there.

Chapter Three

3. Understanding Decisions to Demand, Apply for and Use Varied Credits

Abstract

I employ a random-utility maximizing discrete choice model and Heckman selection model to identify some factors at play in influencing 1) the likelihood of demanding and applying for loans 2) the likelihood of using a particular credit type 3) explore the relationship between formal and informal lenders - whether they serve as substitutes or complements. A typical feature of rural credit markets in many low-income settings is the predominance of informal finance albeit expanding access to formal sector credits. A large theoretical literature exist claiming that poor households obtain credits either from informal sources or borrow concurrently from both. In most of these literatures formal sources of finance is represented by traditional banks. Coexistence and interactions between the two forms of finance basically emanates from the mechanisms they rely on to deal with asymmetric information and to enforce contracts. However, traditional banks are almost absent in the rural credit market in Ethiopia. The formal sources of finance considered here are microcredit providers - chiefly MFIs. Results show that formal and informal finance are both complements and substitutes for each other. There is marked gender difference as far as decisions to participate in the credit markets and to use varied credits are concerned. In particular, there is gender gap in access to microcredit. The chapter also uncovers the effects of, among others, household characteristics, farm and non-farm activities, wealth, remittance and shocks.

3.1. Introduction

A typical feature of the rural credit markets in many low-income countries - including in Ethiopia - is the predominance of informal sources of finance. This is albeit unpopularity of some informal lenders in development thinking and practice. Informal lenders are largely viewed as if they are exploitive and unproductive mainly because they play little role, if any, in inducing saving - a key instrument sought to break vicious circle of poverty. Consequently, in earlier times, governments observed heavily intervening in the financial markets in general and the credit markets in particular via targeted lending programs to curtail their roles. However, prevalence of informal finance persisted even after all-embracing economic and financial liberalization and reform efforts in the 1990s due to seemingly unavoidable constraints - market failures. Neither deliberate distortions nor market mechanisms are able to significantly improve up on weak and incomplete rural credit markets with the amount and kind of finance needed.

Conventional credit market failures necessitated an innovative way of interventions to reach small and marginal farmers and prompted the resurgence of state roles to this effect. Over the last two decades, microcredit providers - chiefly MFIs and financial cooperatives - exerted commendable efforts to curb the role of informal finance. Irrespective of the emergence and expansion of these credit institutions, informal finance still account for a significant share of rural finance in Ethiopia. More fascinating is the practice of households borrowing concurrently from both sources of finance. Some natural questions that follow are why borrowing households increasingly rely on informal finance in a context where formal sources of finance are expanding? Is credit rationing in the formal sector leading to more demand of informal credits and/or expanding access to formal credits is also growing the importance of informal credits? How do households sort themselves into different credit contracts and what are the factors at play in influencing their decisions to use varied credits? In this chapter I try to address these questions.

It is imperative to explore the rationale behind the coexistence of various lending alternatives ranging from extremely undesired money lenders to preferred traditional banks in the credit markets of developing economies. A large theoretical literature has also established the possibility that poor households obtain credits either from informal sources or borrow concurrently from both informal and formal sources. In most of these literatures formal finance is represented by the banks. Banks enjoy better opportunity and have the ability to mobilize sufficient loanable funds, including from the rural poor. Yet, asymmetric information and poor collateral laws critically limit banks' ability to identify credit worthy borrowers; to monitor and control borrowers' non-diligent behavior and to enforce contracts. This leads to a well acknowledged credit rationing problem. Farm households and their farm characteristics exacerbate this problem.

Collateral poor households resort to informal lenders. First hand access to information about potential borrowers enables the latter to substantially reduce the frictions that impede banks' lending ability. It is not always the case though that a borrower prefers formal lenders. Even collateral-rich, but small loan borrowers may find it inefficient to choose formal lenders with substantial delay and transaction costs. Moreover, informal lenders are flexible enough to write state-contingent contracts that some borrowers find it indispensable. It is not always the case also that the two sources of finance substitute each other. There are many situations in which the two can complement each other.

However, banks are almost absent in the Ethiopian rural credit markets. The formal finance I consider is microcredit providers, particularly MFIs. One may think that this does not make any difference as far as the theoretical explanations are concerned. Yet, it is also reasonable to think the other way around. The main dividing lines between formal and informal sources of finance are the mechanisms they rely on to overcome problems posed by asymmetric information and the way they deal with contract enforcements. At least conceptually, there is relatively narrower gap between microcredit

providers and informal lenders when it comes to the information technology they use and the way they enforce contracts. The former are in a better position than banks to share superior informational advantages the latter used to enjoy exclusively. Collateral requirement is not as binding as it is for banks. Microcredit providers are able to substitute limiting collateral requirements with heavy screening, monitoring and enforcement of contracts thanks to their group-liability mechanisms. Yet, it is possible that the group-liability mechanism implicitly picks only relatively better-off households. Thus, resource-poor borrowers may still face credit rationing. Furthermore, most areas still lack access to institutional credits albeit remarkable improvement in the physical access to microcredit recently. Thus, it is interesting and imperative to investigate farm households' decisions to participate in the credit markets, use varied credits and the interactions between various lenders in this setting.

I employ a random-utility maximizing discrete choice model and Heckman selection model to examine the interactions between formal and informal finance and decisions to demand, apply for and use varied credits. Several empirical studies attempted to examine the roles of microcredits in comparison to other rural finance providers. A paper by Abate et al. (2016) analyzes the roles of microcredits in technology adoptions in Ethiopia comparing MFIs with rural financial cooperatives. They use a sample of farm households - different and quite smaller than the sample available to me and propensity-score matching techniques. Unlike Abate et al. (2016), I analyze the roles of microcredit (MFIs) in comparison to semi-formal and informal sources of finance with a special focus to the latter. I treat cooperatives as semi-informal sources of finance with special purpose in the credit market. As for the detection of the relationship between formal and informal lenders - whether they serve as substitutes or complements - earlier studies (for example, Guirkinger, 2008) employ a binary choice model, possibly running the risk of model misspecification. Theoretically, the behavior/choice set from which any farmer selects could be multifold variable rather than twofold: no credit, on-

ly formal credit, only semi-formal credit, only informal credit or different combinations of the latter three.

Some interesting findings come from a series of estimation results. I argue that formal and informal finance are both complements and substitutes for each other in rural Ethiopia. The likelihood of using informal credit is lower in villages where formal sector credit market is relatively less developed. Based on this finding I argue that formal and informal credit/lenders serve as complements. Informal credits substitute formal sector credits where the latter is less available. That is, in regions where formal credit supply delays behind its potential demand, households rely on informal lenders. There is noticeable gender difference as far as decisions to participate in the credit markets and to use varied credits are concerned. Compared to their male counterparts, female headed households are less likely to demand external finance; even when they do demand, they are less likely to apply. Borrowing female headed households are more likely to use either "no credits" (denied access) or informal than formal sector credits.

There is a non-linear relationship between age of household head and the probability of applying for loans. Most variables included to capture the effects of wealth are important both individually and collectively. Wealthier households are less likely to demand external finance, but in case they do demand, they are more likely to apply and use formal than informal sector credits. The likelihood of using formal sector credits than relying on own resources (use no credits) increases with wealth accumulations. Having remittance sources increases the likelihood of applying for and using informal than formal sector credits. Having documentation of legal land right decreases the probability of using either no credits or informal than formal sector credits. Farm and non-farm activities as well as experiencing both common and idiosyncratic shocks are also important in explaining the decisions to demand, apply for and to use varied credits.

The remainder of this chapter is organized as follows: I discuss some theoretical issues related to the coexistence and interactions between formal and informal finance and classification of lenders in section two. In section three I specify the discrete choice model and the Heckman selection model with the rationale behind their choice and estimation strategies. Section four presents estimation results and discussion and section five concludes the chapter.

3.2. Formal and Informal Finance: Coexistence and Interactions

A large theoretical literature has established the possibility that poor households obtain credits either from informal sources or borrow concurrently from both informal and formal sources. In most of these literatures formal finance is represented by the traditional banks. This is not however the case in most low-income agrarian economies with underdeveloped credit markets. Banks enjoy better opportunity and have the ability to mobilize sufficient loanable funds, including from the rural poor. Yet, asymmetric information and poor collateral laws critically limit banks' ability to identify credit worthy borrowers; monitor and control borrowers' non-diligent behavior and to enforce contracts. To overcome these problems, banks focus on serving existing well established clients and impose heavy collateral requirements and/or limit the amount of loans they are willing to offer to others (Stiglitz & Weiss, 1981; Hoff & Stiglitz, 1990; Bell et al., 1997; Conning, 2001; 2005).

Farm households and their farm characteristics exacerbate these problems. Serving geographically dispersed households which demand small loans at a time entails substantial transaction costs. Evidence from the LSMS-ISA shows that demand for loans peaks chiefly during the planting season to finance inputs purchase and during the lean season to smooth consumption including via starting and expanding non-farm activities. These make them not only too risky, but also costly for banks. In fact, most banks have a minimum amount of loans request below which they are not willing to consider thus exclude most rural poor. The latter have limited assets to use as collateral, which banks use to circumvent against any strategic defaults. Poor collateral laws in this setting makes difficult to write and enforce contracts in case of defaults. These partly explain why we observe limited penetration of banks in the rural areas of many low-income countries. However, with the right incentives in place, banks can indirectly enrich rural credit intermediations via backing resource deprived microcredit providers - MFIs and SACCOs. To this effect, however, microcredit providers have to take certain

initiatives. First, they have to proof to banks that there are resource poor, yet productive households in need of additional finance. Second, they have to show their enthusiasm and ability to monitor them during the course of loans duration. This way they can induce and also assure banks that these borrowers are indeed determined to fully use borrowed funds for the intended productive purpose(s) and to repay their debt on time.

Collateral poor households resort to informal lenders. First hand access to information about potential borrowers enables the letter to substantially reduce the frictions that impede banks lending ability. It is not always the case though that a borrower with rewarding project prefers formal lenders. Even collateral-rich, but small loans borrowers may find it inefficient to choose formal lenders with substantial delay and transaction costs (Chung, 1995; Mushinski, 1999). Moreover, informal lenders are flexible enough to write state-continent contracts that some borrowers find it indispensable (Boucher & Guirkinger, 2007). This is especially important for households in low-income, food insecure areas which prefer protecting their meager assets to rewarding, yet risky projects that require external finance. For those which still choose to borrow, informal lenders provide greater flexibility in terms of writing and enforcing contracts.

It is not always the case also that the two sources of finance substitute each other via horizontal relationships (Floro & Ray, 1997). There are many situations where the two serve as complements leading to vertical relationships (Gupta & Chaudhuri, 1997). Empirical support for this theoretical claim is the finding of Sarap (1991) and others who report evidence of substantial delay in disbursing credits from formal sources to small and marginal farmers. Formal lenders also have relatively more rigid terms of repayment usually in conflict with rural households' cash flows. One commonly held belief in the literature is that households tend to use informal and formal loans respectively for consumption smoothing and to finance productive activities.

Access to formal sector loans is vital to substantially ameliorate smallholders' ex-ante cash constraints so that liquidity strapped farmers are able to purchase the necessary farm implements and inputs. However, ex-post credit constraint is equally important, especially for small and marginal farmers, to smooth consumption after input allocation decisions are made. Common practice in low-income settings is that most households sell the lion's share of their produce immediately after harvest to fulfill financial obligations including debt from the previous season. So by the following planting season they hold limited resource including some stored output for home consumption and for seeds. Most households are already in a desperate state to smooth consumption.

Under incomplete informal insurance pooling, ex-post credit constrained households adjust their input allocation decisions to smooth consumption. In this circumstance loans from microcredit providers may do more harm to poor farmers than benefit them.[11] Most poor are not in a position to satisfy household needs, especially during the lean season from their own earnings. The motive to meet an unanticipated household needs provoke a partial/full diversion of borrowed amount at the cost of funds available for long-term livelihood enhancements. Vicious circle of debt is imminent in these cases: households have no choice, but to default on borrowed funds, losing their valuable meager assets and also lessen the possibility of accessing formal loans in the future. Availability of informal sector loans at this juncture increases the capacity of poor borrowers to use formal sector loans for the intended productive purposes. This in turn raises the return to their economic activities and thus, provides more loanable funds for the informal lenders to operate and expand.

Unlike banks, microcredit providers are not well privileged with their ability to mobilize sufficient deposits of their own. For instance, in the Ethiopian case many MFIs/SACCOs rely heavily on mandatory saving/contributions from clients/ members, regional governments and mother NGOs to obtain loanable funds (Wiedmaier-Pfister

[11] This is documented, for example, by Siyoum et al. (2012) in rural Ethiopia.

et al., 2008).[12] Yet, at least conceptually, they are better positioned to serve the rural poor than banks for a number of reasons. They are relatively well equipped to significantly cut on transaction costs associated with borrowing small loans to large coverage of clients in remote rural areas. Microfinance is mainly group-based though some prominent MFIs provide individual lending as well. This implies that they are in a better position to overcome challenges posed by the asymmetric information. Through group-liability mechanisms, MFIs can better screen and monitor non-diligent behavior of their clients without imposing any collateral requirements. Thanks to this mechanism they are relatively closer to their target clients and slightly share some advantages that informal lenders used to enjoy exclusively. A study by Zeller (1994) demonstrates that not only informal lenders, but also group members in rural Madagascar obtain information about the wealth, indebtedness, and income potential of loan applicants.

Despite the fact that collateral requirements is not as restraining as in the case of banks, asset-poor, yet productive households may still face the challenge to access microcredits. It is plausible that the group-liability mechanism implicitly picks only relatively better-off households. Each member's net gain crucially depends on the performance and outcomes of other member's projects and loans, creating an incentive for 'peer-monitoring', 'peer selection' and 'peer-sanction' (Conning & Udry, 2007, p.72). For those with below certain level of asset endowments, monitoring costs becomes counterproductive for group members and hence for microcredit providers. The incentive to fully or partially use borrowed funds for purposes undisclosed to peers, but still may generate higher private satisfaction, increases in the size of loans (Madestam, 2014). Thus, microcredit providers either impose maximum rationing or exclude from group based liability; forcing collateral-poor borrowers to resort to informal lenders. Informal lenders may still possess some advantages over microcredit providers that en-

[12] The foundation for many MFIs currently operating in Ethiopia is a micro-lending project pioneered by their mother NGOs (Amha, 2011).

able them to reduce asymmetric information, control and reduce risk and enforce contracts in case of defaults.

Some informal lenders like money lenders rely less on information technology, but more on their enforcement capacity. More intensive monitoring and enforcement entails higher interest rate and/or severe violence (Collins et al., 2009). For some others such as relatives, neighbors, local merchants, employers, and religious institutions, personal/social and business bonding ensures that borrowed funds are used for the intended purposes. Borrower's efforts to avoid embarrassment facilitate reconciliations in case of defaults. Interest rates, if any, reflects the extent and value of ties between the borrower and these lenders. In this thesis, I consider rural cooperatives as semi-formal sources of finance with special purpose in the credit markets. They are usually established and owned by community members, but are financially weak and less independent. They also serve as a tool for regional governments to provide production credits in remote food insecure areas. Other semi-formal finance providers are the government, NGOs and "others." The government and donors allocate large sum every year mainly in the form of production credits to build assets of chronically food insecure households. Households in more vulnerable regions benefit the most. Amha (2011) notes that some local NGOs provide credit to very poor households in regions where no MFIs are operating. Banks are almost absent in the Ethiopian rural credit market and thus, the formal finance providers I consider in this thesis is MFIs.

3.4. The Discrete Choice and Heckman Selection Models

The econometric exercises in this chapter aim at identifying factors that affect 1) the likelihood of demand for external finance 2) the likelihood of applying for loans 3) the likelihood of using a particular credit type. In addition, I explore the relationship between formal and informal lenders - whether they serve as substitutes or complements.

Consider a decision process in the credit market, which entails two stages: first, the household decides whether external finance is necessary to execute planned economic activities - productive or non-productive - and whether it directs loan request(s) to a particular potential lender. In the second stage, the lender decides upon the same and the borrower either receives the required amount, partial amount or denied. The first stage includes all households with the necessary information on predictors irrespective of their demand for credits status. However, only households with positive notional demand proceed with the next decisions of whether to apply for loans. We know the equilibrium outcome of using a particular credit type only for those which applied. These lead to established selection model (Bingsten et al., 2003).

$$y_{1it} = 1[\beta x_{it} + u_{it} > 0] \tag{3.1}$$

$$y_{2it} = 1[\mu z_{it} + v_{it} > 0] \tag{3.2}$$

Accordingly, equation 3.2 is a selection equation with $y_{2it} = 1$ if and only if an indicator function 1[.] is equal to one, implying that household i's net gain/private benefit would be higher if borrowed and hence the household may wish to borrow at time t. Household and their farm, community level and location-specific characteristics that potentially influence this decision are contained in vector z. Equation 3.1 is subsequent outcome equation - demand-side credit rationing, with y_{1it} observed only when $y_{2it} = 1$. Moreover, $y_{1it} = 1$ if and only if an indicator function 1[.] is equal to one, implying that applying for loans can be counterproductive due to associated risk and transaction costs, thus household i forgo applying. Vector x contains lenders, households and their

farm, community level and location-specific characteristics that affect borrowers' extent of risk and/or transaction costs he/she expects to incur. All variables in x are also in z, but for the sake of credible estimates, the latter contains at least one additional variable that is not in the former as an exclusion restriction. This additional variable is assumed to explain whether the household demands and applies for loans, but not necessarily lenders' decisions to supply. u_{it} and v_{it} are error terms that are allowed to be correlated. Given that both the selection equation and conditional outcome equation are probit models, it is reasonable to assume that the two error terms follow a bivariate normal distribution with mean zero, unit variance, and covariance equal to ρ. The latter signals the extent of selection bias and consistency requires joint estimation of the two equations if it is statistically different from zero. I estimate the main equation first separately using a simple pooled probit followed by a joint estimation via a Heckman probit. I ignore the panel nature of available data in both cases.[13]

I use a random-utility maximizing discrete choice model - MNL - to identify factors that influence the likelihood of using a particular credit type compared to others (usually the base outcome). Put it differently: which household is more likely to use informal loans rather than accessing microcredit? It should be noted that for borrowing households, using a particular loan type is the outcome of a joint decisions that involve lenders too. Thus, observed data represents equilibrium outcomes in the credit markets rather than the demand or supply side decisions. Assume a rational utility maximizing household where the utility function is given by:

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \beta_j x_i + \varepsilon_{ij} \tag{3.3}$$

The first and second terms on the RHS of equation (3.3) are respectively systemic and random components of the utility function. While the former is a function of observables the latter is unobservable to the econometrician. Household i select option j with

[13] I admit that recognizing panel structure of the data does not significantly impact estimation results, but leads to significant lose of important information.

the highest utility among available options in the choice set. Vector x contains socio-economic and location-specific characteristics that affect the level of deterministic utility the household expects to drive from a given alternative, but also lenders' decisions to supply. If the distributional assumptions on the random errors are valid, MNL is simple and computationally efficient - model coefficients can be easily estimated employing standard maximum likelihood estimator - and it permits a simple behavioral interpretation of its parameters (McFadden, 1974). The probability that household $i(i = 1,2,...n)$ use loan type $j(j = 1,2...4)$, $p_{ij} = p_r(y_i = j|x_i)$ is given as follows:

$$p_{ij} = \frac{\exp\ (\beta_j x_i)}{1+\sum_{k=2}^{4} \exp\ (\beta_k x_i)} \tag{3.4}$$

It is assumed that the random component of utility function is i.i.d and draws from extreme value distribution. Inherent in the MNL is the assumption of IIA, which follows from the preceding assumption. Yet, in practice, there are many situations where this assumption would be violated: for instance, due to unobserved characteristics of the choice alternatives (Berry et al., 1995). Unobserved characteristic(s) of the household or a loan, which affects the choice of two or more credit type, can lead to associations across alternatives and thereby biased and inconsistent parameter and choice probability estimates (Chamberlain, 1980). Some of the variables included in the RHS could be endogenous leading to failure of the IIA assumption and hence inconsistent parameter estimates (McFadden, 1974). A large set of empirical literature resorts to performing some diagnostic tests for MNL to witness if these problems are serious enough to reject the IIA. Hausman-McFadden, suest based Hausman test and Small-Hsiao tests are the most commonly performed tests. Yet, several simulation studies show that these tests tell us nothing about the violations of the IIA assumption (Cheng & Long, 2007; Rouwendal, 2018). These studies instead advice using MNL model only in situations where the outcome alternatives can reasonably be assumed to be dissimilar and are not perfect substitutes for one another (McFadden, 1974;

Amemiya, 1981, p.298). If one insists on using these tests, suest-based Hausman test is preferable as results from the other two are typically inconclusive or contradictory (Long & Freese, 2006, p. 243-46). Though computationally intensive, MNP could be one alternative in this circumstances. The advantage is that it does not assume the IIA. Nevertheless, with few alternatives, it is quite manageable and I estimate equation (3.4) also using MNP.

Many existing empirical studies that investigate the relationship between formal and informal lenders specify an empirical model that predicts demand for informal sector credits taking the broader definition of formal credit constraints as a predictor (for example, Guirkinger, 2008). They treat the dependent variable as a binary, possibly running the risk of model misspecification. An alternative - more in line with the underlying behaviour/choice set from which any household select - is to treat the dependent variable as a manifold variable as in equation (3.4). In the latter specification, the base outcome is formal sector credits and I include a variable that captures formal credit market development as a predictor for the likelihood of using informal credits. I also estimate a Heckman selection model predicting the likelihood of using informal credits by treating the dependent variable as a binary and tackling self-selection into applying for loans.

$$IC_{it} = 1[x_{it} + u_{it} > 0] \tag{3.5}$$

$$DA_{it} = 1[w_{it} + \epsilon_{it} > 0] \tag{3.6}$$

Where household i's use of informal credits at time t is represented by IC_{it}, one if an indicator function [.] is equal to one, implying that the household drives higher utility from using informal credits as opposed to other alternatives and informal lender's benefit from borrowing to the same household is higher than the benefit he/she gets from using the same fund for alternative uses. But, it is observed only for households which choose to apply for loans. DA_{it} is an indicator function for applying status, one if ap-

plied and zero otherwise. Vectors x_{it} and w_{it} contain common observed socio-economic and location-specific characteristics as predictors. Included in the set of predictors is also a variable of main interest to identify the relationship between formal and informal lenders. For the sake of credible estimates, the latter vector includes at least one additional variable as an exclusion restriction. u_{it} and ϵ_{it} are error terms assumed to follow a bivariate normal distribution with mean zeros, unit variance and covariance ρ. I estimate the two equations jointly via maximum likelihood.

I treat all the RHS variables in equations (3.5) and (3.6) as an exogenous even if it is well recognized in the literature that credit constraints indicators are likely to be endogenous (Conning & Udry, 2007; Gine, 2011). This is the case, for instance, if unobserved factors affect the equilibrium outcomes for both types of credits simultaneously. Households with more managerial ability are less likely to face formal credit rationing and are less likely to use informal finance. Yet, I believe that the way I derive a variable capturing formal credit market development - proportion of formal credit constraints at the village level - makes it less susceptible to the endogeneity problem. In all the three cases - the two multinomial and the Heckman selection models - I ignore the panel dimension of available data, allowing for the possibility of borrowing from different sources during the years covered in the sample. I assume that the errors are uncorrelated over time, but allow for possible correlation within household and use robust standard errors clustered by the households. This requires going beyond the basic assumption implied by the IIA that introducing a new alternative (or omitting existing one) in the choice set makes no difference on the ratio of probabilities of choosing any two alternatives. In addition to that, I assume that switching among alternatives within household over time satisfies the IIA assumption (Cheng & Long, 2007).

Accordingly, I have four different dependent variables: the likelihood of demand for credits, the likelihood of applying for credits, the likelihood of using a particular credit type (credit choice) and the likelihood of using informal finance. For households which decide to apply, four possible equilibrium outcomes are considered (ignoring the possibility of using mixed credits): formal credit, semi-formal credit, informal credit and "no credit." Not all households which apply get access to the required amount (access denied). In the analysis of the relationship between formal and informal lenders, my variable of interest is the proportion of formal credit constraints. This variable is included to capture formal credit market development at the village level. I derive this variable as: a ratio of number of households in a village which applied for formal sector credits, but are unsatisfied or rejected to total number of reported formal loans requests in the same village.[14] Accordingly, this variable is set to vary across villages, but remains the same for households in the same village. The lower this ratio (closer to zero, the maximum being one) the better is the state of formal credit market development in that village. I expect negative association between this variable and the likelihood of informal sector credits use if formal and informal lenders serve as complements. The underlying assumption is that in villages where many households access microcredits there are better economic activities, providing more loanable funds for the informal lenders to thrive.

The selected explanatory variables are believed theoretically, but also proved in a large strand of empirical literature that they are important to explain the demand and supply sides of rural credit markets in low-income settings. A common set of explanatory variables are included in both the main and selection equations where controlling for the latter is necessary: gender, age (and its square) and education of household head, availability of microfinance branch in the community, oxen owned, a variable proxying household wealth, a variable capturing rain perceptions, whether the household owns

[14] Note that the latter includes all formal loan requests - accessed, unsatisfied and rejected.

non-farm enterprises, cash transfers (remittance), certificate of land right, farm-size, total planted area of maize, teff and wheat, if the household grew banana, coffee and sesame. The last six variables are included to account for the fact that farm households differ in the production of some important agricultural outputs that may affect their liquidity level, demand for loans as well as lenders' decisions to provide finance in case they wish to borrow. For instance, the last two are Ethiopia's major export commodities, with coffee growing mainly in parts of Oromia and the SNNP and sesame mainly in parts of Tigray and Amhara. Households producing coffee and sesame are relatively well connected to the national and global supply chains. They are expected to demand credits to augment their marketing as well as production capacity and easily access it using their produce as a guarantee.[15]

The same holds true for maize and wheat producers, albeit weaker supply chain linkages compared to the former two. Amhara and Oromia take the lion's share of 87% of nation's teff and wheat production and about 82% for maize (Rashid, 2010). Compared to other major cereals, teff is more inputs (fertilizer and chemicals, among others) intensive in Ethiopia, and it has more attractive price, but the lowest yield (Spielman et al., 2010; Yamano & Arai, 2011). So, households producing teff are expected to be relatively more liquid, but also demand external finance to purchase important inputs. Banana is a major fruit crop in Ethiopia, covering respectively about 60% and 68% of the nation's total fruit area and output (CSA, 2015). There are large smallholder farmers who are engaged in its production with few large-scale commercial farms. Its production concentrates mainly in the South and Southwestern parts of Ethiopia, and produced mostly for local consumption. Yet, national banana market is thin and suf-

[15] Government and donors supported ECX was established in 2008. Apart from coordinating agricultural commodities trading, ECX in collaboration with IFC introduced a warehouse receipts financing scheme in 2009 that links farmers, cooperatives, processers and traders with credit providers. So far, nine commodities are added to the trading floor: grains - maize and wheat; pulses - white pea bean, green mung bean, red kidney bean, chickpeas, soybeans and sesame; coffee (both local and export). Yet, the exchange did not succeed in attracting large volumes of grains, at least immediately after its establishment, despite government and donors' aspiration to stimulate cereals trading via the exchange (Rashid, 2010).

fers from weakness of the entire supply chains (Alemu & Dagnew, 2008). Although there are a number of marketing cooperatives, their limited financial capacity forces dominant share of small producers to rely on traditional supply chains. Alemu and Dagnew (2008) document that about 62% of marketed surplus comes from non-member smallholder farmers; transportation costs being a major marketing cost along the chains. This implies that farmers are more likely to depend on village collectors for small and short-term loans given that they harvest their produce, on average, every two months.

Rain variability is an important shock that affects large rural households in Ethiopia (Dercon, 2004; Dercon & Christiaensen, 2011). Risk-averse households refrain from applying for loans, especially from formal sources if they expect low rain. It could also be the case that, for some households, low rain perceptions increase demand for credits to smooth consumption. In a village where there are microcredit providers, households tend to apply for credits in case they wish to use formal finance. In fact, inclusion of this variable might pose econometric challenges as related to sample selection into borrowing from the MFIs and its non-random placement in the community. However, the above specification must control for these sources of bias.[16] The education variable I use in this study captures households' extent of literary and may not necessarily captures actual formal education effects. As such, its effect is expected to be diffused by interaction with some variables that proxy household wealth such as oxen, farm-size and roof. Wealthier households hardly need external finance, but in case they do demand, lenders are more likely to provide them with the amount requested. Households which own non-farm enterprises are more likely to demand and hence apply for credits. Well-informed informal lenders know that some households borrow using anticipated remittance as an assurance. Legal documentation of land right may enable households to access credits using it as a guarantee.

[16] I also run a regression in which this variable is excluded and the result remains robust.

The literature offers a number of different explanations on the relationship between age and gender of household head and his/her credit history. Zeller (1994) argues that older household head's relative position in terms of wealth accumulation and control over resources enables her access formal credits in rural Madagascar. Similarly, Khoiet et al. (2013) find a positive association between household head's age and access to microcredit in rural Vietnam. They argue that the former serves as an indicator of accountability and commitment to repay loans. On the contrary, risk averse older household head is less likely to try a new project, which requires external finance, and hence less likely to borrow. So it makes sense to include both age and its square in the regression to capture these behavioral associations. It is a common observation in rural areas of Ethiopia that most women own and run non-farm enterprises, in part due to culture.[17] So I expect that female headed households tend to demand loans to start or expand their businesses. Yet, it is also reasonable to expect that women's more risk-averse behavior can stand in the way of their participation in the rural credit markets.

I include two additional variables in the selection equation as an exclusion restriction. The first variable indicates whether the household participated in the extension service. Most applied studies on farm households use this variable to measure the effectiveness of extension services typically provided by the government via extension agents. However, if one belief that the beneficiaries (farmers) have different local knowledge, will and effort to seek out extension assistance and to act on it if provided exogenously, then this variable may instead capture farm managerial ability (Dollar et al., 1998). My interest is in the latter case, and I expect that households with better managerial ability are more likely to demand and apply for loans. I assume that this characteristic of the borrower is implicit to potential lenders and does not directly affect the latter's decisions to provide loans. If it affects, it is only indirectly via improving borrower's net return to economic activities and hence his/her repayment capacity.

[17] This is well documented, for instance, in Loening et al. (2008).

The second variable signifies whether the household experienced an idiosyncratic shock. The same argument can be made for this variable. However, this information is hardly implicit to informal lenders if it is to formal lenders. The main concern of lenders is not whether the household experienced a shock, but its post shock income or asset level and ability to repay. The shock is expected to increase household's demand for emergence loans and hence more likely to apply. It may affect lender's decisions indirectly via depleting assets or lowering incomes of the borrower.

3.4. Results and Discussion

This section presents estimation results and provides discussion on some factors that explain household decisions as related to their participation in the credit markets and use of a particular type of credit. In the first part of this section I focus on providing likely answers to two sequential questions: which household is more likely to demand credits? Which household with demand for external finance is more likely to end up without applying - thus, face demand-side credit rationing?

Summary statistics on these issues are provided in table 3.2 and table 3.3. Of total sample respondents about 76% demand external finance, but only about 47% proceed with applying for loans. Information contained in table 3.2 shows significant difference between credit demanding and non-demanding sample respondents as far as some selected covariates are concerned. Mean differences are important, among others, for gender of household head, wealth indicator variables (oxen, education, roof and farm size), owning non-farm enterprises, extension participation and certificate of land right. There is also noticeable variation between demand-side credit rationed non-applicants and their applied counterparts. Predictor variables that are important in explaining this variation are: gender, age and education of household head, number of oxen, non-farm enterprises, extension participation and experiencing idiosyncratic shock and certificate of land right. Regional variation is also important in both cases.

Probit and Heckman selection models estimation results for the determinants of the likelihood of demand for credits and decisions to apply for credits are provided in table 3.5. As expected, there is gender difference as far as demand for credits is concerned. Female headed households are less likely to demand credits compared to their male counterparts all else factors included in the estimation remain constant. Interestingly, all variables included to capture the effects of wealth are negatively associated with the likelihood of demanding credits. Literate household head, households which own oxen and households whose roof of the main dwelling is predominantly made of corrugated

iron sheet are less likely to demand credits. One possible explanation for this is that wealthier households are relatively more liquid and use their own cash. The other variable included to capture wealth effects - farm size - happen to be insignificant perhaps showing homogeneity across households in terms of farm-size owned.[18]

Households which own non-farm enterprises are more likely to demand credits. Both too much and too low rain perceptions have a positive and significant effect on the propensity of credits demand. One possible explanation for this is that in areas with low rain perception households tend to demand credits to smooth consumption. Those perceiving heavier rain than usual may plan to expand their farm activities to take advantage of favorable climate conditions. In some areas too much rain may also be accompanied by unexpected shock like floods increasing the likelihood of borrowing. As expected, variables included as an exclusion restriction in the Heckman selection model significantly affects the likelihood of demand for credits. Households with better managerial ability and those which experience idiosyncratic shocks - death and/or illness of household members - are more likely to demand credits.

Age is important in explaining the decisions to apply. Older household heads are more likely to apply and hence less likely to face demand-side credit rationing. Yet, the likelihood of applying declines for households above a certain age threshold as captured by its square albeit weaker effect. Female headed households are less likely to apply. Higher risk aversion must be at play in these two cases. Wealthier households are less likely to demand external finance, but in case they wish to borrow, they are more likely to apply. This is revealed by the negative and statistically significant effect of education, roof and farm-size on the likelihood of demand-side credit rationing. In fact, education

[18] Most households own land size less than two hectares and land is state owned in Ethiopia and farmers enjoy only usufruct right. Dercon (2001) documents that land buying and selling as well as rent in and rent out is hardly practiced, making cultivated land and land owned remain closely correlated. He estimates that the correlation between household land holdings suitable for cultivation and actual land size cultivated per household (after transactions) is 0.92.

could also capture other effects like familiarity with how to write an application for loans; read and understand written contracts.

Owning non-farm enterprises and having remittance sources increases the probability of applying for credits. Households which cultivate wheat are more likely to apply. Banana growers are less likely to apply for loans and thus more likely to experience demand-side credit rationing. As expected, having legal documentation of land right and experiencing an idiosyncratic shock increases the probability of applying for loans. Finally, it is clear from the results reported in table 3.5 that the effect of sample selection, if any, is negligible. Results remain robust to more appropriate - *rho* is statistically different from zero - model consideration.

Why some households use informal loans while microcredit supply is expanding? Next, I discuss on some factors that are at play in influencing borrowing households' decisions concerning which lenders to approach and the resulting equilibrium outcome in the credit markets. Summary statistics on this issue are contained in table 3.4. As mentioned in the previous section, three different groups of lenders can be considered: formal, semi-formal and informal. Not all households which apply get access to the required amount. Thus, for some households equilibrium outcome is "no credit". Of total borrowing households about 26% use formal sector credits while about 50% of them use informal sector credits. The remaining share of about 10% and 14% are taken by those which use semi-formal sector credits and non-credit users.

Estimation results from MNL model are reported in table 3.6. Formal sector credit is the base outcome. Thus, estimated coefficients for the remaining three alternatives are interpreted relative to this base outcome. But, one may want to know first if this specification is justifiable. Suest based Hausman test results for the IIA assumption is reported in table 3.7. According to the results, there is no serious problem that imperils

the IIA assumptions.[19] Interestingly, estimation results across the two multinomial models - logit and probit - and the Heckman probit are consistent (table 3.6, table 3.8 and table 3.9). Recall that, in this particular case, the latter focuses on the association between formal credit constraints and the likelihood of using informal credits.

Results show that, other predictors included in the regression remain constant, in villages where formal credit market is less developed households are less likely to use informal sector credits. Based on this result, it is reasonable to argue that formal and informal credit/lenders serve as complements in rural Ethiopia as expected. One case this makes more sense in the Ethiopian context is when loans from informal sources is used to smooth consumption and to meet financial obligations including regular repayment of formal sector debts. The motive to meet an unanticipated household needs provoke a partial/full diversion of borrowed amount at the cost of funds available for long-term livelihood enhancement. Formal sources are relatively more rigid and most small and marginal farmers may face a serious difficulty, particularly during the lean season to pay down some debt. Availability of informal loans at this juncture increases the capacity of poor households to use formal loans for the intended productive purposes. This in turn raises the return to their economic activities permitting for larger formal loans in the future and availability of loanable funds for the informal lenders. Most informal finance providers are households which lend out of their own earnings.

Evidence from the survey also shows tremendous variation across regions in terms of institutional credits outreach. Formal lenders are more present in Amhara and Tigray regions followed by Oromia and the SNNP. There is limited presence in the remaining smaller regions of Ethiopia. Results from MNL model shows that the likelihood of using informal credits is higher in regions where microcredit providers are less present. What I can infer based on this result is that informal lenders substitute the formal

[19] I also perform some tests, but results are not reported here, to check if more parsimonious specifications such as binary logit/probit models are adequate to address the question. Wald tests for combining the four outcome categories fail to accept the null hypothesis that categories can be collapsed at 1%.

ones where the latter is less active. That is, in regions where institutional credits supply delays behind its potential demand, households rely on informal lenders. Thus, it can be argued that formal and informal finance are both complements and substitutes for each other.

The likelihood of using informal sector credits declines with extension participation, which if this variable captures managerial ability, implying that households with better ability are more likely to use formal credits. It also makes sense if it captures the more explicit extension service effects. Extension service can positively impacts net returns on farm activities and hence productivity of borrowed funds and repayment capacity of the borrower. Wealthier households are less likely to use informal relative to formal credits. This is evident from negative and statistically significant association between wealth indicator variables: oxen and roof and the relative probability of informal credits use.[20] This finding is in line with the widely held belief in the literature on credit markets in low income settings. Interestingly, the likelihood of using informal credits declines with having legal certificate of land right.

The likelihood of using informal credits increases with experiencing idiosyncratic shocks, if the household is headed by female, have some source of remittance and grow sesame. While some of these associations are in line with existing beliefs and to my expectation some are not. Shocks such as illness and/or death of household members are unexpected and there is no reason to expect that experiencing households approach formal lenders for credits. Significant delays in the disbursement of formal credits, especially to poorer households are well documented. Even collateral poor, but remittance receiving households, may wish to borrow using anticipated amount as a guarantee. Informal lenders are in a better position to get information about the borrower than formal lenders. When microcredit was introduced to the credit markets of low-

[20] Given that the effects of these variables are more likely to be diffused by interaction among them, I also test if they are jointly important, but results are not reported here. Wald tests fail to accept the null hypothesis that all coefficients on wealth indicator variables are zero.

income countries, many believed that traditionally neglected sub-populations and sub-sectors will get better access to credits. It is also surprising to observe sesame growing households relying more on informal lenders given that it is one of the most important export commodities of the nation. One possible explanation for this is that primary producers/farmers rely more on local primary collectors for credits albeit relatively better developed sesame supply chains. Longstanding concern in development discourse is that poor producers in low-income countries benefit a little, if any, from an expanding global supply chains. Access to formal sector credits may allow these farmers to sell when it is most profitable.

It is interesting to observe that semi-formal credit is serving its intended purpose in the rural credit market. Estimation results from MNL model reveals that the likelihood of using semi-formal credit is higher among the very poor. Owning oxen and participating in the extension program increases the probability of using semi-formal than formal credits. These are also in line with the aim of most credit programs that fall in this category. Most semi-formal credit beneficiaries are expected to participate in other components of packages provided by the government such as extension services. Female headed households as well as households in smaller regions of Ethiopia and the SNNP are more likely to rely on their own resources (end up being credit denied) than using formal credits. Negative and statistically significant coefficient on roof shows that the likelihood of relying on own resources decreases with wealth accumulations. Resource poor households with no project that requires external finance prefer protecting their meager asset to borrowing and running the risk of defaulting. The likelihood of using own resources also declines with the size of land area allocated to wheat cultivation and having documentation of land rights.

Lastly, but not least, one may wonder why most variables included to capture the role of farm activities - area planted of maize, teff and wheat; whether the household grew banana, coffee or sesame - in the credit markets participation and use decisions are less

important. There is important variation across regions in the production of these agricultural outputs depending on many factors such as culture and biophysical endowments. We suspect that the impact of these variables captured or diffused by the interaction with regional dummies. For instance, the coefficient on grew banana in table 5.13 column (2) is positive and highly significant, implying that banana growers are more likely to use informal than formal sector credits. Yet, this is the case only when regional dummies are dropped from the estimation.

3.5. Concluding Remarks

In this chapter I tried to explore the implications of recent development in rural credit markets in Ethiopia for households' decisions to participate and use credits. A huge gap is assumed to exist between traditional banks and informal lenders in terms of the mechanisms they use to ameliorate asymmetric information problems and to enforce contracts. The central notion in this chapter is that these differences induce borrowers to sort themselves into different credit contracts. If this is the case, then one may wonder how borrowing households choose lenders and decide to use a particular type of credit in a context where these differences are somewhat narrowing. Moreover, the surge in microfinance lending is not uniform across geographically dispersed population.

Results reveal that there are still important differences between various informal lenders and microcredit providers for the theoretical claims to seem sensible. Informal lenders substitute microcredit providers in areas where the latter are less active. In areas where microcredit is relatively more active, but is less developed - that is, only limited borrowers/amount can use credits/can be obtained - the incidence of informal borrowing is low. It must be the case that the two forms of finance complement each other and the role of informal finance increases with formal finance development. Some prominent MFIs are preparing to graduate to rural banks. Provided this transformation improves upon the current shortcomings of the group-liability mechanisms, we would then expect to observe the proliferation of informal finance playing a complementary role. Alternatively, the same transformation may force subordinate MFIs to expand into areas where microcredit service is limited, reducing the substitutability role. Of course, what happens to the information technology and contract enforcement mechanisms microcredit providers are utilizing determine the extent and direction of these effects.

Contrary to existing beliefs, the emergence and expansion of microcredits may not necessarily raise/reduce women's access to credits/ reliance on informal finance. With their current condition and capacity microcredit providers are less likely to bridge existing and expanding gender gap in access to formal credits. Female headed households are less likely to demand credits; in case they do demand, they are less likely to apply thus more likely to face demand-side credit rationing. Borrowing female headed households are more likely to rely on informal finance or use no credits (access denied) instead of using formal credits. I think that risk aversion is at play in this case. It is well documented that females are more risk averse than males. If this holds true, then for microcredit providers to serve as an instrument to empower women, they should consider expanding their current product/service to include micro-insurance and savings as well. The latter is also important given that there is strong evidence in support of the effects of wealth on the decisions to borrow and equilibrium outcome in the credit markets. In case they wish to borrow, wealthier households are more likely to apply and use formal than informal credits. More to this, the likelihood of using formal credits instead of own resources increases with wealth accumulations.

One way rural households can accumulate wealth is via saving from their meager income or net return on their little investments. At the moment microcredit providers are not in a position to mobilize tolerable level of savings and limited amount mobilized usually comes from mandatory saving by clients. The other area microcredit providers can improve upon to serve as an instrument to reduce reliance on informal finance, especially exploitive ones is via providing efficient remittance transfer services. Results show that remittance receiving households are more likely to apply for credits and use informal instead of formal credits. This works via the information technology the two sources of finance use. It must be the case that informal lenders better know borrowers expected income and repayment capacity than microcredit providers. Some households may wish to borrow pledging their future income including remittance. If

they have to serve the rural poor better, microcredit providers need to turn this trend around. Remittance going via microcredit providers could also indirectly impacts household saving behaviors. Results support ongoing large rural land registration and certification programs in Ethiopia. Apart from other anticipated impacts, legal certificate of land right increases the likelihood of applying for credits and using formal than informal credits or relying on own resources. To sum up, it is not as expected that the "microcredit revolution" completely or significantly change the rural credit landscape.

Chapter Four

4. The Effects of Credit Constraints on Technology Adoptions

Abstract

I employ a panel selection model to examine the effects of credit constraints on the decisions to adopt and intensify agricultural technology in Ethiopia. To this effect, I use three waves of nationally representative LSMS-ISA dataset extracting an unbalanced panel of farm households which are engaged in crop production. An estimation strategy employed in this study allows for addressing major econometric challenges one may encounter in this area of inquiry. Historically agricultural technology adoption rates remained low. Recent recovery is accompanied by tremendous heterogeneity in the intensity of use even across farm households with similar biophysical endowments. Voluminous literature examine the lagging adoption puzzle and offers various explanations ranging from quite rational response by farmers to low return to adoption in most African settings to seemingly inefficient behavior by farmers due to market failures and constraints. I hypothesize that credit constraint is an important driver behind low adoption and heterogeneous intensity of inorganic fertilizer use in the Ethiopian context. By fully exploiting the panel nature of available data, I attempt to identify causal effects of within household changes in credit constraints status on decisions to adopt and intensify. Results suggest that credit constraints have significant negative effects on both adoption variables. The effect is larger when the demand-side credit rationing is accounted for and when within household variation in credit constraints status is considered as opposed to across constrained and unconstrained households.

4.1. Introduction

According to UN projections, SSA population is expected to almost double by 2050. About 60 percent are classified as rural as of 2018, where large share of extreme poor is also concentrated depending on smallholder agriculture and related activities to derive their livelihoods. Yet, underperforming agricultural sector - accounting for a significant share of output and employment - continued to be a major drag to development in the region. Low yield and few signs of productivity growth continued to characterize smallholder agriculture in most SSA economies exposing the region to increasing levels of food deficit, the gap being filled by food aid and imports. Conventional wisdom in input intensification literature is that farmers in SSA countries are reluctant to adopt improved agricultural technologies and related inputs.[21] There is meager sign of farmers who fully exploit existing technologies and inputs, particularly improved seeds and fertilizer which fueled green revolutions of last waves (Hayami & Ruttan, 1985; de Janvry & Sadoulet, 2010; de Janvry et al., 2016). Numerous explanations for the lagging adoption puzzle are offered in the literature including, but are not limited to heterogeneous payoffs to adoptions, credit constraints and risk, inaccessibility, incomplete information. Yet, there is no single barrier that can fully account for low and stagnating rate of adoption of agricultural innovations in different settings.

Using Ethiopia as a case country, this study seeks to investigate the question of whether financial market imperfection is affecting technology adoption/investment levels of farmers. Ethiopia provides an interesting empirical context and example of adoption puzzle. Ethiopia is still an agrarian economy, but performed poorly over a long period. Increasing agricultural productivity and ensuring food security remained at the top of development agendas over the past several decades. More recently, the government has consistently allocated and channeled more than 10% of its total budget to agricultural

[21] Discussions on African agriculture are largely based on macro-level statistics and numerical values until recently (Sheahan & Barrett, 2017).

sector, drew special attention to programs that support productivity growth such as extension services and rural finance (Rashid & Negassa, 2013; Bachewe et al., 2015). Widespread adoption and optimal use of modern technology is often suggested as a promising way to raise productivity of the poor. Ethiopia is among few countries in SSA at the forefront promoting inorganic fertilizer use via extensive subsidy program. However, agricultural land and labour productivity is still among the lowest. This focus to agriculture and widespread availability of modern technologies locally failed to provoke a tolerable level of adoption and intensity of inputs use (Minot & Benson, 2009; Rashid et al., 2013).

A large body of empirical literature has attempted to understand constraints to agricultural technology adoption in low-income countries at least since Feder et al. (1985). In trying to understand constraints to adoptions, the literature has taken two different stands on the interpretation given to farmers' behavior. The first emphasizes profitability, that is, adoption may not be optimal for every farmer (Suri, 2011; Liu, 2013; Matsumoto &Yamano, 2011; Sheahan et al., 2013). Thus, observed technology uptake may represent quite rational response by farmers to the problems of lower rates of return to adoption and input use and highly variable profit. If farmers find it profitable to adopt divisible technologies such as fertilizer, they can obtain the little cash needed to purchase them by any means necessary. The second, more in line with my work, emphasizes some form of market failures and the resulting seemingly inefficient behavior of the farmers to explain deviations from optimal adoptions and inputs use: capital and credit constraints (Croppenstedt et al., 2003; Duflo et al., 2011; Holden & Lunduka, 2013; Lambrecht et al., 2014); risk and uncertainties (Alem et al.,2010; Dercon & Christiansen, 2011); accessibility or supply shortages (Moser & Barrett,2006; Minten et al.,2013; de Janvry et al.,2016) or information failures and the role of learning (Foster & Rosenzweig, 1995; Conley & Udry, 2010). An important implicit assumption here is that under the right conditions farmers are ready to take risk and in-

vest. These interpretations matter when it comes to the choice of appropriate econometric model to deal with the problem of zero-valued outcomes.

It is imperative to identify critical drivers of household adoption decisions in different contexts. Conceptually, the relative importance of these potential constraints could be confounded. Well acknowledged is for credit constraints and risk aversion (Chaudhuri &Osborne, 2002). Ample literature exists documenting that poor rural households suffer the most from credit constraints and incomplete insurance. Credit availability can facilitate the adoption and increased use of improved technology via two channels. Ex-ante credit availability allows resource poor, but productive households to finance lucrative investment opportunities that may otherwise relinquished. Ex-post credit availability enables them to smooth consumption once input allocation decision is made and thus induce even highly risk averse households to take this advantage. Conversely, technology adoption increases farmers risk and uncertainties, perpetuating low demand for credits, low rates of adoption and limited productivity gains. Yet, few empirical studies examine directly how these factors interact and affect the process of technology adoption itself in poor agrarian settings (Foster & Rosenzweig, 2010).

There has been considerable research on constraints to agricultural technology adoption in the Ethiopian context too. Historically, agricultural technology adoption rates remained low and recent recovery is accompanied by tremendous variation across farm households, even among those with similar biophysical endowments (Sheahan & Barrett, 2017) . Lack of access to institutional credit remained a major drag to technical improvement in the Ethiopian smallholder agriculture (Assefa, 1987; 2004; Croppenstedt et al., 2003; Zerfu & Larson, 2010; Abate et al., 2016; Mukasa et al., 2017). The consequence of covariate shocks such as droughts, are acute in Ethiopia, often affecting households welfare many years after the shock (Dercon, 2004; Dercon & Christiaensen, 2011). This partly explains why limited households use credits to fi-

nance inputs purchase (Christiaensen, 2017), albeit significant advance in the physical access to microcredit recently.

Earlier studies approach the topic with different econometric methodologies. Some (including Croppenstedt et al., 2003) applied double hurdle model using cross-sectional data. Observed zero-value on the intensity of fertilizer use is interpreted as if it is an optimal outcome for the household. In a two-stage investigation approach, a probit model of adoption decisions and truncated model of intensity of use are estimated. Some others, more in line with my approach (including Zerfu & Larson, 2010) employ panel selection model. In this case, the non-zero population varies over time, making the distinction between the hurdle and selection models less clear (Ahn, 2004). Panel selection model allows for the possibility of rationality thesis, that is, farmers respond to lower expected net return/utility from using fertilizer while exploring the effects of market imperfections and constraints on households' adoption decisions. Panel data allows for the analysis of household behavior through time. For instance, it is interesting to analyze how access to finance changes over time and how these changes affect adoption decisions. Yet, at least two additional issues arise: unobserved heterogeneity and potential endogeneity of variable of interest, making the estimation strategy complex.

Evidence derived from household panel surveys, especially in the context of SSA, is still relatively scarce, in part due to lack of quality and appropriate data. One challenge in adoption studies using observational data is disentangling the contributions of one constraint from others. To make a meaningful link between lack of technology adoption and credit constraints, we need to observe variation in the latter that was not associated with variation in other constraints. "This is unlikely to be covered by survey without explicit sampling practices and questionnaire design meant to elicit that variation" (Magruder, 2018, p.2). Moreover, measuring access to credit is not an easy task. Many studies use a measure of credit availability that is learned to be problemat-

ic in the literature (Doss, 2006). One measure frequently used is whether the household has access to credits - a yes/no response. They largely focus on capturing the effects across constrained vs. unconstrained farmers or across farmers with access to credit vs. those with no access. The sample available to me allow for making important advance with respect to capturing the true effects of credit constraints.

Results are consistent with the theoretical arguments and many existing empirical findings. For coefficients of main interest, it is not easy though to make direct comparison with findings in existing literature mainly due to different credits and adoption variables used in the empirical exercises. I find stronger effect when the uninsured risk which implicitly lies between adoption decisions and credit constraints is incorporated. Estimation results are also consistent across several alternative estimators. Yet, the effect is larger when within household variation in credit constraints status is considered as opposed to across constrained and unconstrained.

The rest of this chapter is structured as follows: Section two introduces a brief conceptual framework for examining agricultural technology adoption decisions under market failures. This is followed by section three where I specify the panel selection model and outline the estimation strategies; briefly discuss some empirical issues in modeling technology adoption decisions. Section four presents results and discussion. Section five concludes the chapter.

4.2. Conceptual Framework

In this section I briefly introduce a theoretical framework for examining agricultural technology adoption decisions under market failures. Theoretical interpretations derived from non-separable farm household models (Singh et al.,1986) is widely used to understand and explain seemingly inefficient resource allocation, consumption, investment and exchange behavior of rural households in various contexts of failing markets where they make their decisions (Sadoulet & de Janvry, 1995; de Janvry & Sadoulet, 2006; Barrett, 2007). Under market failures and constraints, household production and consumption decisions are no longer separable; the latter affecting the former, but not necessarily the reverse.

In the current context, this translates to situations where household decisions with regard to specific input use; for example, inorganic fertilizer is influenced by its preferences, level of cash on hand, and initial endowments of land, family labor and oxen (livestock), among others. In the Ethiopian context, I can safely assume that credit and insurance, labour as well as land markets are far from being complete. Dercon (2001) notes that land and labour markets are missing and credit and insurance markets are imperfect in the Ethiopian case. Land is state-owned and it is allocated to farmers by a local council, with only usufruct right (right to use). Land buying and selling as well as rent in or rent out is hardly practiced making cultivated land and land owned remains closely correlated. He further notes that own labour remains important as wage labour in rural areas remains relatively rare. Credit market imperfections on its part may lead to heterogeneous application of fertilizer across farmers.

Therefore, in settings where markets fail or are incomplete for one or more of these inputs, households make only sub-optimal decisions pertaining to adoption and intensity of use. Failure in one market leads to failures in all other markets (de Janvry & Sadoulet, 2006). Thus, a complete understanding of decision making under market failures and/or constraints is demanding in terms of modeling. Consequently, most theo-

retical studies resort to analyzing a specific case of market failures using a reduced-form. Theoretical studies of the adoption behaviors at micro level mainly investigate the properties of the solution to particular cases of the temporal optimization problem of the farmer (Feder et al., 1985). One approach to do so is to allow for farmer's discrete choice of a technology from a mix of technologies, including the traditional technology and a set of components of the modern technology package.

A basic theoretical model presented here links farmer's optimization behaviors and financial market imperfections. It demonstrates how binding credit constraint and incomplete informal insurance pooling can lead to a less risky household investment portfolio choice. In order to appreciate the role of incomplete credit and insurance markets in their decision making process, I first assume perfectly competitive market and then relax this assumption to account for the role of imperfect or missing market which actually exist and are pervasive in less developed settings. A theoretical framework suggested by Karlan et al. (2014) and later extended by Magruder (2018) is used to study the behavioral mechanisms through which imperfect financial market may impact agricultural technology adoption in these settings. I rely on this framework to motivate an empirical model specification.

As is the case in many studies of financial market imperfections, I consider a two-period planning problem. A typical farmer/household maximizes the following objective function,

$$u(c^0) + \beta \sum_{s,t \epsilon SxT} \pi_s \pi_t u(c^1_{s,t}) \tag{4.1}$$

Subject to:

$$c^0 = Y - x_r - a \tag{4.2}$$

$$c^1_{s,t} = f_{s,t}(x_r) + R_a$$

$$x_r \geq 0$$

$$a \geq \bar{a}$$

Where $u(c^0)$ and $u(c^1_{s,t})$ are respectively preferences over consumption in the first period and in various states and information sets of the second period, with probability of state s and information sets t equal to $\pi_s$and π_t.[22] β is a discount factor, Y is exogenous cash on hand, x_r is risky input, a is risk free asset with return $R(=\frac{1}{\beta})$ and $\bar{a}$ is credit/capital constraint, $f_{s,t}(x_r)$ is a standard production function that provides second period output, but input x_r purchase is committed before random fundamental risks are realized, that is, in the first period. Price of all inputs is set to be units. x_r and a are the two choice variables in the optimization problem of the farmer.

A. Perfect credit and insurance markets

In the baseline case, perfect credit markets and complete informal risk-pooling is assumed, so that every household consumes the expected value of its second period consumption irrespective of random fundamental risks realized. I assume $f_s(x_r)$ and$f'_s(x_r)$ are increasing in s, so that x_r have higher returns in more favourable states of the world - for instance, good weather conditions and the Inada conditions hold so that the non-negativity constraint on x_r never binds. Ignoring the third constraint - incomplete information with its realization t - for a time being, the first order conditions w.r.t a and x_r respectively are:

$$u'(c^0) = u'(\mathrm{c}^1)$$

$$R = E[f'_s(x_r)] \tag{4.3}$$

Only R, the probabilities of rainfall outcomes and the physical characteristics of the production function determine the level of investment in x_r. Neither additional credit nor insurance products have an impact on the level of investment in x_r.

[22] The farmer faces two forms of uncertainties while making decisions concerning which type of technology to adopt: objective uncertainties with respect to yields (and prices) usually resulting from the state of nature and subjective uncertainties with respect to production function parameters, resulting from incomplete information (Feder et al., 1985). Extension effort and education can enter the optimization problem of the farmer to ameliorate information barriers.

B. Binding credit constraint ($a = \bar{a}$) and complete informal risk pooling

The first order conditions w.r.t. a and x_r are respectively:

$$u'(c^0) = u'(c^1) + \lambda$$

$u'(c^0) = \beta u'(c^1) E[f'_s(x_r)]$, and by substitution,

$$1 + \frac{\lambda}{u'(c^1)} = \beta E[f's(x_r)]$$

Where λ is shadow price of the binding borrowing constraint, and by implicit function theorem: $\frac{\partial x_r^*}{\partial \bar{a}} < 0$, implying that optimal level of input use is increasing in the amount of credit available. Relaxing $\bar{a}$ reduces the shadow price of the binding borrowing constraint and hence raises the relative value of future consumption which in turn induces higher investment in x_r.

C. Binding credit constraints and imperfect insurance markets (incomplete informal risk pooling)

The first order conditions w.r.t. a and x_r are the following

$$u'(c^0) = E[u'(c_s^1] + \lambda$$

$u'(c^0) = \beta E[f'(x_r) E[u'(c_s^1) + cov(f'(x_r), u'(c_s^1))$, and by substitution,

$$R - \frac{cov(f'_s(x_r), u'(c_s^1))}{\beta E(u'(c_s^1))} = E(f'_s(x_r) \tag{4.4}$$

When credit constraint is not binding,

$\lambda = 0$ and $cov\Big(f'(x_r), u'(c_s^1)\Big) = E(u'(c_s^1)) + \beta[E(u'(c_s^1))]E[(f'_s(x_r))] < 0$, and uninsured fundamental risk reduces investments in input x_r (4.4 relative to 4.3). Furthermore, a decline in input acquisition in the first period is accompanied by a lower marginal utility in the first period at any given borrowing choice a (first order condition w.r.t a, case C). Therefore, farmers must cut their consumption in the first period as well, and this is possible by borrowing less.

In a setting with imperfect financial market: where credit constraint is binding ($a = \bar{a}$) and insurance is incomplete, elimination of credit constraint (so that $\lambda = 0$) raises the relative value of expected consumption in the second period (first order condition w.r.t a, case C). However, the farmer is expected to make sub-optimal decisions with regard to the level of borrowing and hence an investment in x_r in the first period due to uninsured risk which is to be realized in the second period. A simultaneous intervention aimed at reducing downside risk in consumption in the second period is therefore anticipated to trigger more borrowing and hence additional investment in input x_r. According to Magruder (2018) "for technology adoption, poor information behaves precisely like additional, uninsurable risk" (p.19.6).

The adapted conceptual framework makes it clear that credit constraint impacts optimal input choice and its level of use - input demand schedule of the farmer. But one needs additional assumption(s) to motivate an empirical model specification. It can safely be assumed that farmers make sequential input allocation decisions as opposed to a one point in time decision problem (Antle, 1983; Weersink & Rozelle, 1997; Kimhi, 2006). The farmer is assumed to first allocate quasi-fixed inputs/non-choice variables - usually land - among competing alternatives given information set and state of nature at the time. "…initially, farmers decide, given information at planting time, how to allocate land among different crops…farmers then can change output only by influencing yield" (Antle 1983, p.133). To continue with the basic conceptual framework, the farmer then makes decisions concerning which plots of land to apply inorganic fertilizer and how much - a channel via which she manipulates yield - before x_r purchase is committed. So the level of output the farmer expects in the second period can be thought of as the product of total cultivated land area and yield. The latter in turn is a function of intensity of input use, including variable and other quasi-fixed inputs. In addition to the updated expectations of the state variables, the optimal x_r choice is

determined by optimal allocation of land.[23] Accordingly, there is an implicit intensity of fertilizer use schedule corresponding to an input demand schedule obtained from the first order conditions. If this is the case, one may further assume that the observed sample data is a realization of outcomes from farmer's joint decisions about input choice and its intensity of use in a given time period. If financial market imperfections affect optimal input choice, there is no reason to expect that it does not affect the intensity of use.

It could be the case that some farmers opt for non-fertilizer using technologies depending on their capacity and preferences. Thus, the input demand schedule of the farmer may or may not contain x_r corresponding to positive or zero outcomes in sample data on the intensity of fertilizer use. This is possible because financial market imperfections impact decisions differently across different households, but also for a single household in different periods. Farmers devise different strategies of their own to ameliorate welfare costs of market failures and the degree of market imperfections can never be the same over time. It should also be noted that there are numerous factors in the state variables set, apart from financial markets, which may facilitate or impede these decision making processes. I also allow for the possibility of rational response by the farmer to lower expected net return/utility from using x_r subject to state of nature's constraints. One may think of including as many factors (state variables) as possible to capture behaviors across all technology choices - including non-fertilizer using ones, that is, zero outcomes in the data. Yet, it is impossible to be exhaustive. It also makes no sense to treat all observed data on intensity of input use as if it is random outcomes for all households from statistical/econometric perspectives. It is very likely that there are many omitted factors, some of which are hard to measure and quantify, but still

[23] State variables refer to prices, access to input and output markets, policy and environmental constraints among others. Optimal allocation of land itself is a function of state variables. Sequential input allocation may necessitate models with simultaneous-equation estimation methods - one for land allocated and the other for input demand - to avoid simultaneity bias (Antle, 1983). I do not think that this problem is relevant in this case because I use household level data as opposed to crop and/or plot levels.

help farmers to sort themselves across different technology choices. One may thus run the risk of model misspecification if these omitted factors influence the likelihood of observing both zero and positive outcomes. It is possible to observe positive amount of x_r applied per hectare only for farmers who decide to use fertilizer given state variables. To account for this empirical phenomenon I specify panel selection model.

4.3. The Panel Selection Model and Estimation Strategy

The foregoing discussion on decision making behavior of farm household under market failures and the resulting non-separable models as well as the adapted conceptual framework is an important input to specify the empirical model. It also serves as a guide to choose control variables and to set an estimation strategy accompanied by existing empirical literature on agricultural technology adoptions in low-income countries. The overarching goal in this chapter is to obtain more reliable estimates of casual effects of credit constraint on both adoption/use and intensification decisions. The panel selection model fits well to behaviors in both theory and sample data.

$$adopts_{it} = 1[\theta IV_{it}^{CC} + \pi \boldsymbol{z}_{it} + b_i + v_{it} > 0] \tag{4.5}$$

$$fertr_{it} = \alpha CC_{it} + \boldsymbol{\beta x}_{it} + a_i + u_{it} \tag{4.6}$$

$$a_i = \overline{\boldsymbol{x}}_i + \gamma_{ai} \tag{4.7}$$

$$b_i = \overline{IV}_{it}^{CC} + \bar{\boldsymbol{z}}_i + \gamma_{bi}$$

Where i denotes the household, t denotes time (wave), $fertr_{it}$ is inorganic fertilizer application rate, CC_{it} is potentially endogenous dummy variable signifying credit constraint status, $\boldsymbol{x}_{it}$ is a vector of control variables that explain intensity of technology use with associated vector of parameters β, a_i is time invariant household unobserved effects, u_{it} is standard error term. $adopts_{it}$ is a binary indicator of adoption status with $adopts_{it} = 1$ if the unobserved $adopts_{it}^{*} > 0$ or an indicator function $1[.]$ is equal to one, in which case the household adopts inorganic fertilizer and$adopts_{it} = 0$ otherwise.[24] IV_{it}^{CC} is instrumental variable for CC_{it}, $\boldsymbol{z}_{it}$ is a vector of exogenous explanatory variables that explain technology adoption decisions with associated vector of parameters π, b_i is time invariant household unobserved effects and v_{it} is error term with zero mean and unit variance.

[24] It is assumed that the household adopts a given agricultural technology (input) if the expected net benefit or utility of adopting /using the technology is greater than zero.

The dichotomous adoption decision of the farmer is represented by a probit selection equation (4.5). Equation (4.6) is a conditional demand function of the farmer. There is at least one important potential source of bias in the estimation of equation (4.5): in most settings, adoption of one technology depends on the availability/adoption of the other, a typical example being improved seeds and fertilizer. A farmer may perceive that using fertilizer boosts her returns from adopting improved seeds. If this is the case, then a univariate Probit selection model used to examine single input adoption decisions may lead to results that are apparently subject to simultaneous equation bias and inconsistency (Feder et al., 1985; Abay et al., 2018). It may also be the case that the farmer finds it more profitable to use fertilizer along with improved seeds, but constraints posed by elements of the enabling environment such as credit constraint force her to adopt sequentially rather than using the two inputs simultaneously (Feder, 1982). These elements of the enabling environment influence the extent and incidence of complementarity. This implies that complementarity effect is likely to be confounded with the effect of both observable and unobservable sources of heterogeneity across farm households in equation (4.5). The latter might be driven by, among others, differences in return to technology adoption (Suri, 2011) and/or differences in risk preferences (Liu, 2013). However, household fixed effects included in the estimation of equation (4.5) are assumed to take care of both time-invariant unobserved heterogeneity effects as well as the complementarity effects.

Two main potential sources of bias can also be mentioned in the estimation of demand equation (4.6). First, unobserved factors that affect decisions to adopt are likely to be correlated with unobserved factors, which affect subsequent intensity of input use. In other words, farmers may self-select into adoption. For instance, households closer to major urban centers may benefit from better infrastructure and social networks, which enhance their consciousness about technology adoption and profitability as well as market conditions. The second issue is potential endogeneity of variable of interest in

this study - credit constraint status. Omitted variables such as managerial quality which might influence credit constraint status might also influence intensity of input use decisions. But, reverse causality might also be at play here: good harvest resulting from fertilizer use may determine credit market participation decisions and outcomes of the farmer, including credit constraint status. I employ an approach developed by Semykina and Wooldridge (2010) to address these two potential sources of bias while allowing for unobserved time invariant household specific effects in both equations. The presence of unobserved time invariant household effects also in the selection equation (4.5) makes consistent estimates of equation (4.6) challenging. Simply adding the inverse Mills ratio obtained from the first stage estimation of equation (4.5) and using a simple fixed effects estimator may not achieve consistent estimates (Semykina & Wooldridge, 2010).

In this approach, Mundlak's (1978) modeling solution is used to model a_i and b_i as in equation (4.7). Where the bar indicates the time average for exogenous time varying covariates in each equation, which are likely correlated with the time constant unobservables. These variables are set to vary only across households, not over time for a given household. γ_{ai} and γ_{bi} are assumed to be normally distributed with mean equal to zero and variance $\sigma_{\gamma bi}$ and $\sigma_{\gamma bi}$ and independent of $\boldsymbol{z}_{it}$, IV_{it}^{CC} and $\boldsymbol{x}_{it}$. In other words, b_i is assumed to relate to $\boldsymbol{z}_{it}$ and IV_{it}^{CC}only through their time averages. Similarly, a_i is assumed to relate to $\boldsymbol{x}_{it}$ only through its time averages. γ_{ai} and γ_{bi} are allowed to be correlated with u_{it} and v_{it} across the two equations. The time averages for explanatory variables in equation (5.8) are computed from the entire sample (including both users and non-users) and as such is free of selection bias (Semykina & Wooldridge, 2010). The advantages of modeling the unobserved heterogeneity this way are two-folds. First, it avoids the problem of incidental parameters (Mundlak, 1978) while doing the jobs of simple fixed effects estimator. Second, it allows measurement of

the effects of time invariant explanatory variables as in the simple random effects estimator (Wooldridge, 2010).

Parameters of main interest are α and θ respectively capturing the impact of potentially endogenous dummy for credit constrained households in the conditional demand and probit selection equations. I hypothesize that there are smallholder farmers who still wish to benefit from the advantages of fertilizer adoption and its optimal usage, but unable to do so due to credit market imperfections. Thus, I expect the sign of α and θ to be negative and statistically significant. $\mathrm{IV}_{\mathrm{it}}^{\mathrm{CC}}$ is generated as the fitted probability from a Probit regression of $\boldsymbol{CC_{it}}$ on an appropriate instrument capturing exogenous variation in the category of credit rationing considered plus the controls in $\boldsymbol{x_{it}}$ and their time averages (Wooldridge, 2010). All the variables in $\boldsymbol{x_{it}}$ are also in $\boldsymbol{z_{it}}$, but the latter includes at least one additional variable that is not in the former as an exclusion restriction tackling selection bias. It must be the case that this exclusion restriction variable captures factors that influence the decisions to adopt fertilizer, but not necessarily subsequent intensification decisions.

Procedure 4.1.1 in Semykina and Wooldridge (2010) is closely followed to estimate the conditional demand equation (4.6), accounting for both potential endogeneity and sample selection while allowing for unobserved heterogeneity in both equations. First, inverse mills ratio (IMR) is generated from Probit estimation of equation (4.5) augmented with time averages of all time varying variables in $\boldsymbol{z_{it}}$ and IV_{it}^{CC}, taking all observations in the sample (including both users and non-users) [25]. Moreover, regional and time dummies are included in the estimation and the effect of clustering at the enumeration areas is accounted for. Next, equation (4.6) is estimated via pooled 2SLS-IV augmented with time averages of all time varying variables in $\boldsymbol{x_{it}}$ and time averages of the generated instruments taking all observations in the sub-sample (only users).

[25] As an alternative, I also generate IMR by estimating equation (4.5) for each wave (period) separately (including both users and non-users) and then pool the sample together after which I regenerate the sub-sample used in the estimation of equation (4.6). Results remain by and large the same.

IMR generated from step one, time dummies and interactions of IMR with time dummies are also included in the estimation. The generated instruments and IMR as well as all variables in $\boldsymbol{x}_{it}$ and their time averages are used as instruments. Standard errors are adjusted for clustering at household level.[26] Standard errors associated with average partial effects are bootstrapped with 500 replications.

There are certain nice features of this identification procedure (Wooldridge, 2010; Secchi et al., 2016). It is robust to misspecification of the first stage probit model. It is also more efficient than directly including the chosen instrument into standard IV procedure. More to these, adjustment for 2SLS-IV standard error is not required. Yet, one needs to rely on goodness of fit from the fitted probability of potentially endogenous variables on selected instruments to validate the suitability of external instruments instead of standard weak instrument test procedures.

4.4. Adoption Variables: Definitions and Some Descriptive Figures

Applied researchers define adoption variables in many different ways depending on contexts. In this study, if the household is using any amount of fertilizer on its plot during a given agricultural season, irrespective of history of use, the household is an adopter or user of this input/technology. This definition is not inconsistent with the fact that farmers keep using and discarding technologies or inputs over time. For users, the next important measure is the proportion of land applied to fertilizer. The intensity of adoption is measured at the household level in a given time period by the per hectare quantity of fertilizer used. Definition of variables is provided in table 3.1.

The choice of control variables focused on household, their farm and community level characteristics that help them cope with decision making in a highly constrained environment. Households devise various strategies of their own to mitigate welfare loses posed by market failures and constraints. If lack of working capital is a constraint to

[26] Standard errors adjusted for clustering at enumeration area is also considered given that the instrument used varies only among clusters and not within household in the same cluster. However, the impact on results is negligible.

adoption of a technology or inputs use, imperfect financial markets induce seemingly inefficient behaviors by the households. They attempt to obtain funds by engaging in non-farm activities or depleting their valuable assets, selling their livestock, renting out part of their land et cetera. Farm households respond to poorly functioning labour market by forgoing the adoption of labour intensive technologies as family labour is the only labour available. Access to recent information about yields and inputs use; effectiveness with improved technologies by the farmer and other farmers in the village has important implications for technology adoption decisions. One important way farmers gain information about new ideas, techniques and practices is via extension services. However, farmers' absorption capacity equally matters and depends on their educational level, age, gender of household head among others.

These factors are also important when it comes to households' risk taking behaviors. Wealthier households are in a better position to deal with these obstacles to adoptions. Many of these factors are expected to affect intensify of use once households decide to adopt. Total area planted is expected to be an important determinant of the intensity of use. In most cases, profitability of improved seeds may importantly depend on farmers' use of fertilizer. Therefore, adoption of the former may induce adoption of the latter.

I include a common set of control variables in both the main equation and the selection equation. The latter also includes regional dummies as an exclusion restriction, assuming that lack of fertilizer supply locally, late delivery, and inadequate infrastructure can be captured by regional dummies. This is in line with previous studies in the Ethiopian context (for example, Croppenstedt et al., 2003). Substantial investment in infrastructure made over the last two decades, especially in all-weather roads is anticipated to make local accessibility of technologies and inputs much easier. According to Moneke (2020) Ethiopia managed to expand all-weather road network roughly four-fold between the late 1990s and today, from approximately 16,000km to approximately

70,000km. Therefore, one may attach less weight to accessibility as limiting factor in adoption decisions. Yet, starting from a very low levels and geographic distribution of this expansion ought to be borne while considering regional dummies for this purpose.

I use three alternative instruments for potentially endogenous variable that captures the extent and forms of credit constraints. There is an ongoing large-scale rural land certification programs in Ethiopia. The most recent one is LIFT, a second round registration and certification program launched in 2013.[27] These programs provide farmers with the legal certificate of right to use plots under their control. The programs aim at, among others, improving smallholder farmers' access to credits (Ghebru & Girmachew, 2019). Albeit poor collateral laws in the country, there is evidence that some farmers in some localities use this certificate as a guarantee to obtain credits.[28] So the first instrument is having certificate of land right. Notwithstanding much improvement in the physical access to credit over the last two decades, most rural poor still have no access to institutional credits. So whether formal credit providers are present in a village and distance to these institutions could be one potential source of heterogeneity across households with regard to their decisions to participate in the credit markets.

As a third instrument, I use total livestock per adult equivalent household. It is also one of the instrumental variables frequently used in literature on credit constraints in low income settings. Relatively wealthier households are expected to face less binding quantity rationing compared to their poorer counterparts. Either they have sufficient own resources or face less difficulty due to collateral in case they wish to borrow. Widely documented thin and imperfect agricultural markets in the country reinforce the validity of these instruments. Land, labour, credit, output markets are far from be-

[27] The first round of this program took place in the last decade and covered some 20 million plots over five years. One of the core objectives of this program was to strength women's land holding rights and to boost land related investments. There is some evidence of positive impacts of this land reform in terms of increased investment, land productivity and land rental market activities (Deininger et al., 2009).

[28] The country also revised its rural land administration and use proclamation in 2020 in a fresh attempt to enable smallholder farmers use their land as collateral to access bank credit.

ing perfect. So for instance, it is very difficult if not impossible for the farmer to consider a strategy of relocation to areas where access to credits is better.

Table 4.1 reports descriptive statistics on adoption variables, variables of main interest and control variables. The table presents mean, standard deviation, minimum and maximum of each variable dividing the entire sample into two, depending on fertilizer adoption status during the years covered in the sample. About 50.5% of sample respondents are non-users. Credit constraint is more prevalent among non-users and this is so irrespective of how one defines it: narrowly defined (includes only quantity rationing) or broadly defined (includes all the three forms of rationing: quantity, risk and transaction costs rationing). This definition is particularly important to somehow separate supply-side from that of demand-side credit constraints.[29] Turning back to table 4.1, data confirms tremendous heterogeneity between users and non-users in terms of credit constraints status, but also control variables. While only 17% of non-users reported to face quantity rationing this share increases to 60% if a broader definition of credit constraints is considered. The corresponding share is only 12% and 46% among users.

Majority of non-users are found to be female headed households, illiterate, poorer and less endowed compared to users. Around 23% and 17% of non-users and users are female headed households respectively. Only about 34% of non-users can read and write in any language while this share stood at 44.5% among users. Variable used to proxy wealth status (roof) shows that the roof of the main dwelling of about 38% of non-users is predominantly made of corrugated iron sheet while this share is 54% among users. Around 63% of users have certificate of land right, but only 35% of non-users have the same documentation. More bank branches are present in rural villages where non-users reside compared to users, but the latter are, on average, closer to available

[29] Sample data shows that the incidence of transaction costs rationing is low in rural Ethiopia, the dominant one being risk rationing. Of the overall reported cases of credit constrained households the former accounts for only 15% and the latter for 57%, quantity rationing takes the remaining share.

bank branches. It seems that there is no significant difference between the two sub-samples as far as livestock per adult equivalent is concerned (0.6 vs. 0.7). Majority of Ethiopian farmers are smallholders; holding less than two hectares of land, but this is even lower among non-users. On average, non-users and users cultivate 1.8 hectares and 2.4 hectares respectively. Users have more labour (measured in labour time, but also in terms of household members) and capital inputs (oxen, livestock). Non-users have limited alternative to inorganic fertilizer such as compost if having fewer livestock corresponds to less availability of organic fertilizer.

Given that they are relatively less endowed and poorer; non-users are observed to engage more in non-farm activities. Its implication for technology adoption decisions among this group of farm households could be both encouraging and daunting. First, given imperfect credit markets, farmers have alternative sources of cash, which may be used to purchase agricultural inputs, facilitating adoptions. In contrast, given poorly functioning labor markets in this setting, more labour time allocated to non-farm activities implies less availability of family labour for agricultural land preparations. It is less likely that households adopt inorganic fertilizer and use it intensively once adopted in the latter case. Only about nine percent of non-users have access to extension services compared to 73% among users, showing severe information constraint among the former. Moreover, only five percent of non-users adopted improved seeds compared to 33% among users. Average intensity of inorganic fertilizer use among users stood at about 134kg/ha. Evidence in table 4.1 also reveals significant variation across regions as far as fertilizer adoption/use is concerned.

4.5. Results and Discussion

The effects of both versions of credit constraint variables are considered in both the selection and main equations of fertilizer adoption decisions. The estimated coefficients can be interpreted as causal effects on adoption variables of within household changes in credit constraints status. Probit and biprobit (IV Probit) specifications are estimated for the selection equation, treating measures of credit constraints status as an exogenous in the former case. Estimation results for fertilizer use decisions are reported in table 4.2. Narrowly defined credit constraint is statistically insignificant in explaining fertilizer use decisions when treated as an exogenous. But, it is highly significant when treated as an endogenous (column (2) & column (3)). As expected, the estimated average partial effect (APE) is negative and stands at 0.213 implying that the probability of adopting inorganic fertilizer is 21.3 percentage points lower for quantity rationed households ceteris paribus. Irrespective of its treatment in the selection equation, credit constraints defined broadly is highly significant (table 4.2: column (5) & column (6)). However, its treatment as an endogenous dummy result in an estimated partial effect of about 32 percentage points more (from just 0.04 to 0.36). If the estimated partial effect is to be trusted - which makes sense given that the broader definition is considered - the probability of adoption is 36 percentage points lower for credit constrained households. However, measurement errors are common in the survey data. Therefore, it is possible that large differences in the coefficient estimates and hence in APEs for both measures of credit constraint variables reveals significant attenuation bias towards zero in the probit estimations.

As expected, extension service and adoption decisions are positively associated. Albeit weak effect, households with larger cultivated land size are more likely to use fertilizer implying that less endowed households keep relying on traditional farming techniques reinforcing rural poverty. Cultivated land size is expected to be more important in explaining variation in the intensity of fertilizer use across farmers. However, given in-

complete or missing land market and the narrow range on cultivated lands, as many argue, it makes no sense to treat land size as a choice variable in the Ethiopian context (Croppenstedt et al., 2003). Households which use improved seeds are more likely to use fertilizer on their plots. Results for education and oxen are also in line with previous studies in the Ethiopian context. The variable I use to proxy education captures households' literacy status and may not necessarily captures actual formal education effects, which is expected to lessen information barriers. As such its effect might be diffused by interaction with some variables that proxy wealth. The chosen instrument - land right - does not explain the dependent variable in the selection equation in both cases, and results remain robust to its inclusion in the estimations (table 4.2: column (1) & column (4)). However, it explains variation in credit constraints status irrespective of how one defines the latter (table 4.4: column (1) & column (2).

Estimation results for the conditional demand equation are reported in table 4.3. In the first column of the table, the demand equation is estimated via simple OLS ignoring the endogeneity of credit constraints status (broadly defined), selection bias and time-invariant unobserved effects. The same holds true for the subsequent two columns with the exception that household fixed effect is controlled. As expected, credit constraint affects the intensity of fertilizer use (in logs) negatively. Next, the demand equation is estimated via pooled 2SLS tackling both sources of bias whilst controlling for time-invariant unobserved effects (table 4.3: column (4)). Again, as expected, credit constraint affects the intensity of use negatively and the point estimate is -1.45 with a 95% confidence interval between -0.454 and -2.447 and it is highly significant. Accordingly, credit constraints could reduce the amount of fertilizer applied per hectare by more than 36.5% all other variables held constant. The coefficient on IMR is significant, implying that controlling for selection bias is appropriate. While results remain consistent the coefficient estimate on credit constraint variable is quite large when estimated using 2SLS-IV approach than OLS, signifying sizable attenuation bias towards

zero in the latter case (table 4.3: column (1) & column (4)).

I use presence of formal lenders in the village and community's distance to the nearest formal lenders (or their branches) as an external instrument in the conditional demand equation. I considered both MFIs and traditional banks, but the performance of the former as an instrument in the estimation is poor (in explaining potentially endogenous variable and in satisfying exclusion restriction). This is in part due to non-trivial missing information on community's distance from MFIs variable for which I also tried to impute from similar information. Both the presence of traditional bank branches in the village and community's distance to the nearest branch explain variation in the dependent variable - fertilizer intensity (table 4.3: column (1)). Nevertheless, the interaction between the two does not. Estimation results in table 4.4, column (3) and column (4) on the other hand show that the former explains variation in credit constraints status only in the sub-sample of fertilizer users. Distance to the nearest branch does not explain variation in credit constraints in both full (including both users and non-users of fertilizer) and sub-samples. In contrast, the interaction between the two explains variation in credit constraints in both full and sub-samples and statistically significant. In fact, there is no much information to lose by not using the presence of MFIs in a village and community's distance from the nearest MFIs branches. Most prominent MFIs are concentrated in major urban areas (district towns) just like the banks. Instead, the real concern should be if these instruments capture guanine credit constraint effects, given that banks serve only limited share of farm households. I will return to this issue in a while.

While it does not explain fertilizer adoption decisions non-farm activities strongly affects its intensity of use. This association can be explained by the role of family labour time in intensification decisions and by the immaterial return from non-farm activities in most rural settings. Farm households usually opt for non-farm activities to smooth consumption, particularly during the lean season (which coincides with the main plant-

ing season in agriculture), but only at the cost of family labour time used to operate on a farm. As such, there is less cash to generate from these activities to use for the purchase of agricultural inputs. This is in line with findings in similar studies, for example, Croppenstedt et al. (2003) who find quite a strong effect of family labour availability on fertilizer adoption decisions. Substantial heterogeneity in the intensity of use is driven by cultivated land area. The result suggests that intensity of use negatively responds to additional hectare of cultivable land. Evidence on the association between intensity of use and farm size remained largely inconclusive in earlier literatures (Feder et al., 1985). While many studies indicate lack of significant association some others find positive or negative links between the two. However, this result is consistent with the one reported by Croppenstedt et al. (2003) and Zerfu and Larson (2010) in the Ethiopian context.

Livestock is used as a proxy for availability of organic fertilizer. While livestock explains intensification decisions positively it is not significant in the specification of main interest. The positive association between the two is in line with finding in Zerfu and Larson (2010). Effectiveness with chemical fertilizer critically depends on the organic content of the soil. Farmers in Africa traditionally use manure to build depleted soil contents. However, it could be the case that its effect diffused by interaction with other variables such as oxen, roof and education given that all may capture wealth effects.

Estimation with Alternative Instrument and Variable of Main Interest

Given that only limited share of farm households have access to bank credit and bank branches are predominantly concentrated in urban areas, one must be curious if this instrument capture only remoteness and not necessarily the extent of credit constraints.[30] It could be the case that these variables capture factors other than credit constraints which influence intensification decisions thus violating the exclusion restriction. By controlling for selection bias and unobserved time-invariant household effects this estimation must curtail factors which may contaminate the exclusion restriction requirements. In addition, I use variables that capture remoteness - if the community is in a woreda (district) town and community's distance from the nearest woreda town, including interaction between the two - as alternative instruments.

Estimation results for the conditional demand equation with these instruments are reported in table 4.5. Only the former explains variation in credit constraints status in the sub-sample and neither the latter nor the interaction between the two explains variation in credit constraints in both the sub-sample and full sample probit estimations (table 4.5: column (1) & column (2)). Yet, the former also explains variation in the dependent variable in the conditional demand equation (table 4.5: column (3)). The estimation of conditional demand equation via pooled 2SLS using these instruments leads to overestimated point estimate on credit constraint, insignificant IMR and close to zero R^2, among others.

I also attempted to establish a link between narrowly defined credit constraint and intensity of use and estimation results are reported in table 4.6. I use total livestock per adult equivalent household as an external instrument. This instrument explains variation in credit constraint status in both the sub-sample and full sample probit estimation of the main equation (Table 4.6: column (1) & column (2)). Conversely, it does

[30] Survey data shows that, on average, credit provided by the MFIs and banks respectively account for only 29.6% and 0.4% of the total credit supplied (including semi-formal and informal sources) during the years included in the sample.

not explain variation in the dependent variable in the conditional demand equation and estimation results from pooled OLS remains robust to its inclusion (table 4.6: column (3) & column (4)). Estimation results, from pooled 2SLS using this instrument, signify that the selected instrument is perhaps weak. The sign on the credit constraint coefficient is as expected, but it is not significant (inflated standard error) with significant IMR. However, estimation results reported in column (2) of table 4.3 and column (4) of table 4.6 indicate that failure to consider a broader definition may lead to underestimation of the true effects of credit constraints on farm households' livelihood stratetegies, fertilizer intensification decisions in particular.

4.6. Concluding Remarks

I have used recently available LSMS-ISA data to investigate the effects of credit constraints on investment decisions in a risky, but potentially productivity enhancing technology. On average, more than 53% of farm households visited during the survey reported to face credit constraints predominantly demand-side, which many previous studies overlooked. State-of-the art estimation strategy is used to obtain more reliable estimate of causal effects of within household variation in credit constraints status. This estimation strategy tackles major empirical challenges one may encounter in this area of inquiry: complementarity effects in input adoption decisions; selection bias and endogeneity and/or reverse causality in input intensification decisions. Measurement error is another potential source of bias in survey data analysis leading to a considerable attenuation bias towards zero for some estimators. The fixed-effect two-stage least square (FE-2SLS) estimator approach in this study is believed to control for these sources of bias.

Consistent with the theoretical arguments and many existing empirical findings, results in this study suggest that credit constraints can deter adoption and optimal use of farm technology thus reinforce rural poverty perpetuation. I found stronger effect when the uninsured risk that implicitly lies between adoption decisions and credit constraints is incorporated. Estimation results are consistent across several alternative estimators: simple Probit vs. IV Probit for the selection model; simple pooled OLS (comparing across constrained and unconstrained households) vs. Pooled FE (which does not control for selection bias and endogeneity) vs. pooled FE-IV (which controls for all potential sources of bias) in the conditional demand model. Yet, the effect is also larger when within household variation in credit constraints status is considered as opposed to across constrained and unconstrained households. For coefficient of main interest; it is not easy to make direct comparison with findings in existing literature mainly due to different credit and adoption variables used in the empirical exercises. While they are

largely consistent with findings in existing empirical literature I do not claim that coefficient estimates on control variables represent casual effects.

In a setting where farm households are increasingly induced to utilize modern agricultural technologies, empirical studies of this sort plays a pivotal role in informing discussions on constraints to technology adoption and optimal utilization. However, findings in this chapter highlight that, an empirical exercise that ignores the demand-side credit constraint is likely to underestimate the true detrimental effect of credit constraints. There is also one important implication of this finding for interventions that aim at stimulating growth in smallholder agriculture via the credit market development. Relaxing institutional credit constraint alone may not necessarily spur increased uptake of credits and instant investment by farm households. For majority of rural poor to take advantage of available credits and improved technology, these interventions should also aim at minimizing downside consumption risk, which is more rampant in a poor, food insecure agrarian setting than emphasized in existing literature.

Chapter Five

5. General Concluding Remarks and Implications

Ethiopia under different regimes tried to transform the agricultural sector from its subsistence centered production to a more sophisticated market oriented production. An approach favored was mainly large scale state farms and to some extent local private and foreign investments. Though limited in size, these farm organizations absorbed much of the resources that could have otherwise be allocated for alternative uses including domestic credit, foreign exchange, fertile cultivated land as well as improved agricultural inputs and implements. Unfortunately, at best the outcome was not satisfactory and at worst the project failed. It is the smallholders that managed to survive and are contributing much to the nation's output, employment and foreign exchange earnings among others. This is an important empirical evidence in support of the old theoretical claim that smallholder is more efficient. But, I think that this efficiency mainly stems from farmers' '*metis*' - century old knowledge embedded in local experience and practices, informal processes, preferences, beliefs or values, creativity in the face of uncertainty and other constraints.

It is difficult to confidently claim that Ethiopian smallholder agriculture is supported by modern techniques, practices and information. At the same time however extreme poverty is more of a rural phenomenon. It is very likely that a marginal raise in smallholder productivity leads to a more than proportionate decline in the level and depth of poverty rate. One way to unlock smallholder potential is to augment these *metis* by improved techniques and practices. I think this is an approach favored by donors and development practitioners, but also policy makers in low income countries over the last few decades. This is manifested by ongoing development thinking and practices. Recently, we are able to see a little sign of productivity surge in the Ethiopian smallholder accompanied by significant drop in the poverty rate. Yet, the outcomes also proved

flimsy in the sense that only a trivial portion of rural employment left agriculture in the face of non-trivial population growth. These are good indicators that interventions made over the last few decades are important, but still demand flawlessness to ignite the much awaited vigorous productivity growth.

There are many who think that financial market imperfections are the source of many other important evils that hinder smallholder development in low-income food insecure settings. I tried to describe and examine the implications of microcredit expansion for rural credit market landscape and smallholder development in Ethiopia. Admittedly, microcredit lending technique is indeed a great advancement over that of conventional banks to provide farm households with institutional credits. There is limited share of formal sector credit denied households at least over the last few years covered in the sample. At the same time, significant share of rural poor still rely on informal finance some of which are highly exploitive. Microcredit is out of reach for the remaining significant share of rural poor who wish to borrow, but fail to do so due to associated transaction costs and risk. With their current mechanisms to deal with information asymmetry and contract enforcements as well as products, microcredit providers are unlikely to induce/enable this group of potential borrowers to uptake credit/ make their way out of vicious circle of poverty via investments and savings.

It seems impossible to think of microcredit as an important instrument to stimulate smallholder growth and reduce rural poverty without the supports of informal sector credits. In areas where the former are expanding/lagging the latter complements/substitutes it. Yet, I think that there is a space for improvement to reduce the role of some undesirable informal lenders. Some prominent MFIs have already started the groundwork to graduate to rural banks. Provided this transformation improves upon the current shortcomings of their mechanisms, we would then expect to observe the proliferation of informal finance playing a complementary role. The same transformation may force subordinate MFIs to expand into areas where microcredit service is

limited, reducing the substitutability role. It is possible that the trend of commercializing MFIs exacerbate formal sector credit constraints and household reliance on informal finance. The extent and direction of the effects importantly depends on what happens to their mechanisms.

Credit constraints can drastically delay widespread adoption and optimal use of improved agricultural technologies - an important instrument sought to enhance productivity of the poor. This is so, especially when the uninsured risk that implicitly lies between adoption and credit use decisions is accounted for. While this lending technique can reduce supply-side credit rationing to some extent it is questionable that they will affect the other side of rationing. That is, the role of microcredit in facilitating technology adoptions and intensification could be severally limited than its anticipated potential. Moreover, it may not necessarily improve upon historically disadvantaged rural sub-populations and sub-sectors' access to formal sector credits. Women and female headed households make up significant share of farm households who are also extremely poor. They are also the one who own and/or run most rural non-farm enterprises, in part due to culture. Results reveal that female headed households are less likely to demand credits; in case they do demand, they are less likely to apply - thus, more likely to face demand-side credit rationing. Borrowing female headed households are more likely to rely on informal credits or own resources (end up being credit denied) instead of using formal credits. Having limited access to microcredit implies that women are less likely to invest in productivity enhancing technologies - perpetuating trivial productivity gains, if any, lower earnings and poverty traps.

Results in this thesis highlight that policy discussions that ignore the demand-side credit rationing is likely to underestimate the true detrimental effects of credit constraints on farm households' livelihood strategies, technology adoption decisions in particular. More importantly, relaxing institutional credit constraints alone may not necessarily spur increased uptake of credits and instant investments by farm households. For

majority of rural poor to take advantage of available credits and improved technology, interventions should aim at promoting the broader financial inclusion than the narrow focus on microcredit expansion. The role of institutional reforms like rural land registration and certification programs in fostering financial inclusion is non-trivial.

Several existing studies tried to show the indispensable role access to credits can play in the Ethiopian context. If smallholder agriculture and the living standard of large population who depend on it have to show some promising sign of progress, a well functioning rural credit market is not a matter of choice. Ofcourse, credit availability alone is not a panacea for low-level equilibrium traps in production and productivity and rural poverty traps. Moreover, inferences in most of these studies are based on a measure of credit constraints variable that is learned to be problematic. I think that important advance is made in this study over existing ones as far as this measure is concerned. Yet, it is far from being perfect to capture the true extent and forms of credit constraints in rural Ethiopia. The one used in this study provides only the incidence of credit constraints - an upper limit of the true credit constraints. That is, not all those who report credit constrained are truly constrained if the decisions of lenders are also incorporated. This matters especially for the demand-side credit constraints status reported by most households. Even for the supply side constraints we know nothing/little about suppliers' decisions. Available data is realization of equilibrium outcomes in the credit markets.

Thus, it does not allow, for instance, for a structural modeling of rural credit market. For an ideal measure of credit constraints - the level of credit constraints - I think we need a more sophisticated survey instruments than the ones employed in the LSMS-ISA. I do not think this is possible in the current study area in the near future. An alternative is an experimental research design - but, at the cost of applicability of the findings derived from this type of studies across large areas and populations. This research design is also preferred in contexts where the effects of important variables are

more likely to be confounded. This is especially important because policy interventions that aim at tackling/improving upon one important variable may or may not affect the other variable(s). This is the case in the analysis preceding this chapter. It is difficult to completely separate the effects of credit constraints from that of risk and uncertainties as well as preferences, among others, with non-experimental design. Yet, I think that an important step is made in this study towards the best one can do with observational data.

REFERENCES

Abate, G. T., Rashid, S., Borzaga, C. and Getnet, K. (2016). Rural Finance and Agricultural Technology Adoption in Ethiopia: Does the Institutional Design of Lending Organizations Matter?. World Development 84: 235-253.

Abay KA, Berhane G, Taffesse AS, Abay K, and Koru B. (2018). Estimating input complementarities with unobserved heterogeneity: evidence from Ethiopia. J. Agric. Econ. 69(2):495-517.

Ahn, J. (2004). Panel Data Sample Selection Model: An Application to Employee Choice of Health Plan Type and Medical Cost Estimation. Econometric Society 2004 Far Eastern Meetings, Econometric Society

Alem, Y., Bezabih, M., Kassie, M. and Zikhali, P. (2010). Does fertilizer use respond to rainfall variability? Panel data evidence from Ethiopia. Agricultural Economics, 41, 165-75.

Alemayehu Seyoum, T. (2009). Crop production in Ethiopia: a spatial structural analysis. Paper presented at the 7th International Conference on the Ethiopian Economy. Ethiopian Economic Association (EEA), Addis Ababa, Ethiopia.

Alemu, Dawit and Dagnew, Asmare (2008). Banana Markets in Ethiopia. Ethiopian Institute of Agricultural Research (research report No.76)

Amemiya, Takeshi (1981). Qualitative Response Models: A Survey. Journal of Economic Literature 19:1483-1536

Amha, W. (2003). Microfinance in Ethiopia: Performance, Challenges and Role in Poverty Reduction. Occasional Paper No.7. Association of Ethiopian Microfinance Institutions (AEMFI), Addis Ababa

Amha, W. (2011). Meeting the financial needs of smallholder farmers in Ethiopia. A paper presented at the sixth biannual conference on the development of microfinance in Ethiopia. AEMFI. Addis Ababa

Amha, W., and Peck, D. (2010). Agricultural Finance Potential in Ethiopia: Constraints and Opportunities for Enhancing the System. Addis Ababa: Association of Ethiopian Microfinance Institutions.

Antle, J.M. (1983). Sequential Decision Making In Production Models. American Journal of Agricultural Economics 65(2): 282-290.

Assefa, Admassie (1987). A Study of the Factors that Affect the Use of Agricultural Credit among Peasant Farmers in Ethiopia: The Case of Two Districts, M. Sc Thesis, Addis Ababa University, June.

Assefa, Admassie (2004). A Review of the performance of agricultural finance in Ethiopia: pre- and- post reform periods. Paper presented at the International Conference

on Agrarian Constraints and Poverty Reduction on 17-18 December 2004 in Addis Ababa, Ethiopia. 14p

Bachewe, F. N., Berhane, G., Minten, B. and Taffesse, A. S. (2015). Agricultural Growth in Ethiopia: Evidence and Drivers, Working Paper No. 81, Ethiopia Strategy Support Program: Addis Ababa.

Banerjee, A., Duflo, E., Glennerster, R. and Kinnan, C. (2015). The Miracle of Microfinance? Evidence from a Randomized Evaluation. American Economic Journal: Applied Economics 7(1): 22-53.

Barrett, C. B. (2007). Displaced distortions: Financial market failures and seemingly inefficient resource allocation in low-income rural communities. In: Bulte, E., Ruben, R. (Eds.), Development economics between markets and institutions: Incentives for growth, food security and sustainable use of the environment, Wageningen: Wageningen Academic Publishers.

Bell, Clive, T. N. Srinivasan, and Christopher Udry (1997). Rationing, Spillover, and Interlinking in Credit Markets: The Case of Rural Punjab. Oxford Economic Papers 49 (4):557-585

Bellemare, Marc F., and Casey J. Wichman (2019). Forthcoming. Elasticities and the Inverse Hyperbolic Sine Transformation, Oxford Bulletin of Economics and Statistics.

Berry, S., Levinsohn, J., and Pakes, A. (1995). Automobile prices in market equilibrium. Econometrica, 63(4), 841-890

Bigsten, A., P. Collier, S. Dercon, M. Fafchamps, B. Gauthier, J.W. Gunning, M. Soderbom, A. Oduro, R. Oostendorp, C. Patillo, F. Teal, and A. Zeufack, (2003). Credit Constraints in Manufacturing Enterprises in Africa. Journal of African Economies, 12 (1), 104-125

Boucher S., Guirkinger, C. and Trivelli, C. (2009). Direct elicitation of credit constraints: conceptual and practical issues with an application to Peruvian agriculture. Economic Development and Cultural Change, 57(4), pp. 609-640.

Boucher, S., and Guirkinger, C. (2007). Risk, wealth and sectoral choice in rural credit markets. American Journal of Agricultural Economics, 89(4), 991-1004

Central Statistical Agency of the Ethiopia (CSA) (2015). Agricultural sample survey 2014/2015 (2007 E.C.). Volume I. report on area and production of major crops in Ethiopia (private peasant holdings, “meher” season)

Chamberlain, G. (1980). Analysis of covariance with qualitative data. Review of Economic Studies, 47, 225-238

Chaudhuri, Shubham, and Theresa Osborne (2002). Financial Market Imperfections and Technical Change in a Poor Agrarian Economy. Working Paper, European University Institute, Florence, Italy

Cheng, S., and Long, J. S. (2007). Testing for IIA in the multinomial logit model. Sociological Methods & Research, 35(4), 583-600

Christiaensen, L. (2017). Agriculture in Africa - Telling myths from facts: A synthesis. Food Policy 67: 1-11.

Chung, I. (1995). Market choice and effective demand for credit: The roles of borrower transaction costs and rationing constraints. Journal of Economic Development, 20(2), 23-44

Collins, D., J. Morduch, S. Rutherford, and O. Ruthven (2009). Portfolios of the Poor: How the World's Poor Live on Two Dollars a Day. Princeton University Press

Conley, T.G, and Udry, C. R. (2010). Learning about a new technology: Pineapple in Ghana. American Economic Review, 100 (1), 35-69.

Conning, J. (2001). Mixing and Matching Loans: Credit Rationing and Spillover in a Rural Credit Market in Chile. mimeo, City University of New York

Conning, J. (2005). Monitoring by Delegates or by Peers? Joint Liability Loans under Moral Hazard. Working Paper

Conning, J., and Udry, C. (2007). Rural Financial Markets in Developing Countries. In Handbook of Agricultural Economics, vol. 3, ed. Robert Evenson, Prabhu Pingali, and T. Paul Schultz, chap. 15. Amsterdam: Elsevier

Croppenstedt, A., Demeke, M.and Meschi, M.M. (2003). Technology adoption in the presence of constraints: the case of fertilizer demand in Ethiopia. Review of Development Economics 7 (1), 58-70.

de Janvry, A., and Sadoulet, E. (2006). Progress in the Modeling of Rural Households' Behavior under Market Failures. In A. De Janvry and R. Kanbur (Eds.), Poverty, Inequality and Development (p. 155-181). New York, NY: Springer.

de Janvry, A. and Sadoulet, E. (2010). Agricultural development in sub-Saharan Africa: an update. African Journal of Agricultural Resource Economics 5, 194-204

de Janvry, Alain, Elisabeth Sadoulet, Manzoor Dar, and Kyle Emerick (2016). The Agricultural Technology Adoption Puzzle: What Can We Learn From Field Experiments? Working Papers P178, FERDI.

Deininger, K., D. A. Ali, and T. Alemu (2009). Impacts of Land Certification on Tenure Security, Investment, and Land Markets: Evidence from Ethiopia. Discussion Paper Series 09-11. Gothenburg: Environment for Development (EfD).

Dercon, S. (2001). The impact of economic reform on households in rural Ethiopia, 1989-1995. Oxford, UK: Center for the Study of African Economies

Dercon, S. (2004). Growth and shocks: evidence from rural Ethiopia. Journal of Development Economics, 74, pp. 309-29.

Dercon, S., and Christiaensen, L. (2011). Consumption risk, technology adoption and poverty traps: Evidence from Ethiopia. Journal of Development Economics 96(2): 159-173.

Dollar, David, Paul Glewwe, and Jennie Litvack, eds. (1998). Household Welfare and Vietnam's Transition. Washington D.C.: World Bank

Doss, Cheryl (2006). Analyzing technology adoption using microstudies: Limitations, challenges, and opportunities for improvement. Agricultural Economics 34:207-219.

Duflo, E., Kremer, M. and Robinson, J. (2011). Nudging farmers to use fertilizer: Evidence from Kenya. American Economic Review, 101 (6), 2350-90.

Evans School Policy Analysis and Research Group (EPAR) (2019). AgDev Priority Indicators: Summary Statistics Round 2 (v7). Seattle: University of Washington.

Feder, G. (1982). Adoption of interrelated agricultural innovations: Complementarity and the impacts of risk, scale, and credit. American Journal of Agricultural Economics, Vol. 64, (1982) pp. 94-102.

Feder, G., Richard, E.J, and David, Z. (1985). Adoption of agricultural innovations in developing countries: a survey. Economic development and cultural change, 33: 255-298

Floro, M. S., and Ray, D. (1997). Vertical Links between Formal and Informal Financial Institutions. Review of Development Economics, 1(1), 34-56

Foster, A. and M. R. Rosenzweig (2010). Microeconomics of Technology Adoption. Annual Review of Economics 2 (1): 395-424.

Foster, A. D. and Rosenzweig, M. R. (1995). Learning by doing and learning from others: Human capital and technical change in agriculture. Journal of Political Economy, 103 (6), 1176-1209.

Geda, Alemayehu (2006). The Structure and Performance of Ethiopia's Financial Sector in the Pre and Post Reform Period: With Special Focus on Banking. mimeo, Department of Economics, Addis Ababa University.

Ghebru H. and Girmachew F. (2019). The impacts of second-level land certification (SLLC) in Ethiopia: Empirical evidence using panel data. Paper prepared for presentation at the 2019 conference on land policy in Africa, Africa land policy center - Abidjan, Cote d'ivoire, November 25-29, 2019

Gine, X. (2011). Access to Capital in Rural Thailand: An Estimated Model of Formal vs. Informal Credit, Journal of Development Economics 96(1), 16-29

Guirkinger, C. (2008). Understanding the Coexistence of Formal and Informal Credit Markets in Piura, Peru. World Development, 36(8), 1436-1452

Gupta, M. R., and Chaudhuri, S. (1997). Formal Credit, Corruption and the Informal Credit Market in Agriculture: A Theoretical Analysis. Economica, 64(254), 331-343

Hayami Y. and Ruttan V. W. (1985). Agricultural development: An international perspective. Baltimore, MD: The Johns Hopkins University Press.

Hayami,Y. and Kikuchi,M.(1981). Asian Villages Economy at the Crossroads. An Economic Approach to Institutional Change. University of Tokyo press, Tokyo.

Heffernan Peter, Fuentes Porfirio and Ariga Joshua (2012). Ethiopia Fertilizer Assessment. IFDC, USA

Hoff, K., and Stiglitz, J. (1990). Imperfect Information and Rural Credit Markets: Puzzles and Policy Perspectives. World Bank Economic Review, 5, 235-250

Holden. S. T. and Lunduka, R. W. (2013). Input subsidies, cash constraints, and timing of input supply. American Journal of Agricultural Economics, 96 (1), 290-307.

Karlan, Dean, Robert Darko Osei, Isaac Osei-Akoto, and Christopher R. Udry. (2014). Agricultural Decisions after Relaxing Credit and Risk Constraints. Quarterly Journal of Economics 129 (2): 597-652.

Khoi, P. D., Gan, C., Nartea, G. V. and Cohen, D. A. (2013). Formal and informal rural credit in the Mekong River Delta of Vietnam: Interaction and accessibility. Journal of Asian Economics, 26, 1-13. doi:10.1016/j.asieco.2013.02.003

Kimhi, A. (2006). Plot Size and Maize Productivity in Zambia: Is There an Inverse Relationship? Agricultural Economics 35(1): 1-9.

Lambrecht, I., Vanlauwe, B., Merckx, R., and Maertens, M. (2014). Understanding the process of agricultural technology adoption: Mineral fertilizer in Eastern DR Congo. World Development, 59, 132-146.

Liu, E. M. (2013). Time to Change What to Sow: Risk Preferences and Technology Adoption decisions of Cotton Farmers in China. Review of Economics and Statistics 95 (4):1386-1403.

Loening, J., Rijkers, B., and Soderbom, M. (2008). Non-farm Microenterprise Performance and the Investment Climate: Evidence from Rural Ethiopia. World Bank, Policy Research Working Paper No. 4577

Long, J. S. and Freese, J. (2006). Regression models for categorical dependent variables using Stata. 2nd ed., Texas: Stata Press

Madestam, A. (2014). Informal finance: A theory of moneylenders. Journal of Development Economics, 107, 157-174

Magruder, J. R. (2018). An assessment of experimental evidence on agricultural technology adoption in developing countries, Annual Review of Resource Economics, 10, 299-316.

Matsumoto, T., and Yamano, T. (2011). The Impacts of Fertilizer Credit on Crop Production and Income in Ethiopia. In T. Yamano, K. Otsuka, & F. Place (Eds.), Emerging Development of Agriculture in East Africa (pp. 58-72). Dordrecht: Springer Netherlands.

McFadden, Daniel (1974). Conditional Logit Analysis of Qualitative Choice Behavior. Pp. 105-42 in Frontiers of Econometrics, edited by P. Zarembka. New York: Academic Press

Minot, N. W. and Benson, T. D. (2009). Fertilizer Subsidies in Africa: Are Vouchers the Answer? Issue briefs No. 60, International Food Policy Research Institute: Washington, DC.

Minten, B., Koru, B., Stifel, D. (2013). The last mile(s) in modern input distribution: Pricing, profitability, and adoption. Agricultural Economics, 44 (6), 629-46.

Moneke, Niclas (2020). Infrastructure and structural transformation: evidence from Ethiopia. PhD thesis, The London School of Economics and Political Science (LSE).

Moser, C. M. and Barrett, C. B. (2006). The complex dynamics of smallholder technology adoption: The case of SRI in Madagascar, Agricultural Economics, Vol. 35, pp. 373-388.

Moser, C.M., C.B. Barrett and B. Minten (2005). Missed opportunities and missing markets: Spatio-temporal arbitrage of rice in Madagascar. Cornell University working paper

Mukasa, A. N., Simpasa, A. M., and Salami, A. O. (2017). Credit constraints and farm productivity: Micro-level evidence from smallholder farmers in Ethiopia. African Development Bank, Abidjan, Côte d'Ivoire.

Mundlak, Y. (1978). On the Pooling of Time Series and Cross Section Data. Econometrica 46(1): 69-85.

Mushinski, D. (1999). An analysis of loan offer functions of banks and credit unions in Guatemala. Journal of Development Studies, 36(2), 88-112

NBE (1996). A Study on the Need for Establishing Rural and Urban Micro-Financial Institutions in Ethiopia, January, Addis Ababa.

Nkonya, E., T. Schroeder, and D. Norman (1997). Factors Affecting Adoption of Improved Maize Seed and Fertilizer in Northern Tanzania, Journal of Agricultural Economics, 48, 1-12.

Rashid, S. (2010). Staple Food Prices in Ethiopia. Prepared for the COMESA Policy Seminar Food Price Variability: Causes, Consequences, and Policy Options on 25-26 January 2010 in Maputo, Mozambique under the COMESA-MSU-IFPRI African Agricultural Markets Project (AAMP)

Rashid, S., and Negassa, A. (2013). Policies and performance of Ethiopian cereal markets. In Dorosh, & Rashid (Eds.), Food and agricultural policies in Ethiopia: Progress and policy challenges (pp. 123-158).

Rashid, S., Tefera, N., Minot, N., and Ayele, G. (2013). Can modern input use be promoted without subsidies? An analysis of fertilizer in Ethiopia. Agric. Econ. 44(6), 595-611.

Rodrik, D. (2014). An African Growth Miracle?. NBER Working Paper 20188. Cambridge MA: National Bureau of Economic Research.

Rouwendal, J. (2018). Specification tests for the multinomial logit model revisited: The role of alternative-specific constants. Discussion papers, No. 17-068/VIII, Tinbergen Institute, Amsterdam. Retrieved from http://www.tinbergen.nl/ on 25 September 2020

Sadoulet, E., and Janvry, A. de (1995). Quantitative Development Policy Analysis. Baltimore, Maryland: The Johns Hopkins University Press.

Sanchez, Susana. M. and Love Inessa (2009). Credit Constraints and Investment Behavior in Mexico's Rural Economy. Policy Research Working Paper, WPS5014. Finance and Private Sector Team, the World Bank Development Research Group

Sarap, K., (1991). Interlinked Agrarian Markets in Rural India. Sage publications, New Delhi.

Secchi, A., F. Tamagni and C. Tomas (2016). Financial Constraints and Firm Exports: Accounting for Heterogeneity, Self-selection and Endogeneity. Industrial and Corporate Change, 25, 813-827.

Semykina, A., and Wooldridge, J.M. (2010). Estimating panel data models in the presence of endogeneity and selection. Journal of Econometrics 157, 375-380

Sheahan, M., and Barrett, C. B. (2017). Ten striking facts about agricultural input use in Sub-Saharan Africa. Food Policy, 67, 12-25.

Sheahan, M., Black, R.and Jayne, T. S. (2013). Are Kenyan farmers under-utilizing fertilizer? Implications for input intensification strategies and research. Food Policy, 41, 39-52.

Singh, Lnderjit, Lyn Squire, and John Strauss, Eds. (1986). Agricultural Household Models: Extensions, Applications, and Policy. Baltimore, Md.: Johns Hopkins University Press.

Siyoum, A.D., Hilhorst, D. and Pankhurst, A. (2012). The differential impact of microcredit on rural livelihoods: case study from Ethiopia. International Journal of Development and sustainability, Vol. 1 No.3 (in press)

Spielman DJ, Byerleer D, Alemu D, and Kelemework D (2010). Policies to promote cereal intensification in Ethiopia: the search for appropriate public and private roles. Food Policy 35:185-194

Stiglitz, J., and Weiss, A. (1981). Credit Rationing in Markets with Imperfect Information. American Economic Review, 73(3), 383-410

Suri, T. (2011). Selection and comparative advantage in technology adoption. Econometrica, 79 (1), 159-209

Tesfamariam, K (2015). Savings and Credit Cooperatives in Ethiopia: Development and Challenges, Journal of Economics and Sustainable Development, (6) 5, 140-146

Weersink, A., and S. Rozelle (1997). Marketing Reforms, Market Development and Agricultural Production in China. J. Agric. Econ. 17:95-114.

Wiedmaier-Pfister, M., D. Gesesse, W. Amha, et al. (2008). Access to Finance in Ethiopia. Sector Assessment Study 2, German Organization for Technical Cooperation (GTZ)

Wooldridge, Jeffrey M. (2010). Econometric Analysis of Cross Section and Panel Data 2nd (second) Edition. The MIT Press.

World Bank (1991). Ethiopia Financial Sector Review 1991, Washington D.C.

World Bank (2016). Ethiopia's Great Run -the Growth Acceleration and How to Pace It. Washington, D.C.: World Bank Group.

Yamano, T., and Arai, A. (2011). Fertilizer policies, price, and application in East Africa. In Yamano, Otsuka and Place (Ed.). Emerging Development of Agriculture in East Africa (pp. 39-57). Springer

Yigezu, Biratu and Zekaria, Samia (2010). Integrated Agricultural and Household Surveys: The Experience of Ethiopia. A paper presented on the fifth International Conference on Agricultural Statistics, 13-15 October 2010, Uganda Kampala.

Zeller, M. (1994). Determinants of credit rationing: a study of informal lenders and formal credit groups in Madagascar. Food Consumption and Nutrition Division, International Food Policy Research Institute, Washington, D.C. U.S.A.

Zerfu, D. and Larson, D. F. (2010). Incomplete Markets and Fertilizer Use Evidence from Ethiopia. Policy Research Working Paper 5235. The Development Research Group, World Bank.

Table 3.1
Variable definitions

VARIABLES	VARIABLE DEFINITIONS
Formal credit constraints	Ratio of unsatisfied and rejected households to total formal credit requests, village level
Inorganic fertilizer use	1 if the household uses any inorganic fertilizer
Inorganic fertilizer rate	Rate of fertilizer application (kgs/ha, winsorized top 1%, in logs)
Improved seeds	1 if the household uses improved seeds
Extension participation	1 if the household participate in the extension program
Extension reach	1 if the household is reached by extension services
Credit constraint_q	1 if constrained (quantity rationing)
Credit constraint_qrtc	1 if constrained (quantity rationing, transaction costs rationing and risk rationing)
Female	1 if the household is headed by female
Household member	Household size
Adult equivalent	Household size in adult equivalent scale
Education	1 if the household head can read and write in any language
Age	household head age (in logs)
Labour time	Total labour days at the planting stage (family plus hired) in logs
Farm size	Farm-size, all cultivated plots in hectare(in inverse hyperbolic sine transformation)
Area planted	Total area planted (winsorized top and bottom 1%, in arcinh transformation)
Livestock	Total household livestock holdings (in TLU, in arcinh transformation)
Livestock, per adult	Livestock holding per adult equivalent scale
Oxen	Number of oxen owned by the household in the main season
Roof	1 if the roof of the main dwelling is predominantly made of corrugated iron sheet
Non-farm	1 if anyone in the household owned non-farm enterprise,12 months preceding the survey
Land right	1 if the household has legal documentation of land right (at least one plot)
MFIs	1 if there is microfinance institutions branch in the community (at cluster level)
Cash	1 if anyone in the household received cash transfers -foreign, 12 months preceding the survey
Banks	1 if there is commercial bank in the community(at cluster level)
Distance banks	Distance to the nearest commercial bank (in km) at community level
Banks*distance banks	An interaction term between banks and distance to banks
Woreda	1 if the community is in the woreda(district) town
Distance woreda	Distance to the nearest woreda (district) town (in km) at community level
Woreda*distance woreda	An interaction term between woreda and distance to woreda
Planted area maize	Total planted area of maize (in ha; in inverse hyperbolic sine transformation)
Planted area teff	Total planted area of teff (in ha; in inverse hyperbolic sine transformation)
Planted area wheat	Total planted area of wheat (in ha; in inverse hyperbolic sine transformation)
grew banana	1 if the household grew banana
grew coffee	1 if the household grew coffee
grew sesame	1 if the household grew sesame
Idiosyncratic shock	1 if the household experience illness and/or death 12 months preceding the survey
Rain too much	1 if rain is too much, normal otherwise, community representative perception
Rain too little	1 if rain is too little, normal otherwise, community representative perception
Amhara	1 if the household resides in Amhara regional state
Oromia	1 if the household resides in Oromia regional state
SNNP	1 if the household resides in SNNP regional state
RegionO	1 if the household resides in the rest regional states
Non-farm*Tigray	Interaction term between non-farm enterprises and Tigray regional state
Non-farm*Amhara	Interaction term between non-farm enterprises and Amhara regional state

arcinh –inverse hyperbolic sine transformation (Bellemare & Witchman, 2019) ;TLU- tropical livestock unit

Table 3.2
Summary statistics: sample respondents' demand for external finance

.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	No demand for credit					Demand credit				
VARIABLES	N	mean	sd	min	max	N	mean	sd	min	max
Female[2]	2,110	0.25	0.43	0	1	6,843	0.23	0.42	0	1
Age	2,110	3.79	0.33	2.8	4.6	6,843	3.78	0.33	2.6	4.6
Education[1]	2,110	0.42	0.49	0	1	6,843	0.38	0.49	0	1
MFIs	2,110	0.28	0.45	0	1	6,843	0.27	0.44	0	1
Oxen[1]	2,110	0.98	1.34	0	12	6,843	0.82	1.09	0	9
Roof[1]	2,110	0.53	0.50	0	1	6,843	0.44	0.50	0	1
Rain too much[1]	2,110	0.17	0.40	0	1	6,843	0.20	0.40	0	1
Rain too little	2,110	0.39	0.50	0	1	6,843	0.39	0.49	0	1
Non-farm[1]	2,110	0.28	0.45	0	1	6,843	0.32	0.47	0	1
Cash	2,110	0.09	0.29	0	1	6,843	0.10	0.30	0	1
Farm-size[2]	2,110	0.66	0.68	0	4.5	6,843	0.63	0.63	0	6.7
Planted area maize	2,110	0.12	0.26	0	3.7	6,843	0.12	0.26	0	5.3
Planted area teff	2,110	0.14	0.32	0	3.4	6,843	0.14	0.29	0	4.1
Planted area wheat[1]	2,110	0.09	0.26	0	3.4	6,843	0.07	0.20	0	3.2
Grew banana[2]	2,110	0.14	0.35	0	1	6,843	0.16	0.36	0	1
Grew coffee[2]	2,110	0.25	0.44	0	1	6,843	0.28	0.45	0	1
Grew sesame	2,110	0.06	0.23	0	1	6,843	0.06	0.24	0	1
Land right[1]	2,110	0.49	0.50	0	1	6,843	0.44	0.50	0	1
Extension participation[1]	2,110	0.05	0.22	0	1	6,843	0.09	0.29	0	1
Idiosyncratic shock	2,110	0.14	0.34	0	1	6,843	0.14	0.35	0	1
Tigray[2]	2,110	0.12	0.32	0	1	6,843	0.10	0.30	0	1
RegionO[1]	2,110	0.20	0.40	0	1	6,843	0.23	0.42	0	1
Amhara[3]	2,110	0.23	0.42	0	1	6,843	0.21	0.41	0	1
Oromia	2,110	0.20	0.40	0	1	6,843	0.19	0.40	0	1
SNNP	2,110	0.26	0.44	0	1	6,843	0.27	0.45	0	1

Two-way t-test that sample means are statistically different between credit demanding and non-demanding sample respondents: 1- significant at 1%, 2- significant at 5% and 3- significant at 10%.

Table 3.3
Summary statistics: credit demanding households' decision to apply

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Non-applicants/Demand-side credit rationed					Applied for credit				
VARIABLES	N	mean	sd	min	max	N	mean	sd	min	max
Female[1]	2,930	0.27	0.445	0	1	2,613	0.18	0.39	0	1
Age[1]	2,930	3.80	0.342	2.6	4.6	2,613	3.80	0.30	2.9	4.6
Education[1]	2,930	0.34	0.475	0	1	2,613	0.44	0.50	0	1
MFIs	2,930	0.27	0.443	0	1	2,613	0.27	0.44	0	1
Oxen[1]	2,930	0.80	1.065	0	8	2,613	0.91	1.11	0	7
Roof	2,930	0.45	0.498	0	1	2,613	0.47	0.50	0	1
Rain too much	2,930	0.19	0.393	0	1	2,613	0.21	0.40	0	1
Rain too little	2,930	0.38	0.486	0	1	2,613	0.38	0.49	0	1
Non-farm[1]	2,930	0.30	0.460	0	1	2,613	0.36	0.48	0	1
Cash	2,930	0.10	0.301	0	1	2,613	0.11	0.31	0	1
Farm-size	2,930	0.62	0.628	0	6.2	2,613	0.72	0.66	0	6.8
Planted area maize	2,930	0.12	0.287	0	5.3	2,613	0.13	0.26	0	3.9
Planted area teff	2,930	0.13	0.295	0	4.1	2,613	0.17	0.30	0	2.6
Planted area wheat[1]	2,930	0.06	0.184	0	3.2	2,613	0.09	0.24	0	2.9
Grew banana[1]	2,930	0.18	0.381	0	1	2,613	0.14	0.35	0	1
Grew coffee[1]	2,930	0.30	0.459	0	1	2,613	0.26	0.44	0	1
Grew sesame	2,930	0.06	0.240	0	1	2,613	0.07	0.26	0	1
Land right[1]	2,930	0.45	0.497	0	1	2,613	0.50	0.50	0	1
Extension participation[1]	2,930	0.09	0.291	0	1	2,613	0.12	0.32	0	1
Idiosyncratic shock[1]	2,930	0.13	0.339	0	1	2,613	0.16	0.37	0	1
Tigray[1]	2,930	0.10	0.295	0	1	2,613	0.14	0.35	0	1
RegionO[1]	2,930	0.21	0.404	0	1	2,613	0.17	0.38	0	1
Amhara[1]	2,930	0.22	0.412	0	1	2,613	0.25	0.44	0	1
Oromia	2,930	0.20	0.399	0	1	2,613	0.19	0.39	0	1
SNNP[1]	2,930	0.28	0.451	0	1	2,613	0.24	0.43	0	1

Note: Not all sample respondents with demand for credit are included in the computation of descriptive statistics reported in this table. Only respondents in a village for which I am able to generate ratio of formal credit constraint variable are considered. Thus, of 6843 respondents with demand for credit (table 3.2), only 5543 are considered here (2930+2613). Two-way t-test that sample means are statistically different between applying and non-applying credit demanding households: 1- significant at 1%, 2- significant at 5% and 3- significant at 10%.

Table 3.4

Summary statistics: borrowing households' choice of lenders and decisions to use credit

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
		Formal credit					Semi-formal credit					Informal credit					No credit			
VARIABLES	N	mean	sd	min	max	N	mean	sd	min	max	N	mean	sd	min	max	N	mean	sd	min	max
Formal credit constraints	687	0.10	0.23	0	1.5	256	0.06	0.22	0	1	1,311	0.06	0.21	0	1	358	0.25	0.40	0	1.5
Female	687	0.14	0.35	0	1	256	0.15	0.36	0	1	1,311	0.20	0.40	0	1	358	0.23	0.42	0	1
Age	687	3.78	0.29	3.0	4.5	256	3.82	0.28	3.2	4.4	1,311	3.74	0.31	2.9	4.6	358	3.72	0.32	2.9	4.5
Education	687	0.44	0.50	0	1	256	0.41	0.49	0	1	1,311	0.45	0.50	0	1	358	0.42	0.49	0	1
Oxen	687	1.22	1.15	0	7	256	1.41	1.17	0	7	1,311	0.71	1.05	0	6	358	0.70	0.96	0	6
Roof	687	0.59	0.49	0	1	256	0.35	0.48	0	1	1,311	0.45	0.50	0	1	358	0.39	0.49	0	1
Non-farm	687	0.36	0.48	0	1	256	0.27	0.44	0	1	1,311	0.38	0.49	0	1	358	0.34	0.47	0	1
Cash	687	0.09	0.28	0	1	256	0.09	0.28	0	1	1,311	0.13	0.34	0	1	358	0.10	0.30	0	1
Farm-size	687	0.89	0.62	0	3.4	256	0.93	0.69	0	4.6	1,311	0.64	0.66	0	6.7	358	0.54	0.59	0	3.7
Planted area maize	687	0.17	0.27	0	1.4	256	0.17	0.38	0	3.9	1,311	0.12	0.23	0	2.3	358	0.10	0.25	0	3.6
Planted area teff	687	0.24	0.33	0	2.6	256	0.26	0.33	0	1.5	1,311	0.13	0.27	0	2.0	358	0.11	0.24	0	1.4
Planted area wheat	687	0.13	0.26	0	2.9	256	0.13	0.29	0	2.2	1,311	0.07	0.24	0	2.8	358	0.03	0.10	0	0.6
Grew banana	687	0.10	0.30	0	1	256	0.13	0.34	0	1	1,311	0.17	0.37	0	1	358	0.15	0.36	0	1
Grew coffee	687	0.22	0.42	0	1	256	0.22	0.41	0	1	1,311	0.29	0.45	0	1	358	0.28	0.45	0	1
Grew sesame	687	0.06	0.24	0	1	256	0.06	0.24	0	1	1,311	0.07	0.26	0	1	358	0.09	0.29	0	1
Land right	687	0.68	0.47	0	1	256	0.68	0.47	0	1	1,311	0.40	0.49	0	1	358	0.35	0.48	0	1
Extension participation	687	0.16	0.37	0	1	256	0.29	0.45	0	1	1,311	0.06	0.25	0	1	358	0.10	0.30	0	1
Idiosyncratic shock	687	0.11	0.31	0	1	256	0.12	0.33	0	1	1,311	0.19	0.39	0	1	358	0.17	0.38	0	1
Tigray	687	0.17	0.38	0	1	256	0.43	0.50	0	1	1,311	0.07	0.26	0	1	358	0.13	0.34	0	1
RegionO	687	0.02	0.14	0	1	256	0.05	0.23	0	1	1,311	0.26	0.44	0	1	358	0.22	0.42	0	1
Amhara	687	0.43	0.50	0	1	256	0.15	0.36	0	1	1,311	0.22	0.41	0	1	358	0.13	0.34	0	1
Oromia	687	0.21	0.41	0	1	256	0.18	0.39	0	1	1,311	0.19	0.39	0	1	358	0.17	0.38	0	1
SNNP	687	0.17	0.38	0	1	256	0.18	0.39	0	1	1,311	0.27	0.44	0	1	358	0.34	0.47	0	1

Note: Proportion of formal credit constraint ranges from zero to one. Yet, as it can be seen in the same table, this is not the case for formal credit and no credit alternatives/choices. In its derivation the numerator includes both unsatisfied and rejected formal credit requests in a village. At the same time, formal credit alternative includes both accessed and unsatisfied requests. Similarly, no credit alternative includes all rejected requests in the credit market irrespective of the source. In fact, my interest, as far as this variable is concerned, is only in the informal credit alternative. I think that this treatment does not pose any threat to estimation results and interpretation of coefficient on this variable.

Table 3.5

Probit and Heckman selection models estimation results for the likelihood of demand for credit and decisions to apply

	(1)	(2)	(3)
VARIABLES	Coefficient	Coefficient	Coefficient
Female	.092**	.103***	-.115***
	(.040)	(.039)	(.038)
Age	-.016***	-.018***	.005
	(.006)	(.006)	(.006)
Age square	.0002***	.0002***	-4.42e-05
	(5.95e-05)	(5.99e-05)	(5.78e-05)
Education	-.125***	-.128***	-.085**
	(.040)	(.031)	(.034)
Oxen	-.025	-.023	-.080***
	(.017)	(.015)	(.015)
Roof	-.086**	-.078**	-.185***
	(.040)	(.030)	(.032)
Non-farm	-.087**	-.107***	.148***
	(.041)	(.033)	(.034)
Cash	-.105**	-.135***	.053
	(.050)	(.048)	(.051)
Farm-size	-.091**	-.097***	.059*
	(.040)	(.032)	(.034)
Planted area wheat	-0.101	-.117***	-.063
	(.072)	(.044)	(.039)
Grew banana	.096	.095**	.072
	(.061)	(.045)	(.049)
Land right	-.072*	-.075**	-.046
	(.041)	(.032)	(.034)
Extension participation	-.061		.320***
	(.078)		(.062)
Idiosyncratic shock	-.205***		.136***
	(.046)		(.039)
rho			.889***
			(.059)
Region FE	Yes	Yes	Yes
Period FE	Yes	Yes	Yes
Pseudo R^2	.038		
Observations	8,953	6,843	8,953

Notes: Column (1) contains estimation results from pooled probit for the probability of demand-side credit rationing without controlling for sample selection. Column (2) and column (3) respectively contains estimation results from the Heckman probit model for the likelihood of demand-side credit rationing and of demanding external finance. Extension participation and idiosyncratic shocks are variables included as an exclusion restriction. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Other variables included in the estimation, but are not reported here: MFIs, planted area of maize, planted area of teff, grew coffee and grew sesame, rain too little, and rain too much. Except the latter two, all are not statistically significant and dropped for the sake of space.

Table 3.6
MNL model estimation results for the determinants of borrowing households' choice of lenders and use of credit

	(Semi-formal credit)	(Informal credit)	(No credit)
VARIABLES	Coefficient	Coefficient	Coefficient
Formal credit constraints	-.820**	-.544**	1.455***
	(.377)	(.238)	(.239)
Extension participation	.630***	-.531***	-.269
	(.184)	(.162)	(.232)
Idiosyncratic shock	.057	.426***	.281
	(.256)	(.155)	(.210)
Female	.008	.489***	.556***
	(.258)	(.167)	(.209)
Age	.007	.002	.004
	(.006)	(.004)	(.006)
Education	-.116	.212	.051
	(.179)	(.130)	(.163)
Oxen	.168**	-.253***	-.157*
	(.074)	(.064)	(.084)
Roof	-.764***	-.380***	-.607***
	(.173)	(.120)	(.156)
Cash	-.305	.354**	-.082
	(.278)	(.177)	(.246)
Farm-size	.112	.032	-.366*
	(.142)	(.125)	(.215)
Planted area wheat	-.0711	.074	-1.246**
	(.158)	(.119)	(.509)
Grew sesame	-.637*	.785***	.822**
	(.373)	(.272)	(.353)
Land right	.127	-.564***	-.672***
	(.188)	(.124)	(.167)
RegionO	.400	3.178***	2.504***
	(.432)	(.401)	(.453)
Amhara	-1.905***	.561***	-.383
	(.248)	(.197)	(.274)
Oromia	-1.087***	.986***	.462
	(.275)	(.216)	(.282)
SNNP	-1.010***	1.337***	.945***
	(.286)	(.231)	(.291)
Pseudo R^2	.156		
Observations	2,612		

Note: Reference category for the equation is formal credit. Tigray is dropped for regional dummies. Robust standard errors clustered at household level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Other variables included in the estimation, but not reported here are: Grew coffee, grew banana, planted area teff, planted are maize.

Table 3.7
Suest based Hausman IIA test results

A	B	C	D		
Omitted Category	Restricted Model categories	Unrestricted model categories	Chi2	df	prob
		Formal credit			
Formal credit	Semi -formal Credit	Semi-formal credit	35.13	21	0.273
	No credit	No credit	38.89	21	0.010
	Formal credit	Formal credit	23.73	21	0.306
Semi-formal credit		Semi-formal credit			
	No credit	No credit	25.19	21	0.240
	Formal credit	Formal credit	20.04	21	0.519
No credit	Semi-formal credit	Semi-formal credit	21.67	21	0.419
		No credit			

Note: For McFadden - Hausman specification test for IIA to hold, coefficients of the equation under B and C should be equal. Under H0 Suest based Hausman test assume that these coefficients are equal. Base category is Informal credit.

Table 3.8

MNP model estimation results for the determinants of borrowing households' choice of lenders and use of credit

	(Semi-formal credit)	(Informal credit)	(No credit)
VARIABLES	Coefficient	Coefficient	Coefficient
Formal credit constraints	-.502**	-.472***	1.019***
	(.241)	(.174)	(.176)
Extension participation	.400***	-.434***	-.215
	(.132)	(.125)	(.153)
Idiosyncratic shock	.121	.351***	.232
	(.163)	(.116)	(.142)
Female	.022	.349***	.359**
	(.169)	(.127)	(.145)
Age	.005	.002	.003
	(.004)	(.003)	(.004)
Education	-.085	.149	.027
	(.121)	(.100)	(.113)
Oxen	.096*	-.191***	-.108*
	(.052)	(.049)	(.057)
Roof	-.529***	-.291***	-.455***
	(.115)	(.093)	(.108)
Cash	-.155	.283**	-.037
	(.188)	(.136)	(.168)
Farm-size	.013	.015	-.236*
	(.104)	(.096)	(.139)
Planted area wheat	-.009	.059	-.843***
	(.110)	(.094)	(.315)
Grew sesame	-.369	.567***	.534**
	(.255)	(.204)	(.235)
Land right	.008	-.445***	-.494***
	(.124)	(.097)	(.114)
RegionO	.175	2.175***	1.518***
	(.250)	(.242)	(.263)
Amhara	-1.267***	.393***	-.318*
	(.173)	(.150)	(.182)
Oromia	-.677***	.752***	.279
	(.188)	(.165)	(.192)
SNNP	-.637***	1.009***	.657***
	(.196)	(.172)	(.194)
Observations	2,612		

Note: Base outcome for the equation is formal credit. Tigray is dropped for regional dummies. Robust standard errors clustered at household level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Other variables included in the estimation, but not reported here are: planted area teff, planted area maize, grew coffee, grew banana.

Table 3.9

Heckman selection model estimation results for the effect of formal credit constraint on borrowing households' decision to use informal credit

	(Informal credit)	(Decision to apply for credit)
VARIABLES	Coefficient	Coefficient
Formal credit constraints	-.532***	-.113*
	(.119)	(.063)
Extension participation		-.083
		(.061)
Idiosyncratic shock		.258***
		(.046)
Female	.320***	-.246***
	(.063)	(.045)
Age	.004**	-.008***
	(.002)	(.001)
Education	.033	.128***
	(.053)	(.039)
Oxen	-.138***	-.005
	(.029)	(.019)
Roof	-.074	-.030
	(.049)	(.037)
Non-farm	-.153***	.195***
	(.050)	(.038)
Cash	.133	.134**
	(.085)	(.057)
Farm-size	-.084	.147***
	(.052)	(.038)
Grew banana	.075	-.117**
	(.075)	(.055)
Grew sesame	.502***	-.135*
	(.104)	(.076)
Land right	-.276***	.093**
	(.054)	(.039)
RegionO	1.294***	-.391***
	(.121)	(.070)
Amhara	.544***	-.179***
	(.086)	(.063)
Oromia	.839***	-.340***
	(.098)	(.068)
SNNP	.963***	-.377***
	(.105)	(.069)
rho	-.777***	
	(.091)	
Observations	5,543	

Tigray is omitted for regional dummies. Standard errors adjusted for clustering is in parentheses *** p<0.01, ** p<0.05, * p<0.1 Other predictors included in the estimation, but are not reported here: planted area maize, planted area teff, planted area wheat, and grew coffee. These are not statistically significant and dropped to save space.

Table 4.10
Descriptive statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inorganic fertilizer status			Non-users					Users		
VARIABLES	N	mean	sd	min	max	N	mean	sd	min	max
Inorganic fertilizer rate						3,822	4.900	1.762	-3.9	11.0
Credit constraint_q	3,901	0.171	0.377	0	1	3,842	0.122	0.327	0	1
Credit constraint_qrtc	3,901	0.599	0.490	0	1	3,842	0.461	0.499	0	1
Household member	3,901	5.671	2.470	1	16	3,842	6.140	2.270	1	17
Land right	3,901	0.351	0.477	0	1	3,842	0.634	0.482	0	1
Improved seeds	3,901	0.053	0.224	0	1	3,842	0.330	0.470	0	1
Extension reach	3,901	0.094	0.291	0	1	3,842	0.735	0.441	0	1
Adult equivalent	3,901	4.077	1.893	0.7	13.1	3,842	4.480	1.749	0.7	12.6
Female	3,901	0.231	0.422	0	1	3,842	0.174	0.379	0	1
Education	3,901	0.342	0.475	0	1	3,842	0.445	0.497	0	1
MFIs	3,901	0.264	0.441	0	1	3,842	0.262	0.440	0	1
Oxen	3,901	0.689	1.074	0	12	3,842	1.246	1.216	0	11
Roof	3,901	0.384	0.486	0	1	3,842	0.538	0.499	0	1
Non-farm	3,901	0.311	0.463	0	1	3,842	0.281	0.449	0	1
Banks	3,901	0.042	0.201	0	1	3,842	0.029	0.167	0	1
Distance banks	3,901	29.57	30.09	0	246	3,842	21.72	23.13	0	246
Banks*distance banks	3,901	0.004	0.120	0	5	3,842	0.012	0.230	0	5
Livestock, per adult	3,901	0.592	0.914	0	24.8	3,842	0.660	1.337	0	73.0
Woreda	3,901	0.096	0.295	0	1	3,842	0.070	0.254	0	1
Distance woreda	3,901	22.05	25.13	0	264	3,842	19.49	21.98	0	264
Woreda*distance woreda	3,901	0.764	6.671	0	120	3,842	0.365	2.949	0	36
Area planted	3,901	0.573	0.542	0	3.0	3,842	0.894	0.603	0	3.0
Livestock	3,901	1.193	0.926	0	4.9	3,842	1.467	0.780	0	6.8
Labor time	3,901	4.602	1.161	0	9.7	3,842	5.361	0.904	1.4	9.9
Age	3,901	3.786	0.337	2.6	4.6	3,842	3.785	0.309	2.8	4.6
Non-farm*Tigray	3,901	0.013	0.115	0	1	3,842	0.035	0.183	0	1
Non-farm*Amhara	3,901	0.033	0.177	0	1	3,842	0.066	0.248	0	1
Tigray	3,901	0.066	0.248	0	1	3,842	0.144	0.351	0	1
Others	3,901	0.283	0.451	0	1	3,842	0.069	0.253	0	1
Amhara	3,901	0.202	0.402	0	1	3,842	0.236	0.425	0	1
Oromia	3,901	0.153	0.360	0	1	3,842	0.249	0.432	0	1
SNNP	3,901	0.296	0.457	0	1	3,842	0.303	0.460	0	1

Note: Only those households observed at least twice are considered in the estimation of the main equation of interest - input intensification equation. As such the users sub-sample in this table doesn't much the number of observations in the estimation. All households represented in this table are also observed at least twice. A value of zero observed for area planted is due to very insignificant value after area is transformed to hectare and does not necessarily corresponds to zero. A zero value for labor time is likely to be due to sharecropping practiced among limited share of smallholder farmers.

Table 4.2
Probit and IV probit results for the effect of credit constraint on inorganic fertilizer use decision

	(1)	(2)	(3)	(4)	(5)	(6)
Panel selection:		Probit	IV Probit		Probit	IV Probit
VARIABLES	APE	APE	APE	APE	APE	APE
Credit constraint_q	-.015	-.017	-.213***			
	(.015)	(.015)	(.062)			
Credit constraint_qrtc				-.039***	-.040***	-.363***
				(.010)	(.010)	(.031)
Land right	.003			.003		
	(.017)			(.016)		
MFIs				.017	.018	.013
				(.017)	(.017)	(.011)
Female	.013	.010	-.002	.016	.013	.006
	(.032)	(.032)	(.033)	(.033)	(.033)	(.032)
Education	-.023	-.024*	-.023	-.024	-.025*	-.027*
	(.014)	(.014)	(.015)	(.014)	(.014)	(.014)
Extension reach	.294***	.293***	.281***	.313***	.312***	.226***
	(.024)	(.024)	(.024)	(.024)	(.024)	(.018)
Oxen				.013*	.013*	.010
				(.007)	(.007)	(.006)
Area planted	.065***	.067***	.075***	.063***	.065***	.061***
	(.016)	(.016)	(.021)	(.016)	(.016)	(.013)
Non-farm	.009	.011	.010			
	(.021)	(.021)	(.023)			
Improved seeds	.059***	.058***	.061***			
	(.021)	(.021)	(.020)			
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7,743	7,743	7,743	7,743	7,743	7,743

Note: Variable selected as an instrument for potentially endogenous credit constraint_q and credit constraint_qrtc is land right. Columns (3) and (6) are estimation results that take care of the endogeneity of credit constraint in the selection equation. Standard errors adjusted for clustering at enumeration areas are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4.3
Instrumental variable estimation results for the effect of credit constraint on intensity of inorganic fertilizer use

Panel selection	(1) Simple OLS	(2) Pooled OLS	(3) Pooled OLS	(4) Pooled 2SLS
VARIABLES	Coefficient	Coefficient	Coefficient	Coefficient
Credit constraint_qrtc	-.231***	-.217***	-.225***	-1.450***
	(.044)	(.044)	(.044)	(.508)
IMR				-.177**
				(.071)
Banks		.434**		
		(0.195)		
Distance banks		.004***		
		(.001)		
Banks*distance banks		.062		
		(.051)		
Non-farm	-.083	-.238**	-.254***	-.235**
	(.057)	(.097)	(.098)	(.119)
Oxen	.195***	.0183	.021	-.012
	(.028)	(.037)	(.037)	(.043)
Female	.102	.072	.058	-.009
	(.064)	(.174)	(.176)	(.202)
Education	-.038	.075	.078	.133
	(.051)	(.076)	(.076)	(.096)
Roof	.174***	.189*	.189*	.174
	(.050)	(.108)	(.108)	(.120)
Livestock	-.010	.125**	.123**	.083
	(.036)	(.056)	(.056)	(.059)
Area planted	-.699**	-.872***	-.865***	-.802***
	(.060)	(.077)	(.077)	(.093)
Labor time	.161***	.207***	.211***	.233***
	(.031)	(.042)	(.042)	(.048)
Constant	4.281***	4.653***	4.590***	5.028***
	(.323)	(.371)	(.367)	(.427)
Household FE	No	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	3,342	3,342	3,342	3,342
R-squared	0.482	0.492	0.490	0.369

Note: That time averages of interaction terms are not included in the estimation. Variables selected as instruments for the potentially endogenous credit constraint_qrtc are: Banks, Distance banks and Banks*distance banks. IMR interacted with time dummies are also included in the estimation under column (3). Standard errors adjusted for clustering at household level is in parentheses *** p<0.01, ** p<0.05, * p<0.1
Other variables included in the estimation, but not reported here are: age, household member

Table 4.4
Fitted probability from a probit regression of endogenous variables on instruments

	(1)	(2)	(3)	(4)
	Selection model		Intensification model	
VARIABLES	Coefficient	Coefficient	Coefficient	Coefficient
Land right	-.150**	-.141**		
	(.076)	(.068)		
Banks			-.494***	-.214
			(.177)	(.205)
Distance banks			.0002	.0004
			(.002)	(.001)
Banks*distance banks			-.480***	-.261***
			(.099)	(.029)
Household FE	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes
Pseudo R^2	.018	.021	.026	.021
Observations	7,743	7,743	3,342	7,743

Note: Columns (1) and (2) respectively depict fitted probability from a probit regression of credit constraint_q and credit constraint_qrtc. Similarly, columns (3) and (4) respectively depict a fitted probability from a probit regression of credit constraint_qrtc in the sub-sample and full sample. Time averages of interaction terms are not included in the estimation. Standard errors adjusted for clustering at enumeration area level is in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Other control variables included in the estimation, but are not reported here: Non-farm, Oxen, Female, Education, Roof, Livestock, Area planted, Labour time, Household member, Age, Extension reach, Improved seeds, MFIs, Non-farm* Tigray, Non-farm *Amhara.

Table 4.5

Instrumental variable results for the effect of credit constraint on intensity of inorganic fertilizer use: with alternative instruments

	(1)	(2)	(3)	(4)	(5)
	Probit		Pooled OLS		Pooled 2SLS
VARIABLES	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Credit constraint_qrtc			-.215***	-.223***	-2.472**
			(.044)	(.044)	(.993)
IMR					-.138
					(.088)
Woreda	-.383**	-.196*	.663***		
	(.184)	(.116)	(.185)		
Distance woreda	.002	-.0006	-.00004		
	(.002)	(.001)	(.001)		
Woreda*distance woreda	-.014*	.006	-.005		
	(.007)	(.006)	(.010)		
Area planted	.131	.027	-.866***	-.865***	-.752***
	(.102)	(.070)	(.077)	(.077)	(.121)
Labor time	.042	.024	.213***	.211***	.249***
	(.047)	(.029)	(.042)	(.042)	(.059)
Constant			4.593***	4.590***	5.401***
			(.370)	(.367)	(.583)
Household FE	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes	Yes
Regional FE	Yes	Yes	No	No	No
Observations	3,342	7,743	3,342	3,342	3,342
R-squared			0.493	0.490	0.075

Note: Columns (1) and (2) depict a fitted probability from a Probit regression of potentially endogenous variable (credit constraint_qrtc) on the instruments selected (Woreda, Distance woreda and Woreda*distance woreda) respectively in the sub-sample and full sample. Time averages of interaction terms are not included in the estimations. IMR interacted with time dummies are also included in the estimation under column (5). Standard errors adjusted for clustering at various level is in parentheses *** p<0.01, ** p<0.05, * p<0.1

Other control variables included in the estimation, but are not reported here: Non-farm, Oxen, Female, Education, Roof, Livestock, Household member, Age.

Table 4.6

Instrumental variable results for the effect of credit constraint on intensity of inorganic fertilizer use: with alternative measure of credit constraints

	(1)	(2)	(3)	(4)	(5)
	Probit		Pooled OLS		Pooled 2SLS
VARIABLES	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Credit constraint_q			-.172***	-.172***	-.266
			(.067)	(.067)	(3.949)
IMR					-.250***
					(.085)
Livestock, per adult	-.101**	-.251**	.0006		
	(.045)	(.100)	(.014)		
Area planted	.015	-.032	-.852***	-.852***	-.852***
	(.079)	(.126)	(.075)	(.075)	(.082)
Labor time	-.021	-.106*	.213***	.213***	.214**
	(.036)	(.059)	(.043)	(.043)	(.099)
Constant			4.542***	4.542***	4.582***
			(.368)	(.368)	(1.008)
Household FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	7,743	3,342	3,342	3,342	3,342
R-squared			0.486	0.486	0.488

Note: Columns (1) and (2) respectively depicts a fitted probability from a Probit regression of potentially endogenous variable (credit constraint_q) on the selected instrument (Livestock per adult) in the full and sub-samples. Time averages of interaction terms are not included in the estimation. IMR interacted with time dummies are also included in the estimation under column (5). Standard errors adjusted for clustering at household level is in parentheses *** p<0.01, ** p<0.05, * p<0.1

Other control variables included in the estimation, but are not reported here: Non-farm, Oxen, Female, Education, Roof, Age and Interaction term between IMR and time dummies (only in the estimation under column (5)).