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SCHOOL OF COMMERCE, DEPARTMENT OF ECONOMICS

THE EFFECT OF CREDIT CONSTRAINTS ON AGRICULTURAL INPUT TECHNOLOGY ADOPTION AMONG SMALLHOLDER FARMERS IN ETHIOPIA

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THE EFFECT OF CREDIT CONSTRAINTS ON AGRICULTURAL INPUT TECHNOLOGY ADOPTION OF FARMERS.

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This is to certify that the thesis prepared by Hikma Sultan Hiyar, entitled: "*The Effect of credit constraints on agricultural input technology adoption among smallholder farmers in Ethiopia*" in Partial Fulfillment of the Requirements for the Degree of Master of Science (MSc) in Development Economics complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Acronyms

SSA: Sub-Saharan Africa

MFIs: Microfinance Institutions

LMICs: Low- and Middle-Income Countries

GDP: Gross Domestic Product

LSMS-ISA: Living Standards Measurement Study - Integrated Surveys on Agriculture

IFAD: International Fund for Agricultural Development

CSA: Climate-Smart Agriculture

HH: Household

ILSSI: Integrated Landscape Management for Sustainable Intensification

SNNPR: Southern Nations, Nationalities, and Peoples' Region

SHF: Smallholder Farmer

FAO: Food and Agriculture Organization

SAPs: Sustainable Agricultural Practices

NBE: National Bank of Ethiopia

USD: United States Dollar

UN: United Nations

ESS4: Ethiopian Socioeconomic Survey Wave 4

AgSS: Agricultural Sample Survey

SRS: Simple Random Sampling

PPS: Probability Proportional to Size

EA: Enumeration Area

SAACO: Savings and Credit Cooperative Organization

CAPI: Computer-Assisted Personal Interviews

TOT: Training of Trainer

MNP: Multinomial Probit

MNL: Multinomial Logit

IIA: Irrelevant Alternatives

SUR: Seemingly Unrelated Regression

OLS: Ordinary Least Squares

FI: Financial Institution

AIC: Akaike Information Criterion

BIC: Bayesian Information Criterion

Abstract

Agricultural credit constraints hinder the adoption of modern input technologies and contribute to low agricultural productivity in developing nations, including Ethiopia. This study investigates the nature of credit constraints among smallholder farmers, factors influencing these constraints, and their impact on the adoption of Chemical fertilizer and agrochemicals. Using nationally representative LSMS-ISA data from 2200 smallholders, two econometric models (MNP and SUR) are employed to estimate credit constraint status and analyze input technology adoption. The findings reveal a significant experience of credit constraints, influenced by both supply-side and demand-side factors. Collateral ownership-related factors (e.g., livestock ownership, land use certificates) influence supply-side credit constraints, while literacy, remittance access, and agricultural extension services affect demand-side credit constraints. Moreover, credit constraints negatively affect the adoption of agrochemical input technology. Addressing credit constraints requires mitigating both supply-side and demand-side factors. Strengthening smallholders' capacity for bankable collateral ownership and providing information literacy, education, and agricultural extension services can alleviate these constraints. Resolving both demand-side and supply-side constraints can enhance credit access, increase the adoption of modern input technologies, and ultimately improve agricultural productivity. Policymakers should focus on targeted measures to enhance credit availability and access, thereby promoting sustainable agricultural development in Ethiopia.

Keywords: *Rural credit constraints, Agricultural input, adoption, Supply-side and demand-side, Ethiopia.*

CHAPTER 1. INTRODUCTION

1.1. Background of the study

Sub-Saharan Africa's (SSA) economies depend heavily on agriculture, which also provides many people in the area with a stable source of income and work. Despite this, SSA agriculture frequently encounters several obstacles that restrict its potential for expansion and development. Around 60% of all people in Sub-Saharan Africa lived in rural areas in 2021, and the vast majority of rural residents in these areas depend on agriculture for a living. (WB, 2022). The primary means of reducing poverty while using agriculture for development is therefore to increase the productivity, profitability, and sustainability of smallholder farming. (WB, 2007). Yields among smallholder farmers in SSA are frequently substantially lower than their potential. (WB, 2007).

Smallholders may be unable to adopt modern farming practices or inputs that would boost output because of a variety of obstacles and market failures. (Jack, 2013; Shiferaw etal, 2015). Governments in sub-Saharan Africa have implemented several initiatives to boost domestic food production by encouraging the use of contemporary inputs and techniques. (Jayne & Rashid, 2013; Rashid etal, 2013). These measures aim to ease one or two major productivity constraints, such as inadequate output markets, lack of input liquidity, risk, and knowledge. (Jack, 2013; Shiferaw etal, 2015).

In low- and middle-income nations, credit constraints are frequently seen as one of the major obstacles to the adoption of new agricultural technologies and low agricultural production. (Magruder, 2018). Previous studies and most of the policy discussion link supply-side variables like limited access to credit sources or high borrowing costs with agricultural credit limitations. The availability of credit to smallholder farming households, however, may also be influenced by demand-side variables as risk aversion and financial illiteracy among borrowers (Balana et al., 2022). According to Adjognon et al. (2017), farmers typically use income from nonfarm activities and crop sales to pay for contemporary input purchases instead of conventional financing, whether official or informal. Tied output-labor contracts appear to be a popular type of agricultural credit. Most rural families remain under-served in the loan markets despite the increasing number of microfinance institutions (MFIs) in several low- and middle-income countries (LMICs) (Karlan & Morduch, 2009; Karlan et al., 2010).

Smallholder farmers face significant obstacles when trying to acquire credit in many developing countries. This challenge tends to be characterized by a lack of access to production finance to buy and use agricultural inputs, pay for non-family farm work costs, and cover other farm maintenance costs. Smallholder farms typically have low productivity because their owners cannot afford inputs that increase output, even when there is technology available that might be used to produce higher yields (Mboulou, 2020). In addition, the absence of collateral is frequently seen as a barrier to expanding lending availability. Lack of collateral or insufficient collateral suggests that the borrower will probably experience credit constraints. The presence of collateral could reduce the moral hazard issue and collateral can serve as an indication of the borrower's quality. (Guirkinger & Boucher, 2008; Hoff & Stiglitz, 1990).

Ethiopia's political, economic, and social development are significantly influenced by agriculture. It contributes to about 34.1% of Ethiopia's GDP, employs 79% of the people, generates 79% of the country's foreign exchange profits, is a major source of raw materials and investment capital, and offers a sizable market. (Diriba, 2020).

According to a recent World Bank research on global financial inclusion, only 22% of Ethiopian adults have access to financial services. (Demirgüç-Kunt etal, 2015). Furthermore, 66.17 percent of families are credit constrained, demonstrating the extreme imperfections of Ethiopia's rural loan market landscape (Zewdie, 2015). The supply-led strategy or inability to adjust to the demand for services by rural families, according to some researches, was one of the reasons for the failure or poor performance of most African government credit schemes (Mpuga, 2008). This study seeks to fill that gap by providing empirical proof of the variables affecting credit accessibility for rural families. Using data from the World Bank's household survey for the Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA), this study will examine the gap (degree of constraint) in access to financing and its determinants, as well as the impact of this constraint on farmers' decisions to adopt technology on their farmland.

1.2. Statement of the problem

Agriculture is Ethiopia's second largest economic sector, contributing about 32.8 percent of the country's GDP and employing more than 67 percent of the working population. More than 95 percent of Ethiopia's agricultural output is generated by subsistence farmers who, on average, own less than 1 hectare (ha) of cultivated land, with poor soil fertility because of continuous cropping and little input of nutrients and little use of mechanization. Subsistence mixed farming, with crop cultivation and livestock husbandry, is dominant on most farms. Heavy reliance on oxen ploughs for tilling the land. The major challenges of the agricultural sector include limited access to improved technologies, finance, inadequate infrastructure and investment, weak institutional capacity, and poor participation of the private
sector.. (IFAD, 2022).

For smallholder farms to become more productive, profitable, and sustainable, A study by Toenniessen, Adesina, and DeVries (2008) found that more affordable yield-enhancing inputs, like well-adapted seeds and new techniques for integrated soil fertility management, as well as output markets where they can sell surplus products, are required. Therefore, with improved access to financing in agriculture, many connected activities, and services, such as technology, soil conservation, irrigation, storage, and marketing, may be easily offered which would also help to reduce production costs. Access to finances is one of the most crucial elements in addressing Ethiopia's economic challenges. Smallholder farmers can boost output and productivity through increasing financing for irrigation, production tools, and supplies, as well as postharvest handling, processing, and marketing. (Amha & Peck, 2010), Similarly, a recent paper in Uganda by Khandker and Koolwal (2014) discussed that credit is essential for helping households in managing risk and acquire inputs and technologies to increase their agricultural productivity.

Ethiopia's agricultural production is still low, in part because small farmers are not employing technologies much. Despite having a direct impact on raising productivity, income, and nutrition levels, agricultural technology adoption in the nation is still low. For instance, adoption rates for irrigation, insecticides, improved seed, and chemical fertilizers in the 2014–15 growing season were 55.06%, 8.55%, 22.32%, and 6.15%, respectively. (Shita et al., 2018). There are several factors binding that can contribute to low levels of farm input technology adoption in Ethiopia. Lack of access to credit, high input technology costs, a lack of education and awareness,

insufficient infrastructure, and restricted market access are some of the barriers preventing Ethiopian farmers from adopting new technologies. (Dercon & Christiaensen, 2011).
Fertilizer is the most used modern agricultural input in Ethiopia. Approximately 38 percent of sorghum fields utilize fertilizers, compared to 83 percent of wheat grain fields for the top five primary cereal crops. For maize, an improved seed is prevalent (31 percent). Between 2 and 8 percent of the remaining crop fields have improved seed application. (CSA, 2012).

In low- and middle-income nations, credit constraints are frequently cited as one of the major obstacles to the adoption of new agricultural technologies and low agricultural production. Previous studies and much of the policy argue link supply-side variables like limited access to credit sources or high borrowing costs with agricultural credit limitations. But demand-side factors like risk aversion and lack of financial knowledge among borrowers may also have an impact on the rationing of loans to smallholder agricultural households. (Balana et al., 2022), but this research covered data only from 549 HH in Ethiopia by using data from ILSSI project in 2017, the other study is by Yohannes (2022) shows farmers who have access to credit are 1.23 units more likely to use agricultural technology than farmers who do not. A study by Fikire and Zegeye (2021) also showed that the adoption of agriculture is significantly impacted by access to credit.

The existing research on the relationship between credit access and agricultural technology adoption in Ethiopia has certain gaps that need to be addressed. Firstly, most of the existing studies have focused on a limited number of households, making it difficult to apply their findings to a larger population of smallholder farmers in Ethiopia. Secondly, these studies have overlooked the influence of demand-side factors, such as risk aversion and limited financial knowledge, on smallholder farmers' ability to access credit. This study aims to fill these gaps by utilizing a comprehensive dataset of smallholder farmers in Ethiopia and examining the adoption of two specific technologies: chemical fertilizer and agrochemicals. By doing so, the study can provide more generalizable insights for the wider population of smallholder farmers in Ethiopia. Moreover, it considers the demand-side factors that can impact farmers' access to credit. The study's findings have important policy implications, emphasizing the need to consider demand-side factors when designing policies aimed at enhancing credit access for smallholder farmers.

1.3. Research Question

1. What are the credit constraint status of smallholder of farmers (i.e., Unconstrained, supply side, and demand side)?
2. What are the factors that affect the credit constraint of smallholder farmers?
3. Does credit constraint influence farmers agricultural input technology adoption?

1.4. Objectives of the study

The general objective of this study is, to analyze the effect of credit constraints on agricultural input technology adoption of farmers in Ethiopia.

The specific objectives are:

- To assess the credit constraint status of smallholder farmers in terms of both the supply and demand sides.
- To identify the main factors that influence credit constraints among smallholder farmers.
- To examine the effect of credit constraints on agricultural input technology adoption among small holder farmers.

1.5. Significance of the Study

This study can be important for several reasons, including the fact that Ethiopia's smallholder farmers are crucial to the country's agriculture industry and have a major effect on the country's economy. The productivity, income, and well-being of smallholder farmers can all be improved, as can the competitiveness of the agriculture sector and the overall development of the nation. These improvements can be made by understanding the challenges that smallholder farmers face in adopting new farm input technologies and how those barriers can be removed. Furthermore, smallholder farmers may find it difficult to implement farm input technology due to credit restrictions because they may not have the available funds to do so.

Understanding the effects of credit constraints on technology adoption can help policymakers and practitioners address constraints, enabling smallholder farmers to access the necessary finances for adopting new technologies and ultimately improving their livelihoods and contributing to economic growth.to the nation's general economic growth by encouraging the adoption of these technologies.

1.6. Scope of the Study

The Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA) project, which was funded by the Bill and Melinda Gates Foundation, provided the household survey data that will be used in this study. The initiative gathered and created a data set from eight Sub-Saharan African nations, including Ethiopia. The statistics come from panel household surveys that are nationally representative and heavily weighted towards agriculture. This study's scope is constrained to Ethiopia, specifically the rural regions of Tigray, Afar, Amhara, Oromia, Somali, Benishangul, SNNPR, Gambela, Harari, and Diredawa, where the data was obtained. By using LSMS-ISA data this study examined whether smallholder households (SHF) are credit constrained or not, which type of constrained, and then analyze the effect of credit constrained on input technology adoption.

1.7. Organization of the Study

The study has a clear organizational framework that enables it to offer a thorough analysis. The research is introduced in Chapter 1 along with its background, objective, scope, and significance. The literature review and research technique are presented in chapters 2 and 3, respectively. The next two chapters—chapters 4 and 5—concentrate on the findings, analyses, conclusions, and policy implications. These chapters summarize and analyze the results, making insightful conclusions and offering useful guidance for decision-makers, practitioners, and researchers.

CHAPTER 2. LITERATURE REVIEW

The adoption of agricultural technologies is essential for improving agricultural productivity, income generation, and food security, particularly for smallholder farmers. However, credit constraints often pose significant challenges, limiting farmers' access to the financial resources required for technology adoption. Understanding the role of credit constraints in agricultural technology adoption is crucial for policymakers, practitioners, and researchers aiming to design effective interventions. This theoretical review aims to examine the existing knowledge and address gaps in understanding the relationship between credit constraints and the adoption of agricultural technologies. By presenting empirical evidence and relevant literature, this review seeks to uncover the mechanisms through which credit constraints influence smallholder farmers' decisions regarding technology adoption. By providing clarity on this critical aspect, the review aims to contribute to the development of targeted policies and interventions that can enhance access to credit and promote widespread adoption of agricultural technologies, ultimately leading to improved livelihoods and sustainable agricultural development.

2.1. Theoretical Literature.

2.1.1. Concept and definition of credit and input technology adoption.

Credit is a contract that binds a lender and a borrower and enables the borrower to access funds or products with the promise of repaying the debt later. As the cost of the investment is paid up front and the rewards are received later, it is a method of supplying liquidity to enable investment. (Petrick, 2004)). Credit in the agricultural industry has the potential to reduce poverty, improve farm inputs like fertilizer, maintain household income, raise output and productivity, and adopt new technology. (FAO 2019)

The use of contemporary agricultural inputs like fertilizers, pesticides, improved seeds, and irrigation to boost crop yields and incomes is known as agricultural input technology adoption. To raise the productivity of the land and profitability, these inputs are frequently employed in conjunction with improved agricultural practices and technologies, such as better soil and water management. (Abdallah, 2016).

2.1.2. Credit constraints and types of credit constraints.

Credit constraints are incidents that occur when a credit application for a demanding person is denied. This can be due to a bad credit history or a credit limit that isn't high enough to fund the transaction. In some circumstances, the inability to obtain credit may be brought on by an absence of lenders ready to make the necessary loans accessible. The lack of creditors and discouragement from approaching creditors may be the cause of the constraint. Rural areas and households with low incomes in Ethiopia are anticipated to have a higher likelihood of being constrained. (Freeman, Ehui, & Jabbar, 1998).

Previous studies have pointed to several variables, including transaction costs, default rates, infrastructure, and restricted access to credit, as the cause of credit constraints in Ethiopia. Lack of accessibility and efficiency among lenders results in rigid loans that don't reach disadvantaged (rural) homes. (Tesfaye, Balana, & Bizimana, 2021). There are three main categories of credit constraints:

Supply-side constraint: the most popular definition of supply-side credit constraint comes from the seminal paper of Stiglitz and Weiss (1981). Some people are granted loans, whereas others who are essentially comparable and ready to borrow money from the same sources are not. Lenders may only accept applications for risky projects at high-interest rates, therefore the amount of credit available may be constrained if they do not raise interest rates to lower excess demand.

Demand-side constraint: Farmers' inability to receive the credit due to their inability to provide collateral, the credit contract's high transaction costs, or the credit contract's high level of risk illustrates the demand-side constraint. (Guirkinger & Boucher, 2008).

Unconstrained: According to Boucher, Guirkinger, and Trivelli (2009) Unconstrained borrowers and non-borrowers are the two types of credit unconstrained. Unconstrained borrowers are households that can borrow the required amount without being restricted by a formal financial sector credit limit. Unconstrained non-borrowers are households that do not employ formal loans since they do not have any profitable initiatives that would necessitate them. These households are unaffected by credit limits.

2.1.3. Major Agricultural input technologies and Agricultural Input technology adoption

Agro-inputs are any outside materials inserted into the soil to increase a farmer's yield in the future. They may be anything from high-tech tractors to premium seeds. They are, in a nutshell, whatever resource you employ to improve the yield of your crop. Although there are countless different forms of agricultural inputs, we divide them all into two categories: consumable inputs and capital inputs. Consumable inputs are the regular agricultural inputs that smallholder farmers use daily, such as seeds, fertilizer, pesticides, etc. Natural resources that will be "consumed" by the crops are typically considered to be consumable inputs.

Contrarily, capital inputs are items like tractors and trellising supplies that typically require a higher investment. (East-West seed group, 2018). Agriculture technology is typically understood to be a brand-new, scientifically generated, frequently sophisticated input offered to farmers by businesses with extensive technical know-how. It could also be described in terms of a perceived-new innovation that boosts productivity. While the extent of a technology's use in agriculture is considered its adoption (Abdallah, 2016).

2.1.4. Mode and sequence of agricultural technology adoption.

The adoption of agricultural technology involves two main strategies: adopting the full package or adopting components sequentially. These approaches are subject to different perspectives among technical scientists and field workers involved in farming systems and participatory research. **(**Beyene, 2008**).**

Farmers should adopt just one useful technology or a small number of them, rather than the full package, according to whole package opponents. (Byerlee & De Polanco, 1986). Several adoption studies reviewed by Nagy and Sanders (1990) concluded that farmers decide to accept inputs in order. adopting just one part of the package at first, then gradually adding more parts, one at a time. Profitability, risk, uncertainty, lumpiness of investment, and institutional constraints are the main justifications frequently cited for the sequential adoption of a package of technologies. (Byerlee & De Polanco, 1986). A farmer starts by choosing the technology that best demonstrates these qualities.

Another study by Ryan and Subrahmanyam (1975) revealed that, in terms of what the farmer may lose if a crop failure occurs during that season, farmers might view each component of the technological package as a less risky endeavor than the full package. Their research concluded that farmers with limited resources should employ technology components in sequence. Farmers will add another component to a package as cash accumulates from the prior adoption of a component based on the proportionate advantage and suitability with their situation. This procedure will continue up till the full adoption of the package.

2.1.5. Factors affecting Agricultural technology adoption.

According to research on technology adoption in developing countries, the different factors that affect adoption can be divided into the following three primary groupings. (1) Factors associated with the characteristics of the producers, or farmers; (2) Factors related to the characteristics and effectiveness of the technology; and (3) Program and institutional considerations. (Teklewold, Kassie, & Shiferaw, 2013; Yu, Nin-Pratt, Funes, & Gemessa, 2011).

The traits of producers are influenced by a variety of variables, including their degree of education, job experience, age, gender, wealth, farm size, plot features, labor availability, resource endowment, risk aversion, and more. Some of the factors affecting the characteristics and performance of the technology and practices are their accessibility and the availability of complementary inputs, the relative profitability of its adoption compared to substitute technologies, the period of investment recovery, local adoption patterns of the technology, the susceptibility of the innovation to failure, and the perception by people of the characteristics, complexity, and performance of the innovation. Among the institutional components are the accessibility of product markets, the quality and quantity of technological information, the availability of funding, the land tenure system, and the availability of inputs. (Teklewold et al., 2013; Yu et al., 2011). Farmers' investments in adopting sustainable technology were found to be positively influenced by enabling policies and programs, market connections, access to institutional support, and loans. (B. A. Shiferaw, Okello, & Reddy, 2009).

2.1.6. Credit and agricultural input technology adoption Nexus

Agricultural credit has been defined by Nwaru, Onyenweaku, Nwagbo, and Nwosu (2004) as the temporary and present transfer of purchasing power from an owner to a buyer, giving the latter the chance to command another person's capital for agricultural objectives while having faith in that person's willingness and ability to return at a certain future period. One effective strategy to get over some of the financial barriers to technology adoption is to have access to agricultural finance. To determine the factual link between credit and technology adoption, numerous studies have been conducted. For example, in a study to determine the impact of credit access on the adoption of agricultural technologies in Zanzibar, Tanzania, Mohamed and Temu (2008) regressed credit with some other factors on the adoption of agricultural technology using a switching regression model.

The findings showed that the adoption of agricultural technologies is highly influenced by the availability of credit, extension contacts, household size, and the value of productive assets. In addition, Donkoh, Tiffin, and Srinivasan (2011) used the probit model to analyze the socioeconomic influences on Ghana's adoption of green revolution technology. The findings showed that households with formal education, higher levels of non-farm income, credit, and labor availability, as well as those residing in urban centers, have a higher proportion of green revolution inputs.

2.1.7. Credit access and agricultural input technology adoption in Ethiopia.

To buy chemical fertilizers, herbicides, high-yielding varieties, and modern agricultural equipment, Ethiopian farmers need credit. The adoption of new technologies by farmers and their overall output potential is constrained by the lack of formal financial services for marginal and smallholder farmers. The availability of financial services allows Ethiopia's majority of farmers—who are among the poorest people in the country—to break free from poverty and ensure their livelihood. (Abate, Rashid, Borzaga, & Getnet, 2016).

Due to the low fertility of the soil and low potential for agricultural production, Ethiopia has a 16.30% adoption percentage share for fertilizers. Thus, it was acknowledged by the majority of agricultural professionals and farmers that chemical fertilizers aid to increase the soil's fertility and thereby increase crop output. (Girma, 2022).

Farmers who have access to credit adopt agricultural technology 1.23 units more frequently than farmers who do not. The outcome of the meta-regression revealed that the primary determinants of heterogeneity in the influence of loan access on farmers' adoption of technology among farmers were family size, total livestock holding, and total income. finance was found to be crucial for increasing technology use, however, most Ethiopian farmers have collateral issues that prevent them from obtaining the finance they need. (Girma, 2022). Teklewold et al. (2013) analyzed the adoption of several sustainable agricultural practices (SAPs) in rural Ethiopia using multivariate and ordered probit models. The investigation revealed that numerous factors, such as credit restrictions, a household's faith in government assistance, spouse education, household wealth, social capital and networks, labor availability, plot size, and market access, have an impact on both the likelihood and the extent of SAP adoption.

2.2. Empirical Literature.

2.2.1. Review of Empirical literature in developing countries.

Due to the fear of losing the assets offered as collateral in the event of a failure to repay, or "risk-rationing," farmers are frequently hesitant to apply for a loan. (Mude & Barrett, 2012). Due to their lack of access to and ownership of agricultural resources, limited options for protecting themselves against systemic shocks, credit constraints, less trust, and increased risk aversion on the demand side, this is particularly true for female-headed households. (Fletschner, Anderson, & Cullen, 2010; Mishra & Sam, 2016; Quisumbing & Pandolfelli, 2010).

On the supply side, the variability of agricultural returns is increased by widespread systemic weather events (such as drought and floods), which have become more frequent because of climate change. (FAO 2016), thereby exposing lenders to substantial un-diversifiable systemic risk. Since men are perceived as being less trustworthy than women, this can be particularly damaging to male farmers. (Buchan, Croson, & Solnick, 2008). Men's lower repaying histories also contribute to the perception that they are less creditworthy. In Malawi, for instance, 92% of female borrowers made on-time payments compared to 83% of male borrowers, and only 1.3% of the female borrowers from Grameen had issues with repayment.

According to a study in Zanzibar, several socioeconomic characteristics play a significant role in determining farm households' access to formal finance. These variables include the frequency of loan access, the ability to keep livestock, the possession of a bank account, the worth of owned

productive assets, household income, and the rate of adoption of agricultural technologies. The frequency of extension contacts, household size, the number of credit accesses, and the value of productive assets were discovered to have a substantial impact on the adoption of agricultural technologies. However, these variables were significant only for the non-credit-constrained families and not for the credit-constrained households, except for the number of credit accesses. (Mohamed etal. (2008).

According to Balana and Oyeyemi (2020**),** In Nigeria, 27% of surveyed families were found to be credit constrained. Demand-side factors accounted for 14.2% of the rise, while supply-side factors were responsible for 12.8 percent. Lack of access to information and communication technologies, extension services, and insurance coverage are the main demand-side factors affecting smallholder credit access.

Owning registered land tiles and cattle improves credit access. Credit constraints have distinct effects on how different agricultural technologies are adopted. The adoption of inorganic fertilizer and improved seed is significantly impacted by credit constraints from both the supply and demand sides, but the use of agricultural machinery is only affected by demand-side factors, while the use of agrochemicals is unaffected by either supply or demand-side credit constraints. While the use of agrochemicals is unaffected by either supply or demand-side credit variables, the use of agricultural machinery is exclusively impacted by demand-side factors. Balana and Oyeyemi (2020**)**

2.2.2. Review of Empirical Literature in Ethiopia.

According to recent empirical studies, microcredit can encourage agricultural investments, including the use of contemporary agricultural inputs. (Giné & Yang, 2009{Abate, 2016 #572); Abate et al. 2016); facilitate the startup of new enterprises and, at least in some cases, reduce poverty (Berhane & Gardebroek, 2011). Hailu, Abrha, and Weldegiorgis (2014) report that credit access is important for the adoption of agricultural technologies.

A study in the Amhara region of northern Ethiopia revealed that the transaction costs of borrowing, the risk-averse behavior of farmers, and the borrower's perceived probability of rejection due to strict lending policies and institutional rigidities all significantly decreased the likelihood of borrowing from the formal credit market. the econometric analysis' findings.

Wordofa et al. (2021) showed that the average household adopting modern farming techniques had 23,031.28 Birr (the Birr is Ethiopia's official currency). On October 4, 2018, the National Bank of Ethiopia (NBE) reported that the exchange rate was 1 USD = 27.6017 Birr greater yearly agricultural revenue in comparison to households without such technologies.

Balana et al. (2022) stated that in Ethiopia and Tanzania, supply-side and demand-side credit constraints both play a role in influencing smallholders' access to finance. In Ethiopia, credit is not statistically significant, whereas credit is a binding limitation for the choice to adopt technology and the intensity of input use in Tanzania. Women are more likely to be credit constrained (from both the supply and demand sides) than men in both study nations.

The result from a study by Fikire and Zegeye (2021) Farmers in the Amhara region were found to be more likely to adopt new or improved agricultural technology when they had higher educational levels, larger families, off-farm participation, livestock, extension contacts, access to credit, and advisory services. They were also found to be closer to their plots, use all-weather roads, reside in zones with towns, and have lower remittance income.

In a recent meta-analysis conducted by Girma (2022)on research conducted in Ethiopia, it was found that farmers who have access to credit are significantly more inclined to adopt agricultural technology, with an increase of 1.23 units compared to farmers without credit access. The meta-analysis also highlighted that family size, total livestock holding, and total income were the primary factors influencing the variation in the impact of loan access on technology adoption among farmers. The findings underscore the importance of financing in facilitating technology adoption. However, a significant barrier faced by the majority of Ethiopian farmers is the challenge of collateral, which hampers their ability to secure credit for adopting new technologies.

This study aims to address the existing gaps and limitations in the literature on credit access and agricultural technology adoption in Ethiopia. The current research lacks generalizability due to small sample sizes, insufficient exploration of demand-side factors, incomplete understanding of

collateral issues, and limited insights into the factors influencing the impact of credit access on technology adoption. To fill these gaps, this study utilizes a comprehensive dataset with a larger sample size, considers both supply-side and demand-side factors, including collateral issues, risk aversion, and financial knowledge. Moreover, it explores the detailed relationships between these factors, providing deeper insights. By contributing these unique aspects, this study aims to enhance the understanding of credit's role in facilitating agricultural technology adoption and inform the development of more targeted interventions in Ethiopia.

2.3. Conceptual Framework of the Study.

This study aims to assess the nature of rural credit constraint status, the factors affecting rural credit constraint status, and the effects of credit constraints on the adoption of two important agricultural input technologies: inorganic fertilizer and agrochemicals. To guide the empirical analysis of credit constraints and their potential impact on technology adoption, I modified the framework for a household credit constraint identification strategy, developed by Boucher et al. (2009) and adopted by Balana and Oyeyemi (2022), as shown in Table 1. This framework offers a method for directly classifying the credit restrictions that apply by categorizing households into three groups: unconstrained, supply-side constrained, and demand-side constrained, as summarized in Table 1.

Table 1.Credit constraint status levels

Unconstrained		**Constrained: Supply-side**		**Constrained: Demand-side**		
					Due to risk-aversion	**Due to transaction costs**
Borrowers:	Farmers who obtained the amount of loan requested	Applied or attempted:	But rejected: Applied or otherwise attempted to obtain a loan. Ready to pay the existing interest rate, but loan application rejected.	Non-borrowers:	Afraid of taking risks, for example, do not want to be indebted, do not want to work in a group.	Information about lenders in the area.
Non-borrowers:	Farmers that do not need a loan and or have enough money	Non-borrowers:	Non-applicants who perceive themselves to "certainly be rejected": Were certain that their loan application would be rejected due to inadequate collateral; past credit history; or have no information about the service.	Non-borrowers:	Due to the capacity to pay back.	High-interest rate.
Non-borrowers:	People who think that credit is useless.			Non-borrowers:	Religious reasons.	Payment in cash is better.

Source: Own development based on Balana and Oyeyemi, (2022)

Different household categories include unconstrained, supply-side constrained, and demand-side constrained based on borrowing status and loan accessibility. Unconstrained households have sufficient liquidity, while supply-side constrained households face loan rejection or anticipate it. Demand-side constrained households exhibit risk aversion or perceive high transaction costs for loans. This framework provides insights into the relationship between credit constraints and technology adoption, guiding policymakers and researchers in addressing household credit constraints and promoting agricultural technology adoption.

A conceptual framework (Figure 1) is proposed to analyze the factors impacting credit constraints and their relationship with the adoption of agricultural input technologies. Limited financial access poses challenges for farmers with low incomes in adopting new agricultural technologies. Various demographic, socioeconomic, infrastructural, and access-related factors influence both credit constraint status and technology adoption. The framework highlights the influence of credit constraints on technology adoption and the potential impact of other socioeconomic variables.

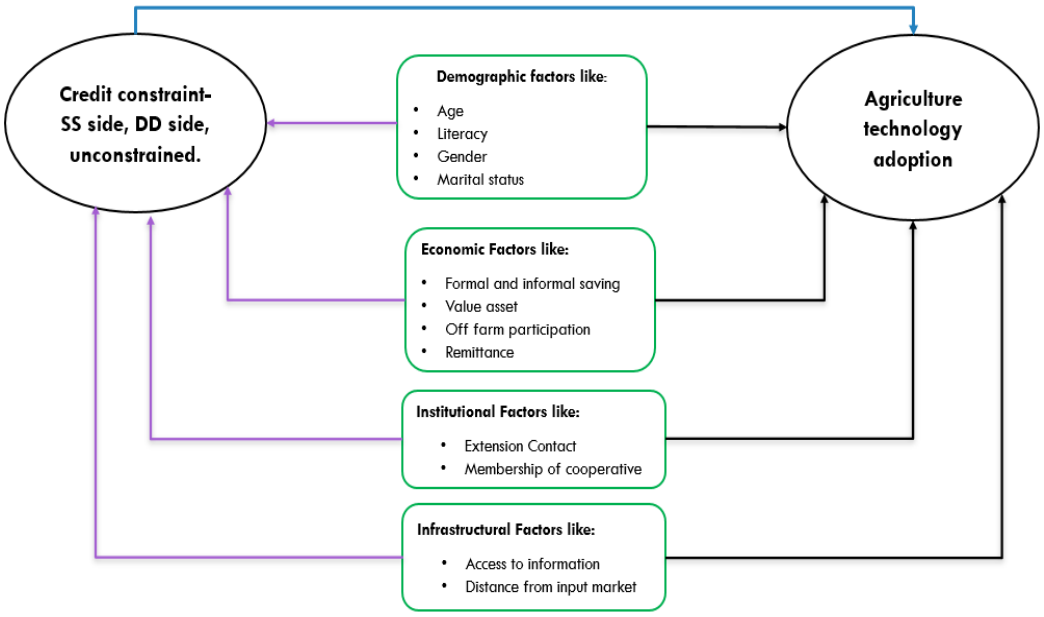

Figure 1. *Conceptual Framework.*

Source: *designed by the author based on the literature*

CHAPTER 3. RESEARCH METHODOLOGY

3.1. Description of the Data

The study used data from the Living Standards Measurement Survey - Integrated Surveys on Agriculture (LSMS-ISA) household survey from the World Bank's 2018–19 round. It included a sample of randomly chosen farmer households from rural Tigray, Afar, Amhara, Oromia, Somalia, Benishangul, SNNPR, Gambela, Harari, and Diredawa regions. Thus, it is considered that the study's statistics are nationally representative of Ethiopia (CSA and LSMS, 2021).

The objective of the LSMS-ISA (Living Standards Measurement Study-Integrated Surveys on Agriculture) data collection is to gather high-quality comprehensive data, nationally representative household surveys that cover a wide range of aspects of living standards, including consumption, income, assets, and agricultural activities. In the areas of agriculture, rural development, poverty reduction, and other relevant subjects, the data is intended to promote the formation of policies, program evaluation, and monitoring based on evidence.

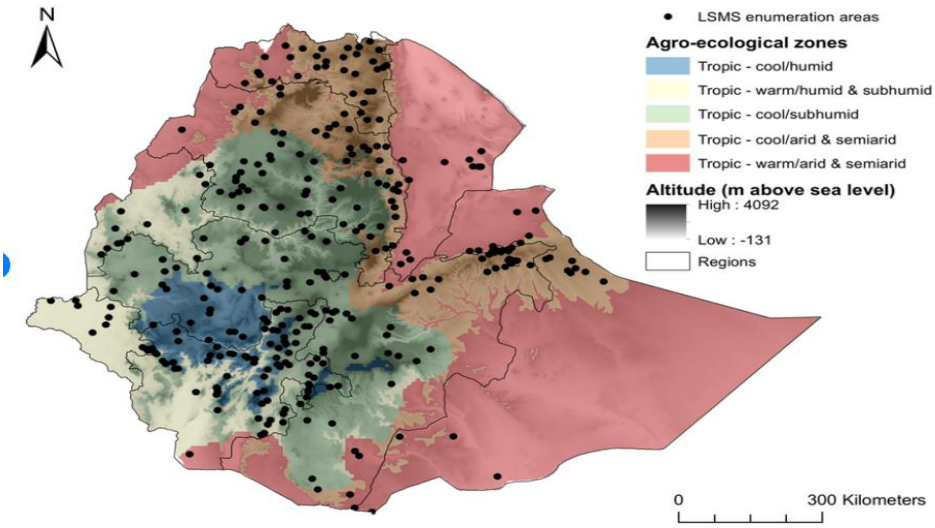

Figure 2. Map of LSMS enumeration areas agro-ecological zones, and region boundaries.

Source: Randell, Grace, and Bakhtsiyarava (2021)

3.2. Research Approach

This study has utilized a quantitative research approach by adopting a secondary survey data from LSMS-ISA.

3.3. Research Design

Both descriptive and econometric research designs are used in this study. The adoption of technology and credit constraints are investigated by a descriptive study. Statistical metrics and visual representations are used to summarize and present the data. In addition, a different regression analysis was used in an explanatory manner to investigate the impact of credit constraints on technology adoption.

3.4. Sampling Design.

This study utilized the sample design employed by the LSMS-ISA, which involved employing simple random sampling to select enumeration areas and systematic sampling to select households. The specific distribution of the sample is presented in the table 2 below.

Table 2. The actual distribution of the final sample

Regions	**Urban**		**Rural**		**Total**	
	Sample EAs	Sample households	Sample EAs	Sample households	Sample EAs	Sample households
Tigray	19	283	35	398	54	681
Afar	15	225	29	321	44	546
Amhara	18	271	43	487	61	758
Oromia	20	300	45	486	65	786
Somali	17	255	35	356	52	611
Benishangul-Gumuz	13	195	19	207	32	402
SNNP	18	269	40	423	58	692
Gambela	20	300	19	209	39	509
Harari	24	360	18	191	42	551
Addis Ababa	52	778	-	-	52	778
Dire Dawa	28	419	14	161	42	580
Ethiopia	**244**	**3,655**	**297**	**3,239**	**541**	**6,894**

Source: Ethiopia Socioeconomic Survey (ESS) ESS Panel II 2018/2019, CSA and LSMS.

3.5. Data Sources and Types

This study utilized the LSMS-ISA data from 2018/19 (wave 4) as secondary quantitative data. The LSMS-ISA is a nationally representative household survey conducted by the World Bank, which provided comprehensive information on credit constraints, technology adoption, and various socio-demographic factors in Ethiopia. The dataset included data on household income, expenditure, assets, credit usage, input technology usage (e.g., fertilizers, seeds), as well as demographic variables such as gender, education, region, socioeconomic status, and membership in cooperatives and SACCOs. Relevant variables related to credit constraints and technology adoption were selected from the dataset for further descriptive and regression analysis.

3.6. Data Collection Procedures

Data for the study were acquired via computer-assisted personal interviews (CAPI), according to CSA (2021). The fieldwork, which required multiple visits at various times, took undertaken between September 2018 and August 2019. The post-planting and livestock questionnaires were distributed during the initial visit to rural areas in September and October 2018. Additionally, crop-cutting activities were carried out in 2018 between September and December. The second visit, which took place in February and March 2019, was limited to rural areas, and was carried out following the harvest. The most recent visits covered both rural and urban areas between June and August of 2019. The last round of household and community surveys were given out during these visits.

3.7. Ethical Consideration

Ethical clearance was not needed for this study because it does not use primary data that required respondents' agreement. Anyone could access the data for free on the website of World Bank and accessing it did not provide any ethical conflict with respect to specific people. This study gives recognition and appreciation to individuals who gathered the data and made it freely available.

3.8. Data Analysis

3.8.1. Multinomial probit (MNP) model.

The multinomial probit and multinomial logit are two popular models for the analysis of categorical variables. However, since the independent errors of MNL need an assumption known as the independence of irrelevant alternatives (IIA), this study will use the multinomial probit model. In essence, IIA stipulates that the addition or removal of a third (irrelevant) alternative from the study must not affect a participant's assessment of one alternative in comparison to another. IIA is not considered by MNP. An MNP model should estimate the error correlations in addition to the coefficients. (Greene 2000).

The multinomial probit model is a statistical model that can be used to predict the likely outcome of an unobserved multi-way trial given the associated explanatory variables. In the process, the model attempts to explain the relative effect of differing explanatory variables on the different outcomes. It is used when there are several possible categories that the dependent variable can fall into. This model is a commonly used probability model when a dependent categorical outcome variable has more than two categories, for example, the type of insurance contract that an individual selects; the type of crop a farmer decides to grow; or the type of fertilizer applied. In such a situation, the dependent variable Y is an unordered categorical variable, and an individual may select or fall under one of the categories.

It is assumed that we have a series of observations Yi of the outcomes of multi-way choices from a categorical distribution of size m for I = 1...n (there are m possible choices). Each observation Yi is accompanied by a set of k observed values x1, i, xk, i of explanatory variables (also known as independent variables). Formally, the outcomes Y_i are described as being categorically distributed data, where each outcome value *h* for observation *i* occurs with an unobserved probability $p_{i,h}$ that is specific to the observation *i* at hand because it is determined by the values of the explanatory variables associated with that observation. Greene, William H. (2012) That is:

$$\#\ \boldsymbol{Y|x1.i,\ldots,xki \sim Catagorical\ (Pi1,\ldots pi,m) for\ i = 1,\ldots n}$$

Multinominal Probit can also be written as follows:

$\#\ Yi1 *= \beta 1.Xi + \varepsilon 1$

$\#\ Yi2 *= \beta 2.Xi + \varepsilon 2$

…

$\# Yim *= \beta m. Xi + \varepsilon m$

So, since the credit constrained has also 3 different categories (i.e., unconstrained, demand side constrained, and supply side constrained) this study employs this model. In our empirical analysis, we let yi be the categorical variable that takes values j=0,1,2 that represent the credit constraint status, i.e., unconstrained, supply-side constrained, and demand-side constrained, respectively, of the ith household. Defining $yi*$ as the unobserved propensity of the ith household to be in credit constraint status j

$$Y *_{ij=} Xi.\beta+\varepsilon ij \quad (1)$$

For this study the MNP equation can be written as:

$$Credit\ unconstraied = Sex.\beta 1+Age\beta 3+ Marital\ staus\beta 3+\ldots+.\varepsilon ij$$

$$Supply\ side\ credit\_const = Sex.\beta 1+Age\beta 3+ Marital\ staus\beta 3+\ldots+.\varepsilon ij$$

$$Demand\ side\ credit\_constr = Sex.\beta 1+Age\beta 3+ Marital\ staus\beta 3+\ldots+.\varepsilon ij$$

3.8.2. Seemingly unrelated regression

For dependent variables such as input technology adoption, we could try to solve the equations independently for each system using the least squares method. However, in SUR models, the error terms from several systems are correlated. At the same time, such systems should be solved as a whole set of equations, according to the general theory of the least square approach, which takes error covariances into consideration. Otherwise, the minimum variance of predicted regression parameter errors cannot be obtained. (Zellner, 1962). So, to get a better result and observe the correlation between errors, this study will employ the SUR model.

The seemingly unrelated regression equations (SURE) model, proposed by Arnold Zellner in (1962), is a generalization of a linear regression model that consists of several regression equations, each having its own dependent variable and potentially different sets of exogenous explanatory variables. Each equation is a valid linear regression on its own and can be estimated separately, which is why the system is called seemingly unrelated.

The model can be estimated equation-by-equation using standard ordinary least squares (OLS). Such estimates are consistent, however generally not as efficient as the SUR method, which amounts to feasible generalized least squares with a specific form of the variance-covariance matrix. Two important cases when SUR is in fact equivalent to OLS are when the error terms are in fact uncorrelated between the equations (so that they are truly unrelated) and when each equation contains the same set of regressors on the right-hand-side. Greene, William H. (2012).

The SUR model can be viewed as either the simplification of the general linear model where certain coefficients in matrix are restricted to be equal to zero or as the generalization of the general linear model where the regressors on the right-hand-side are allowed to be different in each equation. The SUR model can be further generalized into the simultaneous equations model, where the right-hand side regressors are allowed to be the endogenous variables as well. Greene, William H. (2012), we can Express the SUR model with the following equation:

$$y' = x'\theta + \varepsilon' \qquad (3)$$

where: y' is a vector of order $(1\times m)$, representing the mSUR equations, x'= $(x1, \ldots., xk,)$ ′ is a vector of explanatory variables, ε' is a vector of error terms of order $(1\times m)$, and θ is a matrix coefficient of order $(m\times k)$, i.e., k is the number of parameters for each of the m seemingly unrelated simultaneous regression equations. The error terms are assumed to be identically and independently distributed with zero means and a covariance matrix of Σ, i.e., $\varepsilon'|x\sim i.i.d., N\ (0, \Sigma)$.

We used a seemingly unrelated model to assess the impact of credit constraints on technology adoption. As a result, to investigate the effects of credit constraints on farmers' decisions to adopt the various agricultural technologies under consideration, a system of simultaneous equations - the seemingly unrelated regression (SUR) model - was developed to allow for the joint estimation of several regression models, with the error terms associated with the dependent variables assumed to be correlated across the equations (Roodman 2011).

There could be unobservable heterogeneities even when such variables are observable and controllable in the econometric model. such as the farmer's capacity for entrepreneurship, risk-taking, preferences, and business aspirations that may influence adoption choices. Furthermore, the factors influencing a farmer's decision to use one type of agricultural technology may equally influence the adoption of other varieties.

As a result, for the same household, cross-equation error terms of various agricultural technologies may be correlated. Thus, even though the choice to adopt any of these technologies may seem independent or unrelated, and their parameters are assumed to be estimated individually (equation by equation) using a linear model, the error terms of these models are likely going to be correlated. Following the generic equation format, the empirical model of the two agricultural technologies can be written as follows:

$$A_g\,T_{eci1} = \beta_1 CR_{ssi} + \varphi_1 CR_{ddi} + \gamma_1 X_{i1} + \varepsilon_{i1}$$
$$A_g\,T_{eci2} = \beta_1 CR_{ssi} + \varphi_2 CR_{ddi} + \gamma_2 X_{i2} + \varepsilon_{i2}$$

Where $A_gT_{eci1,}$ and A_gT_{eci2},are the two agricultural technologies considered in this study, Css and Cdd represent supply-side and demand-side constrained households respectively and values of 0 or 1 for unconstrained and constrained households, $Xi1$ *to* $Xi2$, are other explanatory variables for the two equations, which are almost the same set of variables in each equation; and βm,ψm, and Υm are parameters of the mth equation to be estimated.

For our variables we can write the SUR model equation as follows:

$$Chemical\ fertlizer = \beta_1 CR_{ssi} + \varphi_1 CR_{ddi} + \gamma_1 X_{i1} + \varepsilon_{i1}$$
$$Agrochemical = \beta_1 CR_{ssi} + \varphi_1 CR_{ddi} + \gamma_1 X_{i1} + \varepsilon_{i1}$$

3.9. Definition and Measurement of operational variables.

3.9.1. Dependent Variables

The chance that a household will fall into one of the credit constraints groups and the likelihood that it will participate in or obtain credit is one of the dependent variables in this study. This study will consider both demand- and supply-side sources of credit constraints and household borrowing behavior, in contrast to other studies that mostly focused on supply-side issues.

The study examines credit constraints and their impact on agricultural technology adoption. Supply-side constraints, driven by creditworthiness concerns and limited liquidity, can limit potential borrowers. By exploring the relationship between credit constraints and technology adoption, the study contributes to understanding their influence on smallholder farmers.

3.9.2. Explanatory Variables.

The selection of variables for this study is guided by the review of related literature, even though there are many factors that affect the credit constraint conditions and input technology adoption.

Sex of respondent affects the adoption decision by; if the sex of the farmer is male headed then the probability of adoption will increase because male headed farmers have better access to resources like land, labor and other than female headed farmers (Hailu et al., 2014). There is a considerable gender-based variation (2.27 percentage gap) in likelihood of being credit constrained, females are vulnerable than their male counter parts (Tilahun, 2015).

Age of the farm household head (AGE): Age of the farmer is one of the factors of adoption decisions. As the age of the farmer increases, their adoption will decrease or increases because old farmers are risk averse and conservative to adopt the new or improved technology (Admassie & Ayele, 2010) or old farmers could have more experience and knowledge than the young farmers, so they will adopt the technology (Mohammed, 2014). Research by Balana and Oyeyemi 2020 household stated that variables, such as age and marital status, are not statistically significant in determining a household's credit constraint status.

Literacy level: According to Musebe et al, (1993), as the household gets more formal education, the probability of obtaining credit increases. Therefore, it was expected that those farmers who can read and write have better credit requirement that leads to access to use formal credit sources. Educational level of the farmer also positively affects the probability of adoption as farmers with more educational levels enable to acquire, analyze, and evaluate information on agricultural technology, market opportunity and its implied benefits (Belay & Mengiste, 2021).

Family labor: This refers to the total number of family members of the household who have the potential to work on the farm which was measured in man equivalent. The larger the number of family labor, the more the labor force available for production purpose. The more the labor force available, lower is the demand for hired labor, this means no or low cost for hired labor. If demand for hired labor decreases due to availability of family labor the need for credit decreases.

Extension contacts: This refers to the number of contacts with extension agents that the respondent made in the month. Farmers who have a frequent contact with extension agents are

expected to have more information that will influence farm household's demand for credit from the formal sources Wossen et al. (2017) reported a positive relationship between credit access and extension services in his research. It also affects the decision to adopt positively because extension service provides information, training and advisory services about the sources and contribution of the technologies to the farmers and participating in input distribution (Mesele, 2019).

Land Title/ownership: Ownership right of plots positively affects the probability of agricultural technology adoption because having a full ownership right will helping the farmers to make a long-term investment and may have no additional cost (as rented). This may result in farmers are tends to produce more by applying different farm technologies (Mohammed, 2014). Households who possess legal titles to their lands are less likely to fall into either the supply-side or demand-side credit constraint categories (Balana and Oyeyemi 2020).

Livestock ownership: Livestock asset have a positive effect on the adoption decisions because farmers who possess a flock of livestock will helps to adopt as the asset becomes a source of income and inputs of organic fertilizer (Admassie & Ayele, 2010). ownership of livestock is an important measure of household assets or wealth that could either substitute for credit or can serve as an indicator of the household's capacity to bear risks (Croppenstedt et al. 2003).

Value Asset: households with a greater value of assets are significantly less likely to be supply-side constrained. An explanation for this relationship is that such assets can be used as collateral and, hence, remove supply-side related credit constraints (Balana and Oyeyemi 2020).

Access to Credit: Credit access by the farmer has a positive effect on the probability of adoption since the access to credit solves liquidity constraints that the farmer could face while they want to buy agricultural technology packages (Belay & Mengiste, 2021).

Demand side constraint: When Farmers have a need for credit, but their ability to offer collateral, the high transaction costs of the credit contract, or the high level of risk associated with the credit contract prevent them from obtaining it show the demand side challenge of obtaining it. (Guirkinger & Boucher, 2008).

Off- farm income: Is an income that a household incurs from activities which does not involve farming, such income can be from piety trading, office jobs or others. Off-farm activities has a

negative effect on the adoption decision since engagement in off-farm activities reduce working hour allotted to agriculture (Mesele, 2019). Conversely, it could have a positive effect o the adoption decision because participating in off-farm activities can generate income and solve the liquidity constraints of the farmers (Mulugeta & Hundie, 2012). People who earn income from non-farm sources have a lower probability of being either supply-side or demand-side credit constrained (Balana and Oyeyemi 2020).

Remittance income: Recipients of remittance income by the farm households has a negative effect on the decision to adopt agricultural technology because the higher remittance inflows to households, and subsequently, the higher income buffer, might have increased the opportunity cost of engaging in agriculture, resulting in reliance on remittance income more than the income from the agriculture sector (Tuladhar et al., 2014). On the other hand, the effect of remittance on the adoption decision is positive because it solves liquidity constraints that the farmer could face while they want to acquisition of agricultural technologies (Mohammed, 2014). Thus indicates an income that a household might get from their family or friends from abroad. This is an income that a household get without engaging in any activities.

Formal Saving: This indicates the habit of a household to save from their expenditure, the formal saving specific that it is done in a formal institutions like microfinance or banks.

Informal Saving: Households having savings in the informal sector and earning are more likely to be credit constrained from both the supply-side and the demand-side (Balana and Oyeyemi 2020).

Distance to market: This variable indicates the distance i.e., how far does the household is located form different input providers like cooperatives or farmer service centers.

Table 3. Summary of Variables, measurement, and Hypothesis (Credit constraint)

No	Variable	Measurement
1	Age	Year/quantitative
2	Gender	Sex/qualitative
3	Marital Status	Qualitative
4	Family labor	Number/quantitative
5	Literacy rate	Level/ qualitative
7	Land title	Title/qualitative
8	Livestock value	Asset/ qualitative
9	Asset Value	Asset/ quantitative
10	Remittance Income	Money/ quantitative
11	Off farm income	Money/quantitative
12	Access to information	Access/qualitative
13	Membership of a cooperative	Membership/qualitative
14	Formal saving	Money/qualitative
15	Informal saving	Money/qualitative
16	Access to extension service.	Access/qualitative

Source: authors preparation in this study, 2023.

Table4. .Summary of Variables, measurement, and Hypothesis (Technology Adoption)

No	Variable	Measurement
1	Age	Year/quantitative
2	Gender	Sex/qualitative
3	Marital status	Qualitative
3	Family labor	Number/quantitative
4	Literacy rate	Level/ qualitative
5	Farm size	Number/ quantitative
6	Land title	Title/qualitative
7	Livestock value	Asset/ qualitative
8	Access to credit	Money/quantitative
9	Remittance Income	Money/ quantitative
10	Off farm income	Money/quantitative
11	Access to information	Access/qualitative
13	Access to extension service.	Access/qualitative
14	Demand side constraint	Money/quantitative
15	Distance from input market	KM/quantitative

Source: authors preparation in this study, 2023.

CHAPTER 4 - RESULTS AND DISCUSSION.

4.1. Descriptive Analysis

The following descriptive statistics analysis provides insights into various household attributes and their relationships with constraints. This analysis aims to understand the patterns and variations among different credit constraint status categories, highlighting key factors that may contribute to household constraints. The analysis examines demographic characteristics, agricultural profiles, geographical factors, income sources, and agricultural practices.

Table 5 below presents an overview of farmers' characteristics credit constraint status for continuous variables with the corresponding t-stat test. The descriptive analysis revealed significant differences in household attributes among households with different levels of constraints. Demand-constrained households had slightly higher average ages of household heads (45.6 years) compared to unconstrained households (46.2 years). In terms of household size, demand-constrained credit constrained households had smaller average sizes (4.72) compared to unconstrained households (5.45), representing a substantial difference of 15.54%.

Table 5. Summary statistics of the continuous variables used in the econometric analysis, by credit constraint status.

Variables/household attributes	Total	Demand constrained	Supply constrained	Unconstrained	Difference (t-stat.)
Household demographics					
Age of household head	45.4 (15.4)	45.6(15.3)	44.5 (14.8)	46.2 (16.6)	2.01
Household size	5.0 (2.45)	4.72 (2.14)	5.28 (2.82)	5.45 (2.20)	15.54***
Rural infrastructure:					
Distance to the formal financial	30(45)	31(49)	30(43)	29(39)	38.08***
Distance to the nearest market (km)	76.62(67.41)	84.15(73.76)	74.55(63.17)	64.15 (57.96)	41.15***
Distance to the main road (km)	22.53(33.10)	26.71(40.20)	19.61(28.44)	18.9 (20.91)	256.2***
Non-farm income (in 1000 birr)	7.56 (1.27)	8.92 (1.44)	5.76 (9.06)	6.66 (10.63)	1.13
Number of observations	**2,939**	**958**	**821**	**441**	

Notes: ***, **, and * denote statistical significances at 1%, 5%, and 10% levels, respectively. HH stands for a household; FI, stands for a financial institution, km stands for kilometers. Note that the t-stat test is between the supply side and demand side constrained HH.

Unconstrained households had significantly shorter average distances to the formal financial institution (29 km) compared to credit constrained households (supply constrained: 30 km, demand constrained: 31 km) and the highest average distance among unconstrained households (45 km).

Similarly, unconstrained households had significantly shorter average distances to the nearest market (64.15 km) compared to supply- side constrained credit constrained households (74.55 km), demand-side credit constrained households (84.15 km), and the highest average distance among unconstrained households (76.62 km). Furthermore, unconstrained households had significantly shorter average distances to the main road (18.9 km) compared to supply-side households (19.61 km), and demand-side credit constrained households (26.71 km), and the highest average distance among unconstrained households (22.53 km). In terms of income sources, demand side constrained households had significantly higher non-farm income (8.92 thousand birrs) compared to unconstrained households (6.66 thousand birr), and supply-constrained households (5.76 thousand).

In addition to t-stat test, the results of the chi-square test used to analyze categorical variables are shown in Table 6. Accordingly, agricultural extension visits exhibited a substantial difference, with unconstrained households having the highest percentage (63.04%), followed by demand-side credit constrained households (43.06%) and supply-constrained households (40.79%). This indicates a strong association between agricultural extension visits and household constraints.

Formal credit service displayed a significant difference, with unconstrained households having the highest percentage (44.44%), followed by demand-constrained households (0.0%) and supply-constrained households (0.00%). This highlights a substantial association between formal credit service and household constraints. While there were no significant differences in having an account at a formal financial institution, formal saving, and borrowing at least 150 brr, variations were observed across the constraint groups.

Additionally, the prevalence of female-headed households was higher among households facing demand constraints (28.29%) compared to unconstrained households (28.34%), indicating a potential association between gender and household constraints. Furthermore, demand-side credit constrained households exhibited higher literacy rates among household heads (56.99%) compared to unconstrained households (43.1%), with a notable difference of 23.5%.

Table 6. Summary statistics of the categorical variables used in the econometric analysis, by credit constraint status.

Variables/household attributes	Total	Demand constrained	Supply constrained	Unconstrained	Difference (X^2)
Household demographics					
Female headed HH (%) ‡	26.2	28.29	22.8	28.34	8.2**
Married household head (%)	75.8	74.84	77.8	74.1	2.98
Literate household head (%)	52.88	56.99	53.35	43.1	23.5***
Asset ownership and right					
Land use right (%)	91.1	90.8	92.2	89.5	2.6
Land certificate (%)	59.91	64.61	52.86	62.81	27.35***
Collateral asset ownership (%)	0.59	0.52	0.73	0.45	0.49
Mobile phone (%)	33.96	34.55	34.59	31.52	1.46
Livestock ownership (%)	52.66	48.67	41.05	59.64	70.45***
Household access to finance					
Agricultural extension visits (%)	43.06	40.79	35.08	63.04	95.27***
Have formal credit service (%)	8.8	0.00	0.00	44.44	867.2***
Have account at formal FI (%)	21.22	20.04	22.41	21.54	1.52
Have formal saving (%)	23.33	21.61	23.09	23.81	3.06
Have informal saving (%)	5.80	7.01	5.04	10.24	6.0744
Borrow at least 150 brr (%)	13.33	13.26	12.91	14.29	0.477
Rural infrastructure:					
Have non Agri business (%)	5.77	7.2	4.99	4.08	6.84***
Use of agricultural technologies:					
Used chemical fertilizer (%)	50.5	51.15	38.00	72.34	135.57***
Used fungicide (%)	20.09	16.39	18.88	30.39	38.04***
Used pesticide (%)	9.73	8.14	6.82	18.59	50.11***
Used herbicide (%)	3.06	2.71	3.90	2.27	3.25
Used agro-chemical (%)	25.72	20.77	22.90	41.72	74.81***
Modern Mechanization (%)	0.95	0.73	1.22	0.91	1.12
Practice crop rotation	68.78	86.69	46.04	85.26	316.76***
Number of observations	**2,939**	**958**	**821**	**441**	

Notes: ***, **, and * denote statistical significances at 1%, 5%, and 10% levels, respectively. Note that the t-stat test is between the supply side and demand side constrained HH.

There is a substantial difference in land certificate ownership between constrained and unconstrained households, with Demand side constrained households having a significantly higher percentage (64.61%) compared to both unconstrained (62.81%) and supply -side credit constrained

households (52.86%), with a difference of 27.35%. Collateral asset ownership exhibited minor differences among the constraint groups, with supply-constrained households having the highest percentage (0.73%) and demand-side credit constrained households having the lowest (0.52%). However, these differences were not statistically significant.

Mobile phone ownership showed slight variations, with slightly higher percentages observed among demand constrained (34.55%) and supply-constrained households (34.59%) compared to unconstrained households (31.52%). However, the differences were not statistically significant. Livestock ownership exhibited a significant difference, with unconstrained households having a notably higher percentage (59.64%) compared to demand-side credit constrained households (48.67%), with a substantial difference of 70.45%. Additionally, Demand-side credit constrained households had the highest percentage of non-agricultural businesses (7.2%), followed by supply-side credit constrained households (4.99%), unconstrained households (4.08%). Unconstrained households had significantly higher percentages in the usage of chemical fertilizer (72.34%), fungicide (30.39%), pesticide (18.59%), and agro-chemicals (41.72%) compared to constrained households. They also practiced crop rotation at a significantly higher percentage (85.26%). There were no significant differences observed among the constraint groups in the usage of herbicide and modern threshers or mechanization.

In summary, the above analysis reveals several key findings regarding unconstrained households compared to households facing credit constraints. Unconstrained households enjoy better access to formal financial institutions, with shorter distances to such institutions, nearest markets, and main roads. Demand side credit constrained households exhibit higher non-farm income, indicating diversified income sources. In terms of agricultural practices, unconstrained households have higher livestock ownership, engage more in agricultural extension visits, and use more agricultural technologies such as chemical fertilizers, fungicides, and pesticides. They also have higher land certificate ownership and practice crop rotation more frequently. Overall, unconstrained households demonstrate better access to resources and financial services, as well as higher engagement in agricultural activities, suggesting potential factors contributing to their lower credit constraint status.

4.2. Econometric Estimations

4.2.1. Determinants of credit constraint status of Households

The determinants of credit constraint status among households were examined using multinomial probit (MNP) regression models, as shown in Table 8. The households were classified into three groups based on their credit constraint status: supply-side constrained, demand-side constrained, or unconstrained households. The analysis utilized various explanatory covariates, including household demographics, asset ownership, household income level, access-related variables such as extension services, and social and financial capital variables. The base category for comparison was the "unconstrained" households in the MNP model. Thus, the estimation results in Table 8 provide insights into the likely effect of each variable included on the credit constraint status of a household, with the coefficients indicating the direction and magnitude of the relationship, and the standard deviations reflecting the associated uncertainty.

Based on the results presented in Table 7, access to agricultural advisory services, extension services, and distance from the market are identified as the important variables that influence the credit constraint status of both supply-side and demand-side constrained households. The coefficient associated with access to agricultural advisory and extension services is negative and statistically significant, indicating that households with access to such advisory and extension services are less likely to be credit constrained. In this respect, this result is consistent with other previous studies Wossen et al.'s (2017) study demonstrates a positive relationship between credit access and extension services. On the demand side, this result suggests that having access to agricultural advice and extension services can give farmers the ability to choose how to use credit wisely. Households can better understand their borrowing needs and manage their credit commitments by receiving advice on financial management, risk assessment, and optimal credit utilization. On the supply side, it implies that offering agricultural advice and extension services to farmers can significantly raise their creditworthiness and capacity to obtain financing. By using these services to give them guidance, information, and support, farmers may increase their knowledge, skills, and overall production.

Table 7. Estimation results of multinomial probit (MNP) regression models

	Demand Side credit Constrained		Supply-side credit Constrained	
	Coefficient	**Sta.Dev**	**Coefficient**	**Sta.Dev**
Age of household head (yrs.)	-0.001	(0.003)	-0.003	(0.003)
Female household head (1/0)	-0.054	(0.147)	-0.267*	(0.155)
The Edu level attained (yrs.)	-0.041***	(0.011)	-0.015	(0.011)
Household size	-0.115***	(0.020)	0.011	(0.020)
Married household head (1/0)	-0.001	(0.150)	-0.096	(0.156)
Has access to agricultural advisory (1/0)	-0.292***	(0.108)	-1.476***	(0.112)
Has remittance income (1/0)	-0.506**	(0.222)	0.053	(0.238)
Number of oxen owned	0.001	(0.002)	-0.183***	(0.041)
Distance from the market (in km)	0.006***	(0.001)	0.005***	(0.001)
Distance from F. Institution (in km)	-0.003**	(0.001)	-0.002	(0.001)
Has formal savings (1/0)	0.055	(0.166)	0.179	(0.172)
Has informal savings (1/0)	-0.272	(0.197)	-0.192	(0.203)
Has owned livestock (1/0)	0.014	(0.095)	-0.470***	(0.099)
Has land certificate (1/0)	0.092	(0.099)	-0.209**	(0.102)
Has collateral asset (1/0)	0.034	(0.614)	-0.125	(0.621)
Have non-agribusiness (1/0)	0.333	(0.210)	0.022	(0.223)
Access to agricultural extension (0/1)	-0.615***	(0.104)	-0.292***	(0.109)
Has mobile phone (0/1)	0.137	(0.100)	0.097	(0.104)
_cons	1.960***	(0.366)	1.863***	(0.385)
Number of observations	2168			
Log-likelihood	-1974.920			
AIC	4025.840			
BIC	4241.739			

The dependent variable is the 'credit constraint status of households and the base category is 'credit-unconstrained' households

Notes: ***, **, and * denote statistical significances at 1%, 5%, and 10% levels, respectively.

On the other hand, the distance from the market has a statistically significant positive coefficient. This suggests that households farther from the market experience more credit restrictions. This result is consistent with work by Mukasa et al. (2017), who found a link between supply-side and demand-side credit constraints and market distance. The fact that the coefficient on distance to market has a positive sign in the observation may be due to the fact that living close to a significant market implies that farmers have the opportunity to interact with other farmers who likely face comparable financial challenges.

As a result, people can gain insight from those who have already applied for loans and receive valuable advice on how to find trustworthy lenders and how to improve their chances of getting credit. This makes it harder for farmers who are located far from major markets to learn about credit, which increases the likelihood that they will run into issues when attempting to obtain financing.

The results further provide insights into the factors that differentially affect demand-side and supply-side-constrained households in terms of credit constraint status. Among demand-side-constrained households, several variables show a significant relationship. Firstly, the education level attained exhibits a negative coefficient, indicating that higher levels of education are associated with a lower likelihood of facing credit constraints. This implies that a household with higher education is less likely to face challenges regarding the demand for credit. This result is also supported by the study by Balana et al. (2022), which indicates that HH with higher education is less likely to be demand-side constrained.

Furthermore, household size has a negative coefficient, suggesting that larger households are less likely to be demand-side credit-constrained. Implying that when the household has a large family member, they tend to be willing to take a loan; this might be because of the need for high capital for living and engaging in different income-generating activities. Conversely, remittance income shows a negative coefficient, implying that households receiving remittances have a lower probability of facing demand-side credit constraints. This implies that households may be able to meet their financial obligations and access credit more easily if they have more money at their disposal. Also, the economic stability and income diversity of households can both be improved via remittances. Having a second source of income may help households become more financially resilient and suffer less income fluctuation.

Distance from the financial institution displays a negative coefficient, indicating that households located farther from financial institutions are less likely to be demand-side credit constrained This can be explained by the limited accessibility to formal financial services in remote areas, which makes it more difficult for households to access credit. Additionally, the lack of information and awareness about available credit options in these areas may contribute to lower demand for credit. As a result, households residing farther from financial institutions may rely on alternative sources

of credit or adopt strategies that mitigate the need for formal credit, leading to lower levels of demand-side credit constraints.

The estimation results reveal that three more important asset ownership-related variables, such as the number of oxen owned, ownership of livestock, and possession of a land certificate, significantly influence the credit constraint status of supply-side credit-constrained households. The ratio between livestock ownership and the number of oxen owned exhibits a significant negative coefficient, indicating that households with a higher number of oxen are less likely to face supply-side credit constraints. The ownership of such assets signifies access to productive assets that can be used for agricultural activities, enhance productivity, and serve as valuable collateral for credit transactions. This result is consistent with earlier studies by Feder et al. (1988), Boucher et al. (2009), and Balana and Oyeyemi (2022), which found that land titles can be used as official collateral, lowering the risk to the lender and easing collateral restrictions for borrowers. Because of this, households with land titles have easier access to loans. Owning cattle is an important measure of household wealth or assets in the context of rural African smallholder families. It may serve as a credit replacement or illustrate the household's capacity for risk management (Croppenstedt et al. 2003).

Results indicate that approximately 80 percent of surveyed households are likely to be credit constrained. Among these, around 37 percent are identified as supply-side constrained, while 43 percent are categorized as demand-side constrained households (Table 9). These results are consistent with those of a prior study carried out in Ethiopia by Lemecha (2023), which mainly noted demand-side constraints. This finding is interesting in that many studies highlight that credit constraints smallholders face are associated with supply-side factors and recommend improving credit access through mitigating supply-side constraints to boost agricultural technology adoption (Abate et al., 2016; Khandker & Koolwal, 2016).

However, these findings show that credit constraints for smallholders resulted not only from supply-side factors but from demand-side factors as well. In this study, the demand-side credit-constrained appears even stronger than the supply-side credit-constrained. Thus, improving credit access via easing supply-side constraints may not necessarily address the problem of credit access for Ethiopian smallholders without equally addressing demand-side factors (Adjognon, Liverpool-Tasie, & Reardon, 2017; Woutersen & Khandker, 2013).

Table 8. Marginal effects of multinomial probit (MNP) regressors on the probability of a household being credit constraint.

	Credit unconstrained		Demand Side credit Constrained		Supply-side credit Constrained	
	dy/dx	**sd.Err**	**dy/dx**	**sd.Err**	**dy/dx**	**sd.Err**
Age of household head (yrs.)	.0005	(.0006)	.0003	(.0008)	-.0007	(.0007)
Female household head (1/0)	.0308	(.0288)	.0330	(.0358)	-.0637*	(.0337)
The Edu level attained (yrs.)	.0064***	(.0020)	-.0097***	(.0026)	.0034	(.0024)
Household size	.0131***	(.0037)	-.0374***	(.0051)	.0242***	(.0045)
Married household head (1/0)	.0088	(.0292)	.0175	(.0362)	-.0264	(.0340)
Has access to agricultural advisory (1/0)	.1693***	(.0205)	.1833***	(.0263)	-.3530***	(.0251)
Has remittance income (1/0)	.0569	(.0444)	-.1649***	(.0511)	.1080**	(.0493)
Number of oxen owned	.0165***	(.0036)	.03409***	.0072)	-.0505***	(.0106)
Distance from the market (in km)	-.0017***	(.0002	.0009***	(.0002)	.0002	(.0002)
Distance from F. Institution (in km)	.0005**	(.0003)	-.0004	(.0003)	-.0001	(.0003)
Has formal savings (1/0)	-.0229	(.0322)	-.0161	(.0400)	.0390	(.0373)
Has informal savings (1/0)	.0505	(.0381)	-.0478	(.0478)	-.0027	(.0444)
Has owned livestock (1/0)	.0409**	(.0185)	.0913***	(.0230)	-.1322***	(.0217)
Has land certificate (1/0)	.0078	(.0192)	.0668***	(.0239)	-.0746***	(.0223)
Has collateral asset (1/0)	.0073	(.1180)	.0334	(.1488)	-.0407	(.1353)
Have non-Agri business (1/0)	-.0426	(.0417)	.0981**	(.0489)	-.0555	(.0465)
Access to agricultural extension (0/1)	.1014***	(.0201)	-.1345***	(.0259)	.0331	(.0244)
Has mobile phone (0/1)	-.0255	(.0195)	.0239	(.0239)	.0016	(.0225)
Pr (credit constraint status):		.1963		.4300		.3737

Notes: ***, **, and * denote statistical significances at 1%, 5%, and 10% levels, respectively.

Starting with credit-unconstrained households, factors such as education level, household size, access to agricultural advisory, ownership of oxen, and distance from the market significantly influence the probability of being credit unconstrained. Firstly, the education level attained by the household head has a positive and significant impact on the probability of being credit unconstrained. This suggests that for each additional year of education, the probability of being credit-unconstrained increases by 0.64%.

Furthermore, household size also plays a significant role in credit constraint, suggesting that for each additional household member, the probability of being credit unconstrained increases by 1.31%. Access to agricultural advisory services is another influential factor, showing that

households with access are 16.93% more likely to be credit unconstrained compared to those without access. Ownership of oxen shows a positive relationship with credit constraint, indicating that for each additional oxen owned, the probability of being credit unconstrained increases by 1.65%. On the other hand, the distance from the market has a negative effect on credit constraint status for unconstrained households, suggesting that for each additional kilometer away from the market, the probability of being credit unconstrained decreases by 0.17%.

Moving on to demand-side credit-constrained households, education level attained, household size, remittance income, ownership of oxen, distance from the market, access to agricultural extension services, and having a non-agricultural business show significant effects. Each additional year of education reduces the probability of being demand-side credit-constrained by 0.97%. Larger household size leads to a decrease of 3.74% in the likelihood of being demand-side credit-constrained per additional household member. Access to agricultural advisory services is associated with an 18.33% lower probability of being demand-side credit-constrained. Other significant factors include remittance income, ownership of oxen, longer distances from the market, and access to agricultural extension services.

In the case of supply-side constrained households, several variables show statistically significant marginal effects. Household size, access to agricultural advisory, remittance income, ownership of livestock, possession of a land certificate, and having a non-agricultural business are key variables with statistically significant effects. Possessing a land certificate is associated with a 7.46% lower probability of being supply-side credit constrained. Owning livestock and having a land certificate reduce the likelihood of being supply-side credit constrained by 13.22% and 7.46% respectively. Additionally, households with access to agricultural advisory services are 35.3% less likely to be supply-side credit constrained.

The MNP model includes built-in diagnostic tests for heteroscedasticity and multicollinearity, indicating that there are no significant issues of multicollinearity or heteroscedasticity within the model. Furthermore, the AIC and BIC criteria demonstrate a strong model fit, outperforming the prominent MNL model. This indicates that the MNP model is well-suited for the analysis and provides reliable estimates of the relationships between variables.

4.2.2. Credit Constraint and agricultural technology Adoption

Table 9 presents the results from a seemingly unrelated regression (SUR) model where adoption decisions for two agricultural technologies—inorganic fertilizer, and agrochemicals—were estimated simultaneously. This SUR model allows for the correlation between error terms affecting the adoption decisions of different technologies. By jointly estimating the two equations, we gain valuable insights into the relationships between these technologies and the explanatory variables. The coefficient estimates in Table 9 provide quantitative measures of the effects of the explanatory variables on adoption decisions, allowing us to assess the significance and direction of these relationships.

Table 9. Results from seemingly unrelated regression (SUR) models

	Agrochemicals		**Inorganic Fertilizer**	
	Coefficient	**Std. Err.**	**Coefficient**	**Std. Err.**
Demand-side credit constrained (1/0)	-0.487***	(0.019)	0.175***	(0.020)
Supply-side credit constrained (1/0)	-0.413***	(0.023)	0.098***	(0.022)
Age of household head (yrs.)	-0.000	(0.001)	0.001*	(0.000)
The Edu level attained (yrs.)	-0.001	(0.002)	0.001	(0.001)
Female household head (1/0)	0.004	(0.022)	-0.009	(0.021)
Household size	-0.008*	(0.003)	0.015***	(0.003)
Married household head (1/0)	0.028	(0.023)	-0.007	(0.021)
Has land certificate (1/0)	-0.037*	(0.015)	0.089***	(0.014)
Have non-Agri business (1/0)	-0.029	(0.033)	-0.029	(0.031)
Has remittance income (1/0)	-0.048	(0.058)	0.074	(0.054)
Access to agricultural extension (0/1)	-0.154***	(0.017)	0.605***	(0.016)
Has other income (1/0)	0.001	(0.050)	0.059	(0.047)
Has owned livestock (1/0)	0.018	(0.015)	0.041**	(0.014)
Has mobile phone (0/1)	-0.005	(0.016)	-0.013	(0.015)
Has collateral asset (1/0)	-0.093	(0.092)	-0.089	(0.085)
Has formal savings (1/0)	0.024	(0.019)	-0.020	(0.017)
Hired labor (1/0)	0.005	(0.048)	-0.120**	(0.044)
Has access to agricultural advisory (1/0)	0.163***	(0.019)	0.017	(0.018)
HH labor (1/0)	0.245	(0.289)	-0.147	(0.268)
Uses Agrochemical (1/0)			0.091***	(0.017)
_cons	0.501	(0.300)	0.071	(0.278)

Error correlations (rhos): r12=0.000, Breusch–Pagan test of independence: chi2(1) = 1.000, Pr = 0.000

Notes: ***, **, and * denote statistical significances at 1%, 5%, and 10% levels, respectively.

The share of rural farmers adopting the two technologies varies; approximately 44% used agrochemicals and 50.2% used inorganic fertilizer. Our primary purpose in this study is to look at how constraints on credit affect the adoption of these technologies, even though we also included several control factors to look at how these adoptions are conditioned. In all two equations, we essentially employed the same set of control variables.

The coefficient estimate for the demand-side constraint for the adoption of agrochemicals highlights the significant negative impact of credit constraints, suggesting that farmers with limited access to credit are less likely to adopt agrochemical technologies. Similar to this, the coefficient estimate for the supply-side constraint demonstrates that greater credit availability has a favorable effect on the adoption of agrochemicals. The findings highlight the important role credit constraints play in agrochemical uptake. Farmers who have limited access to credit find it challenging to adopt agrochemical technologies.

Household size is one of the other control variables that has a significant negative impact on the adoption of agrochemicals, which has several implications. Larger household sizes frequently indicate insufficient resources per capita, including financial constraints and labor availability, which can hinder the adoption of agrochemicals through associated costs and labor-intensive applications. In subsistence agriculture settings, agrochemicals and other external inputs might not be as crucial for larger households as meeting immediate food needs. Additionally, the varied knowledge and experiences of larger households may encourage alternative methods of insect control and soil fertility management, reducing the need for agrochemicals. A higher level of environmental consciousness among farmers in households with more people may also be indicated by the negative correlation between household size and agrochemical adoption, prompting them to select practices that lessen their reliance on chemical inputs and promote ecological sustainability.

The use of agrochemicals and the possession of a land ownership certificate are also associated negatively. This result is unexpected, but it can be explained by the possibility that landowners have more resources and knowledge to use alternative agricultural practices that reduce the need for agrochemicals, such as integrated pest management or organic farming. Furthermore, since landowners have a greater incentive to maintain the long-term productivity and environmental

sustainability of their property, they might be more inclined to adopt practices that minimize chemical inputs.

The adoption of agrochemicals, however, has a significantly negative relationship with participation in extension programs while having a positive relationship with advisory services. This can be explained by the fact that farmers who choose not to take part in extension programs might not have access to the alternative farming techniques and sustainable farming methods that these programs promote. On the other hand, farmers who seek assistance from advisory services are more likely to adopt agrochemicals due to the specialized expertise, tailored recommendations, and technical direction offered by these services. This highlights the need to close the knowledge gap between the two strategies, promote sustainable farming methods, and make sure farmers have access to comprehensive information and expert advice when making decisions about the use of agrochemicals.

Significant aspects that provide insight on its affecting factors are shown by the research on the use of inorganic fertilizer. According to the favorable effect of credit constraints on adoption, farmers with little access to financing are more inclined to switch to using inorganic fertilizer as a substitute to enhance agricultural practices. This suggests that farmers chose inorganic fertilizer as a comparatively affordable choice due to budgetary restrictions. Contrarily, the negative impact of credit accessibility on adoption suggests that, maybe because of other factors, increased credit access makes adoption more difficult. This implies that despite more access to loans, farmers may still encounter challenges or think about adopting more sustainable practices that lessen their reliance on artificial fertilizers. Interventions should attempt to increase farmers' access to credit while promoting sustainable farming methods that reduce reliance on inorganic fertilizers, establishing a balance between productivity and environmental sustainability.

Among the control variables, household size demonstrates a significant positive relationship with the adoption of inorganic fertilizer. The results support a previous study by Kibrom et al. (2016) that also found an association between household size and fertilizer use. Households with more people who are actively working could be more likely to adopt particular agricultural methods, which could be one explanation for this relationship. In other words, larger households are more likely to adopt these technologies, maybe as a result of the need to increase output to accommodate a larger family.

Similarly, it has been shown that having a land ownership certificate influences the use of inorganic fertilizer in a way that is positively significant. This suggests that inorganic fertilizers are more likely to be adopted and used by households or farmers who have official documentation of land ownership. The finding may have the potential to enable farmers to make long-term investments in their land and farming endeavors by giving them a sense of security and stability. Farmers may have greater access to loans, resources, and agricultural support services, such as knowledge about the advantages of utilizing inorganic fertilizers, if land ownership is recognized legally. As a result, people are more inspired and empowered to adopt new technologies, which eventually boost productivity and the results of agriculture. The possession of a land ownership certificate can, therefore, be regarded as a crucial factor affecting farmers' willingness to adopt organic fertilizers.

In addition to land ownership, there is a significantly positive relationship between the use of chemical fertilizer and the number of livestock. This suggests that households with more livestock are more likely to use chemical fertilizers in their farming operations. Kibrom et al. (2016) have also found a positive relationship. The demand for increasing grain yields in livestock production to supply the animals' dietary requirements can be one explanation for this association. Farmers can increase soil fertility and raise the yield and quality of their forage or feed crops by applying chemical fertilizers. Consequently, farmers who own more livestock are more inclined to use chemical fertilizers to support their livestock production.

Moreover, this study demonstrates a significant positive relationship between the usage of inorganic fertilizers and the age of the household head (HH). In the same way, Mohammed (2014) argues that this positive association may be explained by older farmers' higher knowledge and expertise compared to younger farmers, which encourages them to use the technology. An implication of this finding can be that as farmers get older, their knowledge and experience in farming increase, and they become more conscious of the benefits of utilizing fertilizers to increase crop output. Additionally, older farmers may have more finances and financial stability, allowing them to invest in fertilizer inputs.

There is a significant positive link between participation in extension programs and the use of inorganic fertilizer, which is in line with the conclusions made by Kibrom et al. (2016) and Mesele (2019). This can be explained by the fact that households that have had extension agents visit them are more likely to use fertilizer. In other words, it implies that these extension agents serve as a

source of knowledge for households. These findings suggest that farmers who actively engage in extension programs are more likely to adopt these technologies. This is probably because these programs allow the sharing of information and knowledge.

The use of chemical fertilizer is found to be negatively correlated with the presence of hired labor. This indicates that households or farmers are less likely to adopt or use chemical fertilizers in their agricultural activities if they hire labor. This implies that employing hired labor may be related to less chemically dependent farming methods or management techniques. It might imply that these farmers favor organic or alternative techniques for improving soil fertility and crop productivity, possibly driven by things like personal preferences, market needs, or environmental concerns. As a result, having hired labor available might be thought of as a factor influencing the use of chemical fertilizers in farming, with implications for the choice of agricultural practices and inputs.

The variable representing the current use of agrochemicals in the household has a significant positive relationship with the adoption of agrochemicals, indicating that farmers who already use agrochemicals are more inclined to adopt inorganic fertilizer as a complementary input in their farming practices.

The error correlations (rhos) in the SUR model are very low, with a value of 0.000 for r12. This indicates that there is almost no correlation between the errors of the different equations in the model. Additionally, the Breusch-Pagan test of independence results in a chi-square statistic of 1.000 with a p-value of 0.000, suggesting a significant lack of dependence among the error terms. These findings indicate that the error terms in the SUR model are not correlated and exhibit independence, which supports the assumption of the SUR model that the equations are not affected by each other's error terms.

CHAPTER 5. SUMMARY, CONCLUSION, & IMPLICATIONS.

5.1. Summary

This study investigates the rural credit constraint status, factors influencing credit constraints, and the impact of credit constraints on the adoption of modern agricultural input technologies in Ethiopia. The research utilized data from 2200 smallholder farmers in Ethiopia, collected through the nationally representative LSMS-ISA surveys. Two econometric models, the multinomial probit (MNP) model and the seemingly unrelated regression (SUR) model, were employed to analyze the data.

The findings of the study indicated that a significant portion of smallholder farmers in Ethiopia faced credit constraints, suggesting that both supply-side and demand-side factors play crucial roles in shaping credit access. Supply-side factors such as collateral ownership, including livestock ownership and land use certificates, as well as access to agricultural extension services, were identified as key influences on the credit-constrained status. On the demand side, variables like literacy, access to remittances, and access to agricultural extension services were found to be important determinants of credit constraints. The study also revealed that credit constraints, whether from the supply or demand side, had a negative effect on the adoption of agrochemicals, while the effect on chemical fertilizer is positive.

5.2. Conclusion

In conclusion, this study underscores the significant presence of credit constraints among smallholder farmers in Ethiopia, emphasizing the combined influence of both supply-side and demand-side factors. Addressing these constraints necessitates considering various factors that affect farmers' credit access from both sides. Particularly, demand-side factors account for 43% of the observed credit constraints, indicating their crucial role. It is essential to integrate supply-side and demand-side considerations when devising interventions to enhance credit access and foster the adoption of agricultural technologies among smallholder farmers in Ethiopia.

The study findings suggest that solely addressing supply-side constraints is insufficient to improve credit access for smallholders in Ethiopia. The limited participation of smallholders in the credit market cannot be solely attributed to their inability to obtain credit; it may also stem from risk aversion and inadequate information about credit sources and terms. Therefore, effectively

addressing credit constraints necessitates addressing demand-side factors, such as providing extension services.

Focusing on demand-side factors, particularly extension services, offers a promising approach to alleviating credit constraints faced by smallholders and promoting the adoption of modern agricultural technologies, thereby enhancing productivity. By prioritizing the improvement of access to credit and information for smallholder farmers, significant strides can be made in agricultural development and the improvement of farmers livelihood in Ethiopia.

Overall, this study highlights the importance of addressing credit constraints to foster the adoption of agricultural technologies among smallholder farmers. Policymakers should consider implementing targeted interventions, such as providing agricultural advisory services, training and educating farmers, improving asset ownership and entitlement to addressing credit constraints in the rural Ethiopia. By comprehensively addressing supply-side and demand-side factors, there could be better access and availability of credit access thereby an improved input technology adoption which will enhance productivity and income of the farmers.

5.3. Recommendations and Policy Implications.

Based on the result, the following recommendations and **policy implication** are suggested.

- Promote and strengthen smallholders' capacity to obtain bankable collateral, such as land use certificates and land titles or asset ownerships. A key contributor to supply-side credit limitations is asset ownership, including livestock and land certificates. Providing clear collateralization systems, securing land entitlements and certifications, and simplifying asset ownership can enhance smallholder farmers' creditworthiness and access to finance.
- In addition to addressing supply-side constraints to improve credit access, it is equally important to focus on addressing demand-side factors in order to enhance the utilization of agricultural credit. This can be done by promoting financial literacy programs and training initiatives to enhance smallholders' understanding of credit and financial practices. Further, expand the reach of agricultural extension services to ensure a wider availability of information and guidance on credit options.
- The fact that distance from the market and credit constraint status are positively correlated suggests that households positioned further from the market may experience more credit constraints. In order to fix this, efforts should be made to improve financial inclusion in rural

areas by setting up mobile banking services or giving financial institutions incentives to broaden their clientele. The availability of loans for households in rural areas would improve as a result.

- It has been observed that the household head's education level has a positive effect on whether they are under credit constraint. Supporting education and skill-building initiatives can empower households, allowing them to make better financial decisions and possibly easing lending restrictions. To improve smallholders' understanding of credit and financial practices, this can be accomplished by promoting financial literacy programs and training initiatives.
- The use of agrochemicals, an essential modern agricultural input, is substantially impacted by both the demand for and availability of finance. Targeted policy interventions are required to improve smallholders' access to credit and give them the financial means to embrace these essential agricultural inputs. By promoting the use of agrochemicals, these initiatives seek to boost productivity and enhance rural communities' standard of living.

Research Limitations and Future Research Recommendations

This study used the most recent nationally representative panel data from LSMS-ISA, which gave important insights about credit constraints and input technology use in rural areas across the nation. However, it's important to acknowledge that in the same enumeration areas, data was not collected for different reasons, and as a result, the data was not there, and we have to drop those observations from the sample. These data gaps might have impacted the dataset's completeness, affected the representativeness of the sample, and introduced biases in the analysis. Additionally, by including any modifications or advancements made since the 2018 wave, adopting a more recent dataset would have strengthened the study's recent insights and policy implications.

For future researchers, this study recommends using a new panel from the LSMS-ISA dataset in future research and updating the information and policy recommendations. With the 2018/19 wave serving as a pilot for the next panel data, a new panel study would allow longitudinal analyses, tracking changes in credit constraints and input technology adoption over time. Researchers will also be able to examine a wider range of data, enabling more comprehensive analyses, insights, and policy recommendations, with future waves of the LSMS-ISA dataset anticipated to be collected soon.

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