Ethiopian Economics Association (EEA)

PROCEEDINGS OF THE NINETEENTH INTERNATIONAL CONFERENCE ON THE ETHIOPIAN ECONOMY

June 2023

Published: June 2023

ISBN – 978-99944-54-97-6

Partners and Sponsors of EEA are:

- Bill and Melinda Gates Foundation
- Frederich Ebert Stiftung
- European Union
- OSIEA
- Economic Commission for Africa (ECA)

Table of Contents

Keynote Speech

By Dr. Yinager Dessie, Governor, National Bank of Ethiopia

19th International Conference on Ethiopian Economy, (July 22-23, 2022)

Your Excellences,
Ladies and Gentlemen,

1. It is an honor for me to address the distinguished participants of the 19th International Conference on the Ethiopian economy. In my key note address today, I would like to share with you some of the salient features of the Ethiopian financial system and its role in socio-economic growth and development of the country in recent few years and highlight some set of key reform measures undertaken to bolster the sector.
2. As you all know, a well-functioning financial system is a powerful tool in influencing economic growth and development of a country. It can be considered as lubricant that assists financial resource mobilization and influences the optimum resource allocation among various users. It promotes economic growth and development by increasing trade, investment, production and productivity, savings mobilization, capital accumulation, job creation and technological progress.
3. The Ethiopian economy has continued to show resilience, despite external and internal shocks. The Home Grown Economic Reform Program and the 10 Year Perspective Plan has laid clear foundations for the country's growth trajectory. The Home Grown Economic Program has focused on transforming agriculture, industry, mining, IT and tourism which are the main pillars of the economy. Yet, the Ethiopian economy, despite its resilience and growing merchandize exports, is facing challenges which include high inflationary pressure, shortage of foreign exchange and widening current account deficit. The driving factors for stubbornly high inflation consist of high global commodity prices, shortage of foreign exchange, instability in some regions of the country, expansionary monetary policy and structural bottlenecks related to production and productivity. The NBE, in line with its mandate is doing its best to rectify the problems and change the challenges into opportunities.
4. Against this backdrop, let me highlight some of the recent financial system developments in Ethiopia. In the Ethiopian context, the financial sector

comprises banks, insurance companies, microfinance institutions and capital goods finance companies. As of June 2022, there were 30 banks, having 8,944 branches, with another 13 banks being under formation. Of the total banks, merely two banks are state owned. Although the share of CBE, the biggest state owned bank, in deposit mobilization, credit allocation and capital size still remains relatively significant, it is on a downward trajectory as private banks continued to expand their outreach services. Similarly, the number of insurance companies remained at 18, of which 17 are private, while their branches stood at 690. Likewise, the number of microfinance institutions, which largely cater for low income groups both in rural and urban areas, has reached 40, serving about 4.3 million clients.

5. Regarding resource mobilization, total deposits mobilized by the banking system rose 25.7 percent over last year and reached Birr 1.7 trillion by end of June 2022. Meanwhile, their outstanding loan disbursement also went up from Birr 1.28 trillion to Birr 1.5 trillion showing a 20.4 percent annual growth. Micro finance institutions, which largely cater for low income groups of society both in rural and urban areas, have mobilized Birr 56.7 billion in deposit savings by March 2022 and their outstanding loan has reached Birr 73.3 billion.

6. All the financial indicators show that the Ethiopian financial sector is adequately capitalized, profitable and resilient. No financial institution has faced serious financial stress and risk of failure, thanks to stringent regulatory and supervisory functions of the NBE and possibly due to insulation from foreign competition.

7. Despite this notable progress, access to finance and financial inclusion still remain modest in Ethiopia. A significant proportion of the population still remains unbanked. Yet, the number of bank borrowers has been depressingly low. This highlights the fact that access to bank credit is highly constrained partly due to stringent credit policy of banks which is largely based on collateral lending. This has also led to a missing middle with respect to small enterprises constrained by limited access to formal banking sector finance. Moreover, although it is growing, most of the banks have low capital compared to their peers in some of the African countries, which also resulted in limited capacity to lend to big businesses in the absence of robust financial market.

8. Commercial banks, in particular, are increasingly investing in technology to increase efficiency and competitiveness. In addition, digital payment instruments are becoming more and more accessible to users. Yet, given a huge potential and untapped market, there is a need to expand such digital financial

services and to promote access to finance and financial inclusion in a country with over 110 million population and steadily growing economy.

9. While economic growth averaged 6-7 percent during the last five years with a slowing trend in recent years due to external and internal shocks including, the impact of COVID-19 and absence of peace in some parts of the country and due to Russia-Ukraine war.

Ladies and Gentlemen,

10. Please allow me now to share with you some of the key reform measures undertaken by NBE over the last three years to enhance the development of the financial system, including the payments system and to increase financial intermediation and financial deepening in light of the goals and objectives highlighted in the 10 year perspective plan and the 3 year Home Grown Economic Reform Program.

11. Here are some of the key reform measures undertaken by NBE:-
    - A number of proclamations and directives related to financial institutions, payments system and digital finance have been newly issued, revised and/or harmonized;
    - Demonetization of the currency notes has been successfully conducted;
    - Domestic digital finance instrument issuers are allowed to operate in Ethiopia;
    - Capital Market Proclamation has been issued and preparations are underway to establish capital market authority and security exchange;
    - Deposit insurance Fund Regulation has been issued to protect small depositors;
    - Microfinance institutions are allowed to graduate to commercial banks without abandoning their core MFI functions of serving low income groups and creating assets. Accordingly, since August, 2020, 3 MFIs have already been relicensed to join the banking business;
    - Besides allowing Ethiopian diaspora, a comprehensive policy study is ongoing to allow foreign investment in the Ethiopian financial sector;
    - Market based Treasury bill auction system is introduced to increase indirect monetary policy instruments and to provide investment means to commercial banks and to create an alternative source of deficit financing for the government.
    - NBE revised and implemented directives on standing facilities with the aim of providing short and long term refinancing facilities to banks and injected

liquidity to the banking system during Covid-19 pandemic to enable banks to meet their liquidity challenges and to provide adequate credit allocation to economic agents. Similarly, the Bank has discontinued the 27 percent rule for the purchase of NBE bills by commercial banks;

- NBE eased forex regulations by issuing directive for foreign currency intermediation to allow commercial banks to access foreign funds to cater for their and that of their clients;
- Allowed the establishment of full-fledged interest free banking businesses besides banks providing a dedicated window service for the purpose with a view of enhancing financial inclusion. Accordingly, 2 full-fledged interest free banks have already become operational and more such banks are under formation;
- Similarly, NBE has issued directive to license takaful operator or authorize takaful window operator to ensure access to insurance business services;
- Credit reference bureau has been upgraded to enable financial institutions to access the creditworthiness of borrowers and to make prudent lending decisions to overcome the risk;
- NBE issued Use of Agents Directive to allow for broader access to agent network management whereby banks and non-bank financial institutions shall be licensed to manage agent networks for financial services;
- Moveable Property Security Right Proclamation has been issued to enable owners of moveable property to use it as collateral to borrow from financial institutions and to enhance access to finance, promote financial inclusion.
- National Financial Education Strategy was prepared to enhance the capability of targeted people to change their behavior to act and manage financial resources and transactions through understanding, selecting and making use of financial products and services that fit one's needs;
- Financial Consumers' Protection Directive has been issued to promote trust and confidence of financial consumers and to enhance financial inclusion, healthy financial transactions and to stimulate growth;
- Issued Licensing and Authorization of Payment Instrument Issuers Directive to provide for non-bank financial institutions to be licensed as financial service providers which include mobile network operators and FinTechs. This directive was issued to allow Ethiopian diaspora to invest in payment instrument issuance and payment system operator business in Ethiopia;

- Licensing and Authorization of Payment System Operators Directive was issued to foster transparency, ensure interoperability, guarantee effective protection of customers, create competitive environment and promote financial inclusion by maintaining safety and efficiency of the national payment system and by regulating and setting standards to oversee the payment system operators.
- NBE has developed National Digital Payment Strategy (2020-2024) to initiate transformation in the payment ecosystem to move towards a cash-lite and more financially inclusive economy. It is part of the modernization plan of the overall Ethiopian national retail payment system.

Distinguished Guests
Ladies and Gentlemen

12. These reform measures and those on the pipeline are intended to bring about meaningful changes in the overall architecture of the financial system in country and to match with international standards as we prepare for opening up the financial sector to foreign investment which is expected to increase contestability, advanced technology and know-how, FDI and job opportunities. To this end, the NBE is pressing for more robust and comprehensive reform agenda to prepare both itself and the financial industry to the upcoming challenges.
13. Therefore, I would like to call upon the Ethiopian Economics Association and its distinguished members, to closely collaborate with the NBE on undertaking research and studies on topics related to inflation, financial inclusion and digital payments system to modernize the financial sector and the overall payments system with a view of contributing to policy advice and as valuable input for policy makers and regulators.
14. Finally, I would like to congratulate the Ethiopian Economics Association for its past contributions and for successfully organizing this conference. I wish you a fruitful deliberation to all and for those who came from abroad to participate in the conference, a happy stay in Addis.

THANK YOU FOR YOUR ATTENTION!

The Effect of Land Certification on-Farm Investment and Intermediate Input Use: Evidence from Rural Ethiopia

Kefyalew Endale[1], Hailu Elias, Getnet Alemu, and Worku Gebeyehu

Abstract

This study investigates the effect of plot certification (measured by the number of years since the plot was certified) on land investment and intermediate input use by using three rounds of panel household data collected in 2011/12, 2013/14, and 2015/16 as part of Ethiopian Socioeconomic Surveys. The regression results show a significant positive relationship between plot certification and terracing, especially on erosion-prone plots. The increase in terracing due to the certification program is, in turn, found to induce larger chemical fertilizer use on terraced plots. The results further show that the perceived quality of the certified plot increases the adoption of organic fertilizer but decrease chemical fertilizer use. Farmers are reluctant to use chemical fertilizers on fertile plots probably due to fear of on soil depletion. Non-fertile plots, on the other hand, are largely those prone to erosion and farmers are less likely to use organic fertilizers due to risk of erosion before the benefit of this important nutrient is reaped in full. The findings suggest that an improved extension approach and material supports in terracing to improve the effectiveness of the investments in erosion prevention. This could foster the effects of plot certification by enhancing the use of organic fertilizer on terraced plots for a sustainable restoration of fertility. Moreover, promoting biofertilizers to overcome soil depletion from using chemical fertilizers.

Key words: Plot certification, terracing, fallowing, tree planting, farm intermediate inputs
JEL: Q15; Q16; Q24

[1] Addis Ababa University Institute of Development for Policy and Research (IDPR) May 2022

1. Introduction

Experience from currently developed countries shows the central role played by well-developed legal structures and secured right over property (such as land) in economic development (De Soto, 2000). Investments in land improvement and farm intensification largely depend on land ownership rights and land tenure security (Otsuka and Place 2001). But in many developing countries land rights are not established by land titles but maintained by the continuous use of the land (De Janvry et al., 2015). Lack of secured rights over land in turn discourages long-term productivity-enhancing investments because without secured right there is no guarantee to reap the rewards of investment (Jacoby, 2002). The Low-cost land certification program has been promoted and implemented in many developing countries to reduce land tenure insecurity (Holden et al., 2009).

Ethiopia is among the developing countries which implemented the low-cost land certification program on a larger scale. Consequently, many empirical studies have been conducted to investigate the impact of the program and uncovered its key roles in transforming the rural economy. Some of the empirical evidence on the effects of land certification include: increased take-up of agricultural extension packages, participation in community-level sustainable land and water management, and the adoption of chemical fertilizer (Adamie, 2021); enhanced tenure security over landholding (Deininger et al., 2011; Holden et al., 2011), increased terracing and bunding (Deninger et al., 2008); repairs and new investments in soil and water conservation (Deininger et al., 2011), repairs of existing soil conservation structures (Holden et al., 2009), stimulated land rental transactions (Deininger et al., 2011; Holden et al.,2011), encourages tree planting (Holden et al., 2009; Mekonnen et al., 2013), boost land productivity (Melesse, 2015; Holden et al.,2009), and improved household welfare (Holden and Ghebru, 2013).

Though many of the studies seem to suggest positive effects of land certification in Ethiopia, some studies found that the program has no significant effect on farm investment. For instance, Tesfaye et al., (2014) found that land certification has no significant relationship with soil conservation using data collected from 498 rural households in the Gedeb watershed area of the Amhara region. Similarly, Holden et al., (2009) found land certificates as insignificant on soil bunds and weakly positive (i.e., not a robust one) evidence on terraces in Tigray. One of the motivation of the current study is to provide additional evidence on the effect of land certification on farm and intermediate input use.

This study also differs from most of the previous studies on land certification by the type of data used. Most of the existing studies on land certification in Ethiopia depend on cross-sectional data and from narrow geographical coverages. An exception in this regard is Adamie (2021) study who used panel household data from rural areas in 10 regions to analyses the effect of land certification on agricultural extension packages, participation in community-level sustainable land and water management, and chemical fertilizer use. Household level Panel data enables to control time invariant household specific characteristics unlike cross-sectional based analysis. Our study is also based on panel household data collected from the rural areas in 10 administrative regions but the main outcome variables are level farm investments, fallowing, tree planting, and intermediate input use (which includes improved seeds, chemical fertilizers, and organic fertilizers).

The third contribution of the current study is that it investigates whether the induced long-term investment in soil conservation due to the certification program affects the use of intermediate inputs or not. The role of plot certification on soil conservation is a well-documented issue both in the theoretical and empirical literature (Deninger et al., 2008, Deninger et al., 2011). When land-related investments such as terracing increases due to tenure security as a result of certification program, farmers could be induced to use farm intermediate inputs intensively. This is because investments in soil conservations are complementary with intermediate input use such as fertilizers, improved seeds, herbicides and pesticides in boosting farming productivity (Cornia, 1985). Previous studies have given emphasis only to the direct effects of certification on intermediate inputs with no emphasis to the complementary effect of the program. Investigating the complementary consequence of the certification program is the additional contribution of the existing study.

The fourth contribution of the current study is to provide an evidence on whether the perceived quality of the certified plot moderates the effect of plot certification on intermediate input use with a focus on chemical and organic fertilizers. Chemical and organic fertilizers are helpful in raising crop yield but they affect soil fertility differently. Chemical fertilizers are very effective in raising crop yield in the short-run but may destroys soil texture and soil fertility in the long run (Cheng et al., 2020; Chen 2016; Mishra et al., 2013; Nkoa, 2014). Use of organic fertilizer, on the other hand, increases not only crop yield but also improves the soil fertility in the long-run by enhancing soil texture and its water holding capacity (Leifeld, 2010). The certification program, through its effect on tenure security, could affect the type of fertilizer differently depending on the quality of the certified plot. Certification of quality plots could encourage farmers to increase the use of organic fertilizer instead of chemical fertilizers to protect their plot from soil depletion arising from the continuous use of chemical fertilizers. Exploring these issue is among the main focuses of this study.

The remaining section of this study is organized as follows: Section II provides the conceptual framework and empirical specification, Section III provides the descriptive and regression analysis, and finally Section IV concludes the study with brief policy recommendation.

2. Conceptual Framework, Empirical Specification, and Type of Data

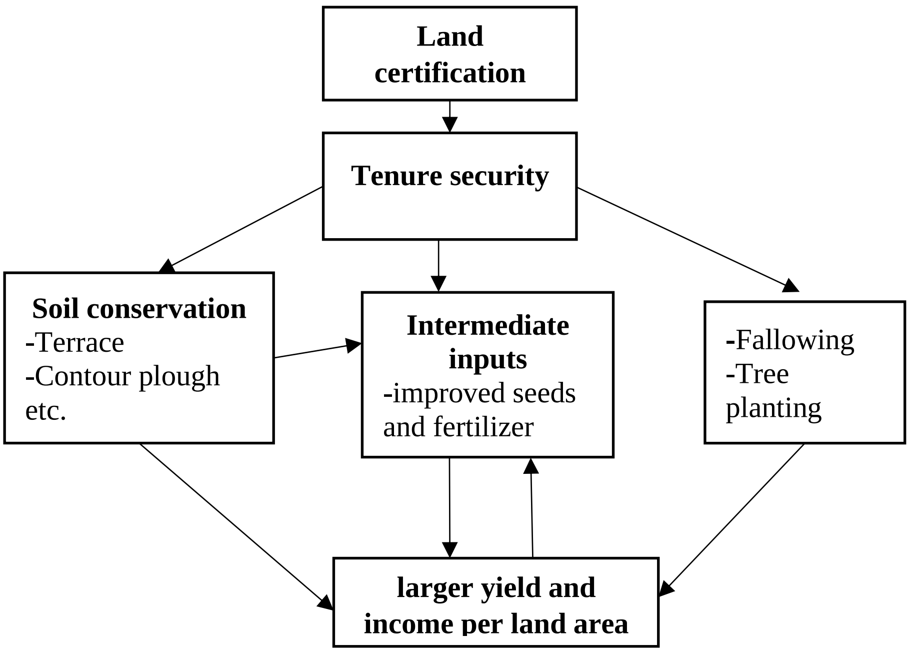
2.1 Conceptual framework

The literature suggests that land certification increases the tenure security of farmers by reducing the land related conflict between farmers and fear of expropriations by government authorities (Deininger et al., 2011; Holden et al., 2009). The enhanced tenure security, in turn, among others, improves land investments which could take different forms such as soil conservation (Deininger et al., 2011, Holden et al., 2009), tree planting (Fenske, 2011; Holden et al., 2009; and Mekonnen et al., 2013;), fallowing (Fenske, 2011; Goldstein, 2018), extension packages, fertilizer, and watershed (Adamie, 2021).

Because of the complementarity between soil conservation and farm intermediate inputs (Cornia, 1985), plot certification could boost the use of intermediate inputs through its effect on soil conservation especially long-term soil conservations practices. In other words, farmers who made efforts in soil conservation and related investments in farmland are more likely to increase the use of complementary farm intermediate inputs such as improved seeds, chemical fertilizers, organic fertilizer, pesticides, herbicides and so on to enhance crop yield per plot. This effect is denoted by the arrow from soil conservation to intermediate input (Figure 1).

The middle arrow shows the direct effect from tenure security to intermediate inputs: organic fertilizer, chemical fertilizer, and improved seeds. Organic fertilizer use increases the organic content of the soil, soil water retention capacity, and the beneficial bacteria and decreases soil acidity (Cheng et al., 2020; Chen 2016). Due to these sustainable roles of organic fertilizer the enhanced tenure security due to land certification is expected to increase the adoption of organic fertilizer on fertile plots. Excessive use of chemical fertilizers use, on the other hand, result in undesirable soil quality consequences such as acidification, destruction of soil friendly microorganisms and soil structure (Chen, 2020). Thus, the use of chemical fertilizer use could decline as tenure security improves over the fertile plots increases due to the certification programs. Improved seeds are short-term and their use could increases when the other intermediate inputs increases. In addition to tenure security, the increases income due to improved crop yield, tree planting, and related investments might reduce farmers financial constraint for the purchases of chemical fertilizers and improved seeds. These effects are expected to be positive on the intermediate input uses. This is denoted by the arrow from the bottom box to middle box. The framework adopted in this study is, therefore, similar in approach with most of the existing empirical works which examine the implications of land certification on farm investments and intermediate inputs through its effect on tenure security of farmers. The figure below summaries the channels through which land certification affects the various outcome variables of interest. The arrows in the chart denote causation.

Figure 1: The links between land certification and farm investment



Source: own construction based Deininger *et al.*, 20011, Holden *et al.*, 2009, Goldstein *et al.*, 2018

2.2. Empirical specification

Based on the literatures that land certification increases tenure security of farmers (Deininger et al., 2011; Holden et al.,2011) and the enhanced tenure security in turn improves land investment (Besley, 1995; Deininger et al., 2011; Goldstein et al., 2018), the following specification is used to investigate the relationship between parcel certification and the various parcel/plot2 level outcome variables.

$$Inv_{itp} = \alpha_t + \beta Yrs\_Certified_{itp} + \gamma H_{it} + \varphi P_{itP} + c_i + u_{it} \qquad \textbf{(1)}$$

Where $Inv$is the outcome variable which takes a value "1" or "0" for binary outcome variables (soil conservation methods, fallowing, and tree planting) for household i at wave t in parcel/ plot p. $Yrs\_Certified_{itp}$ is the main policy variable of the study which is the number of years in wave t since the parcel/plot p of household i was certified. H_{it} is the vector of household characteristics and household level variables like household size, access to credit, size of farmland, and household head characteristics such as age, gender, literacy, and marital status. P_{itP}, on the other hand, is the vector of Parcel/plot characteristics such as method of acquisition of the parcel (accessed from woreda land administration, inheritance, rent, etc), plot size, quality, slope, and so on. The intercepts α_t captures the time effects and c_i capture the time invariant household-specific unobserved heterogeneity across the waves and u_{it} is the error term.

Our other specification is for the intermediate input use to investigate whether plot certification intersects with soil conservation in inducing intermediate input uses. According to the inverse farm-size productivity hypothesis, labor effort per farmland in the form of soil conservation increase as farm-size decreases and this is accompanied by intensive use of intermediate inputs due to complementarities between soil conservation practices and intermediate input uses (Cornia, 1985). The empirical specification for investigating the complementarity is provided below in Equation 2. The outcome variables in Equation 3 are intermediate inputs (dummies for improved seeds and organic fertilizer and the natural logarithm of chemical fertilizer used (in kg)). The subscript p in equation 2 denotes plot and the other subscripts are as defined above in equation 1. The coefficient of the interaction term of the number of years since the plot was certified with the dummy of soil

2 Soil conservation variables are at parcel level whereas fallowing, tree planting, and intermediate input use are at plot level

conservation captures whether plot certification induces intermediate input uses or not through its effect on soil conservation.

$$Intermediate\_Inputs_{itp} = \alpha_t + \beta Yrs\_Certified_{itp} + \delta Yrs\_Certified_{itp} * Terraces_{itp} + \gamma H_{it} + \varphi P_{itP} + c_i + u_{it} \quad \textbf{(2)}$$

This specification examines the moderating role of terracing on the relationship between certification and input use. As a result it demands testing four different hypothesis:

1. If β>0 and δ>0, certification will have a positive effect on input use and terracing will further enhance the positive effect
2. If β>0 and δ<0, certification will have a positive effect on input use but terracing will influence the positive effect adversely.
3. If β<0 and δ>0, certification will have a negative effect on input use but existence of terracing will mitigate the negative effect
4. Finally, if β<0 and δ<0, certficaiton will have a negative effect on input use and existence of terracing will further aggravate the negative effect

This study further examines whether farmers choice of intermediate inputs varies by the quality of certified plots. To investigate whether the effect of certification varies by plot quality, an interaction term between the number of years since the plot was certified with the plot quality indicator dummy (that takes a value “1” if the household perceives the quality as good and “0” otherwise) is additionally controlled in the specification (Equation 3). The outcome variables in Equation 3 are as defined above in Equation 2. The coefficient of the interaction term δ captures whether the effect of plot certification on the outcome variables vary by plot quality or not.

$$Intermediate\_Inputs_{itp} = \alpha_t + \beta Yrs\_Certified_{itp} + \delta Yrs\_Certified_{itp} * Fertile\ Plot_{itp} + \gamma H_{it} + \varphi P_{itP} + c_i + u_{it} \quad \textbf{(3)}$$

This specification examines the moderating role of plot quality on the relationship between certification and input use. As a result it demands testing four different hypothesis:

1. $If\ \beta>0\ and\ \delta>0,$ certification will have a positive effect on input use and plot quality will further ehnace the postiv effect,

2. *If* β>0 *and* δ<0, certification will have a positive effect on input use but plot quality will influence the positive effect adversely,
3. *If* β<0 *and* δ>0, certification will have a negative effect on input use but existence of plot quality will mitigate the negative effect,
4. Finally, *if* β<0 *and* δ<0, certficaiton will have a negative effect on input use and existence of plot quality will further aggravate the negative effect.

Methods of estimation

For the binary outcome variables, household fixed effect panel logit regression method is employed and for the continuous outcome variable (the natural logarithm of chemical fertilizer used in kg), panel Tobit regression is used because the variable is bounded at zero from below in plots without chemical fertilizer use. For each regression both the coefficients and the corresponding marginal effects are reported.

2.3. Data source

This paper uses panel data from Ethiopian Socioeconomic Survey (ESS) conducted as part of the World Bank's Living Standard Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA). The survey was first conducted in 2011/12 in ten regions[3] in rural areas and small towns. The second and third rounds were respectively conducted in 2013/14 and 2015/16. Medium and large towns[4] were included as part of the surveys in addition to rural and small towns in the second and third rounds.[5] In total 3969 households (3,466 from rural and 503 from small towns) were interviewed in 2011/12, 5,262 households (3,323 from rural, 453 from small towns, and 1,486 from medium and larger towns) were interviewed in 2013/14, and 4,954 households (3,272 from rural, 427 from small towns, and 1,255 from medium and large towns) were interviewed in 2015/16. For this study we consider only the rural samples as our topic of research is about land certification of rural farms.

[3] Tigray, Afar, Amhara, Oromia, Somali, Benishangul Gumuz, Southern Nations, Nationalities and People (SNNP), Gambella, Harari, and Dire Dawa city administration

[4] Addis Ababa city administration was included as an additional sample region in the second and third rounds.

[5] Another round of ESS was conducted in 2018/19 in all regions. But this time a fresh list of samples were drawn and hence a panel data cannot be formed with the previous three rounds.

3. Data Presentation and Analysis

3.1. Descriptive statistics

In this section summary statistics for the main outcome variables and independent variables by household and parcel certification status is presented over the three waves depending on data availability. The results help to explore whether land certification has a possible relationship with the various outcome variables and the direction of the relationship before proceeding to the regression method.

3.1.1. Demographic characteristics of households

Table 1 shows the summary statistics of household head and household level variables across the three waves. As expected the characteristics of household heads did not change much in the three waves. About 24% of the households are female headed. The average age of heads increased from 45 years in 2011/12 to 48 years in 2015/16 while the literate heads increased marginally from 37% to 39%. Household size increased from 4.9 to 5 between the first two waves and further increased to 5.1 between the last two waves. On the other hand, access to credit increased by four percentage points between 2011/12 and 2013/14 but then decreased by three percentage points between 2013/14 and 2015/16.

Table 1: Household and household head characteristics across the three waves

Variable	2011/12 (Wave 1)			2013/14 (Wave 2)			2015/16 (Wave 3)		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Female headed (=1)	3410	0.24	0.43	3322	0.25	0.43	3268	0.25	0.43
Age of Head	3403	44.5	15.8	3317	46.2	15.3	3262	47.9	15.2
Married head (=1)	3395	0.77	0.42	3297	0.76	0.43	3249	0.76	0.43
Never married (=1)	3395	0.03	0.18	3297	0.03	0.16	3249	0.02	0.13
Divorced (=1)	3395	0.05	0.21	3297	0.06	0.24	3249	0.06	0.24
Separated (=1)	3395	0.02	0.14	3297	0.01	0.12	3249	0.01	0.12
Widowed (=1)	3395	0.13	0.34	3297	0.14	0.35	3249	0.15	0.36
Literate (=1)	3390	0.37	0.48	3293	0.38	0.48	3251	0.39	0.49
Household size	3466	4.9	2.37	3323	5.02	2.35	3269	5.14	2.37
Credit access (=1)	3381	0.24	0.43	3314	0.28	0.45	3269	0.25	0.43

3.1.2. Soil conservation and plot purpose by parcel certification status

Table 2 provides the descriptive summary statistics of soil conservation and plot purpose across the three waves by parcel level certification status which takes a value "1" if the plot is part of a certified parcel and "0" otherwise. The average number of years[6] since certification (for certified parcels) increased from 4.42 years in Wave 1 to 6.8 and 8.1 years in Wave 2 and Wave 3, respectively.

Table 2: Types of soil conservation investments and plot purpose by certification status

	2011/12 (Wave 1)		2013/14 (Wave 2)		2015/16 (Wave 3)	
	Uncertified	Certified	Uncertified	Uncertified	Certified	Uncertified
Years certified		4.42		6.8		8.1
(observations)		(3,657)		(5,067)		(5,662)
Soil conservations						
Any soil conserve.(%)	28.0	29.2	47.8	53.2***	47.4	54***
Terrace (%)	17.5	10.6***	23.6	23.2	24.7	24.4
Water catchm (=1)	1.4	0***	0.4	0.3	1.1	0.7***
Afforestation (%)	0.3	1.1**	0.6	0.7	0.4	0.9***
Contour ploug (%)	6.5	8.7**	12.3	15.8***	14.7	17.8***
Others (%)	2.2	8.9***	10.8	13***	6.4	10.2***
Number of plots	1,194	1,563	10,061	13,545	8,482	14,992
Plot purpose						
Cultivated (%)	71.1	74.1***	66.1	69.7***	66.9	71.3***
Pasture (%)	5.7	7.9***	6.1	7.9***	5.8	8.1***
Fallow (%)	2.4	2.1	3.9	3.3**	3.8	4
Forest (%)	4.2	4	2.4	3.9***	2.3	3.9***
Number of plots	14,242	13,583	12,546	15,868	10,519	16,934

Note: ***, **, and * denotes statistical significance between the mean difference between certified and uncertified parcels/plots at 1%, 5%, and 10% significant level.

In the discussion of soil conservation practices, emphasis is given to the second and third waves because information regarding the practices were not

[6] There were parcels which were uncertified until Wave 1 (2010/11) but certified between Wave 1 and Wave 2 and there are also parcels which were certified between Wave 2 and Wave 3.

gathered from most of the households during the first wave. The likelihood of practicing one or more type of erosion protecting methods was significantly larger on certified over the uncertified parcels both in Wave 2 (53.2% vs 47.8%, p<0.01) and Wave 3 (54.1% vs 47.4%, p<0.01). Terracing is the dominant method practiced on both certified and uncertified plots with a prevalence rate of 23% in Wave 2 and 24% in Wave 3. The simple mean difference does not show statistically significant differences in the adoption of plot level terrace by certification status but it is investigated rigorously in the next regression section by accounting for the key determinants such as slope of the parcel.

The second most common erosion prevention method is contour ploughing and its adoption rate increases with plot certification. The share of plots with contour plough on the certified plots increased from 15.8% to 17.8% between Wave 2 and Wave 3 while the share on uncertified plots increased from 12.3% to 14.7%. The other method constitutes the third common types of soil conservation and is also significantly larger on certified plots over the uncertified ones: 13% vs. 10.8% (p<0.01) in wave 2 and 10.2% vs. 6.4% (p<0.01) in Wave 3. Finally, water catchment and afforestation are practiced by a very small share of households on both waves. In terms of main purpose of plots, the analysis shows that crop cultivation is the dominant purpose with over 66% of certified as well as uncertified plots followed by pasture for cattle grazing purpose with over 5.7% of the plots. The use of certified plots (over the uncertified) tend to be larger in cultivation, pasture, and forest but not in fallowing (Table 2).

3.1.3. Intermediate input use in agriculture

The use of intermediate input use by plot certification status is presented on Table 3. Panel A shows the results from all plots regardless of soil conservation and plot quality statuses. Improved seed adoption rate is generally low (below 7%) across the three waves. Improved seed adoption rate between certified and non-certified plots was not significant in Wave 1 but it is found to be significantly larger on certified plots in Wave 2 (3.6% vs 5.3% , p<0.01) and Wave 3 (4.4% vs 6%, p<0.01). With regard to chemical fertilizer adoption, the largest adoption rate was 27% which is reported on the certified plots in Wave 2 indicating that majority of the plots (over 73%) are planted without chemical fertilizer.

Table 3: Intermediate input use by wave and plot certification status

	2011/12 (Wave 1)		2013/14 (Wave 2)		2015/16 (Wave 3)	
	Uncert.	**Certif.**	**Uncert.**	**Certif.**	**Uncert.**	**Certif.**
Panel A: on all plots						
Improved seed (%)	4.5	4.8	3.6	5.3***	4.4	6.0***
	(9,940)	(9,857)	(8,303)	(11,033)	(7,039)	(12,062)
Chemical Fertilizer (%)	15.0	22.0***	17.2	26.9***	15.9	26.2***
	(10,042)	(9,768)	(8,413)	(11,203)	(7,049)	(12,085)
Chemical fertilizer (kg)	2.3	4.5***	3.9	6.5***	4.7	7.1***
	(9,215)	(8,821)	(7,823)	(9,995)	(6,502)	(10,641)
Chemical fertilizer on	32.5	33.8	36.0	36.0	53.5	43.6
fertilized (kg)	(660)	(1,176)	(850)	(1793)	(573)	(1723)
Organic fertilizer (%)	27.8	33.3***	31.3	36.6***	27.7	35.1***
	(10,099)	(9,968)	(8,377)	(11,161)	(7,052)	(12,090)
Panel B:erosion-protected plots						
Improved seed (%)			3.9	6.1***	4.8	6.5***
			(4,358)	(6,458)	(3,659)	(7,252)
Chemical Fertilizer (%)			25.5	36.6***	22.0	36.7
			(4,390)	(6,547)	(3,672)	(7,274)
Chemical fertilizer (kg)			5.5	8.5***	6.7	9.5**
			(3,928)	(5,618)	(3,312)	(6,119)
Organicfertilizer (%)			33.5	36.1**	29.0	32.7***
			(4,373)	(6,517)	(3,674)	(7,277)
Panel C: on fertile plots						
Improved seed (%)			3.8	5.7***	5.3	7.2***
			(3,241)	(3,893)	(2,770)	(3,734)
Chemical Fertilizer (%)			16.1	23.3***	14.4	25.2***
			(3,297)	(3,955)	(2,762)	(3,747)
Chemical fertilizer (kg)			3.6	5.7***	3.7	6.2
			(3,080)	(3,587)	(2,582)	(3,362)
Organic fertilizer (%)			32.5	38.8	25.2	38.9
			(3,279)	(3,940)	(2,763)	(3,749)

Note: ***, **, and * denotes statistical significance between the mean difference between certified and uncertified parcels/plots at 1%, 5%, and 10% significant level. The elements in parenthesis are the number of observations. Erosion prevention and plot quality information was not gathered in Wave 1.

Moderate increases in the adoption of fertilizer observed between Wave 1 and Wave 2 but then slight decreases recorded between Wave 2 and Wave 3. The decrease in the adoption of chemical fertilizer between Wave 2 and Wave 3 could be due to dis-adoption of the input by some farmers as a result of the severe drought in 2015/16. Comparison of chemical fertilizer adoption by plot certification status shows significantly larger adoption rate in certified over the uncertified plots in all waves. The quantity of chemical fertilizer used (in kg) across the three Waves indicates no reduction in the quantity of the input used on average terms even if some farmers have dis-adopted the input due to the 2015/16 drought. The highest quantity of chemical fertilizer used (on fertilized plots) was 53 kg which was observed in Wave 3 on uncertified plots). No significant differences in the quantity of chemical fertilizer used (on fertilized plots) found between certified and non-certified plots.7 In sum the results implies that plot certification is associated with significant increase in the adoption as well as quantity of chemical fertilizer use.

The use of intermediate inputs is further investigated by soil conservation status (Panel B) and plot qualities (Panel C) to explore whether the impact of plot certification intersects with soil conservation and plot quality in inducing the use of intermediate inputs. The adoption rates of improved seeds and chemical fertilizers as well as the average quantity of chemical fertilizer on certified and soil conserved plots (in Panel B) are larger in both Wave 2 and Wave 3 than the respective adoption rates and average quantity on certified plots (regardless of soil conservation status) reported in Panel A. For instance, the rate of chemical fertilizer use and quantity on certified plots (regardless of soil conservation status on plots) are 26.9% and 6.5 kg in Wave 1 and these increased to 36.6% and 8.5 kg in the same period when certified and soil conserved plots are considered. The adoption rate of organic fertilizer on certified and soil conserved plots, on the other hand, are lower (36.1% in Wave 2 and 32.7% in Wave 3) than the figures obtained from certified plots regardless of soil conservation status (36.6% in Wave 2 and 35.3% in Wave 3). Thus, comparison of the results in Panels A & B (Table 3) suggests that plot certification could induce improved seed and chemical fertilizer adoption through its effect on soil conservation but no such effect on the adoption of organic fertilizers.

Comparison of the results on Panels A and C (Table 3) for certified plots, on the other hand, shows that certification of fertile plots is associated with increases in the adoption rates of improved seeds and organic fertilizer but decreases the adoption

[7] The mean difference for this variable has to be taken with precaution. The number of certified plots with non-zero fertilizer are roughly twice as much as the uncertified in each Wave and there are many plots with smaller chemical fertilizer quantities on certified plots (than the uncertified) and this understates the average quantity on certified relative to the uncertified.

as well as the quantity of chemical fertilizer use. In sum results in Table 3 suggest that plot certification is significantly associated with the adoption of improved seeds, chemical fertilizer, organic fertilizer and on the quantity of chemical fertilizer. A further finding is that plot certification could induce improved seed and chemical fertilizer by inducing soil conservation whereas certification of fertile plots increases the adoption of improved seeds and organic fertilizer but it decreases the use of chemical fertilizers.

3.1.4. Plot characteristics, parcel acquisition and certification status

Table 4 presents the summary information about slope, households perceived quality of their plots, and the method of plot acquisition. With regard to slope, the dominant share of plots are flat, followed by moderately slope and steep slope plots. About 60% of the plot are flat, 30% are moderately slopped, and 10% are steep slope. In Waves 1 and 2, the share of certified flat slopes exceed that of the uncertified flat slopes. The share of certified moderately slope plots were smaller (than uncertified moderately slopped plots) in Wave 1 but in Wave 3 the share of certified moderately slopped plots exceeded significantly. The share of certified steep slope plots (compared to uncertified steep slope) was significantly larger in Wave 1 but significantly lower in Wave 2 and Wave 3. The results, in sum, do not suggest systematic relationship between plot slope and certification status.

With regard to plot quality, the information was collected only in Wave 2 and Wave 3. Majority of the plots are fairly quality (47%), followed by fertile plot (36%) and poor quality (17%). The results show that smaller share of fertile plots (compared to uncertified fertile plots) in Wave 2 as well as Wave 3. There are larger share of certified fairly fertile plots (than the uncertified fairly fertile) in both Wave 2 and Wave 3. There are also significantly larger shares of certified poor quality plots (than uncertified poor quality plots) in Wave 3. This suggests no systematic relationship is found between plot quality and certification status.

Looking at the plot acquisition method, most of the plots were acquired through grants from local administrators followed by inheritance (Table 4). It is found that plots acquired from local administrators is more likely to be certified whereas plots acquired through inheritance are less likely to be certified which may be related to issues raised by the other relative over plots received through inheritance. Plots acquired through just moved-in (without permission) and other methods are also less likely to be certified probably due to lack of proper documents to start the certification process.

Table 4: Plot characteristics and method of acquisition by year and certification status

	2011/12 (Wave 1)		2013/14 (Wave 2)		2015/16 (Wave 3)	
	Uncert.	**Certif.**	**Uncert.**	**Certif.**	**Uncert.**	**Certif.**
Flat (%)	59.0	61.4***	56.4	58.9***	58.8	59.4
	(12,368)	(11,354)	(12,282)	(15,294)	(10,486)	(16,917)
Moderate (%)	32.4	28.4***	30.7	30.6	31.2	32.9***
	(12,368)	(11,354)	(12,282)	(15,294)	(10,486)	(16,917)
Steep (%)	8.7	10.4***	13	10.6***	10.1	7.8***
	(12,368)	(11,354)	(12,282)	(15,294)	(10,486)	(16,917)
Fertile plot[8] (%)			38.9	34.9***	39.0	31.2***
			(12,481)	(15,860)	(9,998)	(17,074)
Fairly fertile (%)			43.6	48.2***	47.2	53.1***
			(12,481)	(15,860)	(9,998)	(17,074)
Poor quality (%)			17.4	17.0	13.8	15.7***
			(12,481)	(15,860)	(9,998)	(17,074)
Field_size (ha)	0.12	0.13**	0.13	0.14	0.14	0.11***
	(12,077)	(11,050)	(12,481)	(15,175)	(10,293)	(16,739)
Parcel acquisition						
Granted from local	28.6	57.1***	26	52.8***	23.2	49.6***
leaders (=1)	(14,355)	(13,756)	(12,625)	(15,933)	(10,716)	(17,437)
Inherited (%)	56.3	43.7***	65	45.2***	71.2	49.8***
	(14,355)	(13,756)	(12,625)	(15,933)	(10,716)	(17,437)
Moved-in (%)	6.8	0***	4.6	0***	4.9	0.5***
	(14,355)	(13,756)	(12,625)	(15,933)	(10,716)	(17,437)
Others (%)	9.5	0.5***	4.4	1.9***	0.7	0.1***
	(14,355)	(13,756)	(12,625)	(15,933)	(10,716)	(17,437)

Note: ***, **, and * denotes statistical significance between the mean difference between certified and uncertified parcels/plots at 1%, 5%, and 10% significant level. The elements in parenthesis are the number of observations. Plot quality information was not gathered in Wave 1.

The correlations between soil conservation, plot quality, and slope are presented in Table 5. Soil conservation is found to be positively associated with moderate and steep plot slopes but negatively associated with flat plot slope. The correlation between plot quality and soil conservation, on the other hand, is negative.

8 Soil quality is available only in the 2nd and 3rd wave and hence not controlled in outcome variables with observations from the three waves such as improved seeds

Soil conservation especially terracing is undertaken on erosion prone plots and these plots are less fertile than the non-conserved plots (which are flat slope plot and less vulnerable to erosion). The results imply that the soil conservations investments on sloppy plots are not effective enough to restore the quality of degraded plots.

Table 5: Correlations between soil conservation, plot quality, and slope

Erosion protection (=1)	1								
Terracing (=1)	0.547	1							
Contour plough (=1)	0.417	-0.241	1						
Good quality (=1)	-0.105	-0.066	-0.030	1					
Fair quality (=1)	0.035	0.002	0.032	-0.72	1				
Poor quality (=1)	0.090	0.083	-0.006	-0.321	-0.43	1			
Flat (=1)	-0.062	-0.087	0.040	0.089	-0.014	-0.097	1		
Moderately slope (=1)	0.029	0.044	-0.027	-0.056	0.039	0.020	-0.80	1	
Steep slope (=1)	0.054	0.071	-0.022	-0.057	-0.04	0.123	-0.40	-0.25	1

3.2. Regression analyses

3.2.1. Land certification and soil conservation

Table 6 shows the coefficients and the average marginal effects of panel logit fixed effect regressions of plot level soil conservation practices on the number of years since plot certification and other correlates. The outcome variable in Columns (1) and (2) is a dummy variable which takes "1" if there is any type of soil conservation in the plot and "0" otherwise. The outcome variable in Columns (3), (5), and (7) is a terrace dummy and in Columns (4) and (6) is a dummy for other soil conservation practices which takes "1" for soil conservation practices other than terrace (contour plough, water catchment, afforestation, and others) and "0" otherwise. The estimation in Column (7) is conducted using only the subsample of soil conserved plots. The coefficients and average marginal effects in Columns 3-7 are used to examine whether plot certification has differential effects on long term and short term soil conservation practices.

The years of certification is not statistically significant when soil conservation adoption is measured by dummy variable which takes "1" when any erosion prevention methods is adopted and "0" when there is no any soil erosion prevention investment on the plot. The coefficients and average marginal effects in the Columns 4-7, on the other hand, shows that the measure of plot certification is statistically significant on the different types of soil conservation practices but with mixed sign. One more year of plot certification is found to increase terrace adoption by 1.18 percentage points ($p<0.01$) but decreases the other soil conservations (short-term conservation methods) by 0.6 percentage points ($p<0.1$). The average marginal effect in Column (7) also shows that one more year of parcel certification is associated with a 0.7 percentage point ($p<0.01$) increase in the adoption of terraces relative to the reference short-term soil conservation method. The results from Table 6, therefore, shows that plot certification has facilitated the substitution of short-term soil conservation methods by long-term conservation methods. Similar results are reported in Gebremedhin and Swinton (2003) which reported that tenure secured farmers practice long-term soil conservation methods (stone terraces) whereas tenure insecure farmers tend to practice short-term soil conservation method like soil bunds in Tigray Region.

Table 6 also shows that soil conservation practices are mainly undertaken on sloppy parcels (both steep and moderate) and on less fertile parcels (fairly fertile and poor quality). Sloppy parcels are highly exposed to soil erosion and the fertility could decrease if there are no effective erosion protection investments. The inverse relationship between soil fertility and soil conservation highlights the need for effective soil conservations on especially on sloppy parcels and regular maintenance work on the terraces to deter soil depletion and restore land quality. Since long-term soil conservation practices are needed mainly in erosion prone parcels, we offered the estimation of soil conservation practices in Table 7 using only the subsample of moderately slope and steep slope plots. The results show that land certification is significantly associated with larger likelihood of investment in terraces on sloppy parcels. Even if parcels slopes are key drivers of long-term soil conservation investments, the effect of certification on the adoption of terraces remain robust to slope and other parcel as well as household characteristics.

Table 6: Panel logit fixed effect regressions of plot level soil conservation methods on plot certification and other correlates

Variables	Any soil conservation (=1)		Terrace (=1)		Others (Short-term) (=1)		Terrace vs others (=1)	
	Coeff	Meff	Coeff	Meff	Coeff	Meff	Coeff	Meff
	1	2	3	4	5	6	7	8
No. of years since certified	0.005	0.001	0.05***	0.012	-0.02***	-0.006	0.06***	0.007
	(0.74)		(6.78)		(-4.13)		(5.50)	
Female-Headed (=1)	-0.427**	-0.101	-0.24	-0.05	-0.33*	-0.08	0.652*	0.081
	(-2.49)		(-1.05)		(-1.84)		(1.93)	
Age of Head (years)	-0.01*	-0.002	-0.02***	-0.005	0.001	0.0003	-0.03***	-0.004
	(-1.84)		(-2.72)		(0.21)		(-3.41)	
Never married (=1)	-0.333	-0.079	0.22	0.05	-0.43**	-0.103	-0.56	-0.07
	(-1.63)		(0.75)		(-2.07)		(-1.540)	
Divorced (=1)	-0.86***	-0.204	-0.49**	-0.104	-0.54**	-0.131	0.476	0.0590
	(-3.97)		(-2.11)		(-2.35)		(1.28)	
Separated (=1)	0.940***	0.223	-0.013	-0.003	0.77**	0.187	-0.461	-0.057
	(2.662)		(-0.03)		(2.41)		(-0.83)	
Widowed (=1)	-0.196	-0.046	-0.62***	-0.130	0.16	0.040	-1.24***	-0.153
	(-1.39)		(-3.08)		(1.14)		(-4.0)	
Literate (=1)	-0.09	-0.022	-0.41***	-0.09	0.184**	0.04	-0.71***	-0.088
	(-1.30)		(-4.5)		(2.51)		(-5.86)	
Household size	0.008	0.002	0.026	0.006	-0.009	-0.002	0.023	0.003
	(0.37)		(0.90)		(-0.41)		(0.57)	
Farm size (in ha)	-0.006	-0.001	-0.12***	-0.03	0.025	0.006	-0.3***	-0.04
	(-0.65)		(-3.8)		(1.46)		(-6.31)	
Steep slope	0.86***	0.203	0.53***	0.11	0.49***	0.118	0.43***	0.054
	(15.00)		(7.86)		(8.51)		(4.8)	
Moderate slope	0.55***	0.13	0.43***	0.09	0.25***	0.060	0.32***	0.04
	(14.6)		(9.5)		(6.581)		(5.3)	

Fairquality plot (=1)	0.22***	0.053	-0.003	-0.001	0.224***	0.054	-0.061	-0.008
	(5.510)		(-0.06)		(5.513)		(-0.93)	
Poor quality plot (=1)	0.192***	0.046	0.17***	0.036	0.066	0.016	0.22***	0.02
	(3.438)		(2.7)		(1.181)		(2.6)	
Field size (ha.)	0.311***	0.074	0.49***	0.10	0.141***	0.034	0.414***	0.051
	(5.937)		(5.9)		(3.013)		(3.60)	
Inherited plot (=1)	-0.001	-0.001	0.184***	0.04	-0.135**	-0.033	0.152*	0.02
	(-0.03)		(2.76)		(-2.478)		(1.65)	
Just moved-in (=1)	-0.13	-0.03	-0.70***	-0.15	0.249	0.06	-0.72**	-0.09
	(-0.72)		(-2.80)		(1.374)		(-2.1)	
Other methods (=1)	-0.26	-0.06	-0.183	-0.039	-0.244	-0.06	-0.21	-0.026
	(-1.433)		(-0.686)		(-1.272)		(-0.51)	
Wave 3 (=1)	0.038	0.009	0.115***	0.024	-0.0120	-0.003	0.04	0.005
	(1.20)		(2.82)		(-0.38)		(0.70)	
Observations	32,487	32,487	21,423	21,423	30,939	30,939	11,701	11,701
Number of hhid	1,711		1,182		1,668		867	

z-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The results in columns (7) is are based on subsample of plots where erosion protection was implemented.

Table 7: Panel logit fixed effect regressions of soil conservation on sloppy parcels on plot certification and other correlates

	Erosion prevention (=1)		Terrace (=1)		Others (short-term (=1))	
	Coeff	Meff	Coeff	Meff	Coeff	Meff
Variables	**1**	**2**	**(3)**	**(4)**	**(5)**	**(6)**
No. of years since certified	0.0485***	0.0117	0.0414***	0.00391	0.0153	0.00338
	(4.175)		(3.070)		(1.364)	
Female Headed (=1)	-0.0523	-0.0126	-0.457	-0.0432	-0.143	-0.0314
	(-0.180)		(-1.205)		(-0.436)	
Age of Head (years)	-0.00850	-0.00205	-0.053***	-0.00503	0.0138	0.00305
	(-0.892)		(-3.335)		(1.516)	
Never married (=1)	0.0373	0.00901	-0.385	-0.0364	0.261	0.0573
	(0.113)		(-0.808)		(0.718)	
Divorced (=1)	-0.602	-0.145	-1.268***	-0.120	0.784*	0.173
	(-1.408)		(-3.155)		(1.684)	
Separated (=1)	2.389**	0.576	-0.452	-0.0427	1.558**	0.343
	(2.082)		(-0.589)		(2.486)	
Widowed (=1)	-0.0494	-0.0119	-0.737**	-0.0696	0.565**	0.124
	(-0.218)		(-2.482)		(2.252)	
Literate (=1)	-0.237*	-0.0572	-0.220	-0.0208	-0.104	-0.0228
	(-1.769)		(-1.369)		(-0.738)	
Household size	-0.0152	-0.00366	0.0432	0.00409	-0.0460	-0.0101
	(-0.403)		(0.855)		(-1.152)	
Farm size (in ha)	-0.00567	-0.00137	-0.0955*	-0.00902	0.0129	0.00285
	(-0.685)		(-1.700)		(0.906)	
Steep slope (=1)	0.309***	0.0746	0.0719	0.00680	0.266***	0.0586
	(5.297)		(1.014)		(4.397)	
Fair quality plot (=1)	0.157**	0.0379	-0.111	-0.0105	0.252***	0.0554
	(2.327)		(-1.350)		(3.570)	
Poor quality plot (=1)	0.135	0.0326	-0.0915	-0.00864	0.211**	0.0464
	(1.584)		(-0.911)		(2.393)	
Field size (ha.)	0.0518**	0.0125	0.624***	0.0589	0.0235	0.00517
	(2.061)		(4.245)		(0.903)	
Inherited plot (=1)	0.0527	0.0127	0.318***	0.0301	-0.155*	-0.0342
	(0.624)		(2.996)		(-1.695)	
Just moved-in (=1)	0.177	0.0426	-0.130	-0.0122	0.194	0.0428
	(0.634)		(-0.358)		(0.662)	
Other methods (=1)	0.185	0.0447	0.396	0.0374	-0.0635	-0.0140
	(0.712)		(1.022)		(-0.231)	
Wave 3 (=1)	-0.0999*	-0.0241	0.0864	0.00817	-0.128**	-0.0283
	(-1.858)		(1.259)		(-2.320)	
Observations	13,106	13,106	8,958	8,958	12,139	12,139
Number of hhid	1,001		731		970	

z-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1,

3.2.1. The regressions results of fallowing and tree planting on plot certification

Table 8 offers the coefficients and average marginal effects from the panel logit fixed effect regressions on fallowing (Columns 1 and 2) and tree planting (Columns 3 and 4). The respective reference groups are plot uses for cultivation or pasture, or forest (Columns 1 and 2) and cultivation or pasture or fallowing (Columns 3 and 4). The number of years since the plot is certified is positive with average marginal effect of 0.7 percentage point ($p<0.01$) on the probability of planting trees on a plot. This finding is consistent with the findings of Holden et al., (2009) and Mekonnen et al., (2013) who uncovered significantly positive effect of land certification on plot level tree planting in Tigray. But there is no evidence of statistical significant relationships between plot certification and fallowing.

From the other correlates household size and plot acquisition through inheritance are found to decrease the likelihood of practicing fallowing with respective average marginal effects of 1.6 and 4.4 percentage points. The negative effect of household size indicates that as family members increase the demand for food and basic needs increases and this makes fallowing as unlikely choice in larger families. The use of fallowing approach as a soil fertility enhancing mechanism decreases with population pressure but improved tenure security and individualization of land rights could induce soil conservations, crop rotation, tree covers, and so on to protect soil degradation from the shortening of fallow period (Otsuka and Place, 2014). The negative estimate of inheritance, on the other hand, implies the landholder may be insecure to leave the land as fallow due to insecurity from the claims by other close relatives. Farm-size is positive and significant on tree planting highlights the allocation of land for trees with an increase in total landholding whereas in land poor households priority is given to crop cultivation. Plot size, on the other hand, is significantly negative on tree which suggests that a farmer with plots of different size allocates larger ones for crop production and smaller ones for tree planting because majority of the farmers are subsistent producers.

Both moderate and steep slope (relative to flat ones) are significantly associated with higher likelihoods of allocating the plots for fallowing and tree planting. Sloppy plots are prone to soil erosion during high rainfall than non-sloppy plots. Thus, farmers with several plots of different slopes allocates the non-sloppy ones for crop production where the rate of erosion during heavy rainfall is lower and the sloppy ones for fallowing and tree planting as they reduces the depletion of soil in rainy seasons. Plots acquired through just moved in (grabbed by the farmers without the permission of local land administration) are more likely to be used for tree planting instead of using them for crop cultivation. This may be because undertaking permanent investments on plots with lower tenure security could increase the right on the plot. This is consistent with Besley (1995) finding in

Thailand that farmers undertake long-term investment such as trees on less secured plots because these investments strengthen the farmers right over the plots.

Table 8: Panel logit fixed regression of fallow and tree planting on plot certification and other correlates

Variables	Fallowing (=1)		Tree planting (=1)	
	Coef	M.Eff	Coef	M.Eff
No. years since certified	-0.0053	-0.001	0.031***	0.007
	(-0.518)		(3.283)	
Female Headed (=1)	-0.174	-0.041	-0.229	-0.053
	(-0.924)		(-1.085)	
Age of Head (years)	-0.005	-0.001	-0.001	0.000
	(-0.912)		(-0.200)	
Never married (=1)	-0.509	-0.121	-0.315	-0.072
	(-1.544)		(-1.150)	
Divorced (=1)	-0.109	-0.026	-0.0829	-0.019
	(-0.401)		(-0.303)	
Separated (=1)	-0.231	-0.055	-0.227	-0.052
	(-0.706)		(-0.623)	
Widowed (=1)	-0.0743	-0.018	-0.294	-0.067
	(-0.402)		(-1.539)	
Literate (=1)	-0.0849	-0.020	-0.108	-0.025
	(-0.832)		(-1.105)	
Household size	-0.0654**	-0.016	-0.0206	-0.005
	(-2.368)		(-0.780)	
Farm size (in ha)	0.000919	0.000	0.0431***	0.010
	(0.264)		(3.004)	
Steep slope (=1)	0.546***	0.129	1.112***	0.255
	(6.866)		(14.02)	
Moderate slope (=1)	0.284***	0.067	0.488***	0.112
	(5.116)		(8.412)	
Field size (ha.)	0.306***	0.073	-2.966***	-0.68
	(5.431)		(-13.62)	
Inherited plot (=1)	-0.184**	-0.044	0.0484	0.011
	(-2.343)		(0.635)	
Just moved-in (=1)	-0.0455	-0.011	0.805***	0.185
	(-0.238)		(3.716)	
Other methods (=1)	-0.295	-0.070	0.0963	0.022
	(-1.473)		(0.565)	
Wave 2 (=1)	0.425***	0.099	-0.326***	-0.075
	(6.914)		(-5.717)	
Wave 3 (=1)	0.563***	0.133	-0.298***	-0.069
	(8.149)		(-4.436)	
Observations	35,096		37,878	
Number of HHID	1,109		1,090	

z-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1, reference groups for fallowing and tree planting are other purposes such as cultivation and pasture

3.2.2. The regression of farm intermediate inputs on plot certification

Table 9 shows the coefficients and average marginal effects of panel logit fixed effect and panel Tobit regressions of intermediate input uses on the number of years since plot certification and other covariates. The adoptions of improved seeds and organic fertilizer are estimated by panel logit fixed effect regression and the quantity of chemical fertilizer use (in kg) is estimated by panel Tobit regression. The number of years since the plot is certified is positive and statistically significant on the quantity of chemical fertilizer used (in kg) ($p<0.01$) and on the adoption of improved seeds ($p<0.1$) but negative on the adoption of organic fertilizer use ($p<0.1$). This marginal effect is capturing the overall effect of certification on chemical fertilizer use which ranges from the increases in income from improved crop yields and planting of permanent crops and trees for the purchases of these intermediate inputs. Our finding on chemical fertilizer use and plot certification is consistent with the finding of Adamie (2021).

In Table 10, the interaction terms of plot certification with terracing and good-quality plot are controlled to respectively investigate the complementary effect of soil conservation and the heterogeneity in certification based on plot quality. There is no evidence of complementarity between plot certification and terracing on the adoption of improved seeds. Plot quality, on the other hand, is found to enhance the effect of certification on improved seeds significantly ($p<0.01$).

The interaction of years of plot certification with terrace suggests a 1.4% ($p<0.01$) increase in the quantity of chemical fertilizer but it is significantly associated with 0.01 (0.05) decrease in the probability of adopting organic fertilizer. In other words, plot certification is found to encourage an increase in the quantity of chemical fertilizer use and terracing further enhances the positive effect of the certification. The estimates of plot certification and the interaction of years of plot certification with good quality plot dummy on the quantity of chemical fertilizer, on the other hand, are significant but with mixed sign. The estimates suggest that plot certification increases the quantity of chemical fertilizer but plot quality decreases the positive effect.

Regarding organic fertilizer use, terracing is found to reduce the adoption of organic fertilizer significantly. The regression with the interaction of plot certification and plot quality, on the other hand, shows that plot certification reduces organic fertilizer use significantly but plot quality mitigates the negative effect. From the soil conservation analysis in Tables 6 and 7, we have observed that soil conservation especially terracing is undertaken mainly on erosion prone parcels and farmers rated the fertility level of these parcels as either fair or poor. The result from Tables 6, 7, and 8 suggest that farmers tend to use chemical fertilizer on terraced certified plots and these plots have lower fertility due to several years of exposure to excessive erosion.

Table 9: Coefficients and average marginal effects from Panel fixed regressions of farm intermediate inputs on plot certification and other correlates

Variables	Improved seed(=1)		Ln(Chemical fertilizer in kg)		Organic fertilizer (=1)	
	Coef	M. Eff	Coef.	M. Eff	Coef.	M. Eff
	(1)	(2)	(3)	(4)	(5)	(6)
No. years since the plot was certified	0.0149	0.002	0.055***	0.007	0.004	0.001
	(1.473)		(4.463)		(0.781)	
Female Headed (=1)	0.564**	0.100	0.489*	0.066	0.142	0.034
	(2.327)		(1.959)		(1.227)	
Age of Head (years)	0.0163**	0.003	-0.00601	-0.001	-0.003	-0.001
	(2.345)		(-1.019)		(-1.057)	
Never married (=1)	0.656**	0.116	-0.362	-0.05	-0.196	-0.046
	(2.267)		(-0.894)		(-1.248)	
Divorced (=1)	-0.90***	-0.159	-0.551	-0.074	-0.09	-0.023
	(-2.978)		(-1.554)		(-0.709)	
Separated (=1)	-0.229	-0.04	0.0535	0.007	0.215	0.051
	(-0.523)		(0.105)		(1.200)	
Widowed (=1)	-0.403*	-0.071	-0.78***	-0.105	-0.207**	-0.049
	(-1.896)		(-2.958)		(-1.981)	
Literate (=1)	0.0674	0.012	0.0610	0.008	0.150***	0.035
	(0.649)		(0.493)		(2.864)	
Household size	0.0546**	0.01	0.09***	0.012	0.0184	0.004
	(2.008)		(2.751)		(1.305)	
Credit Access (=1)	0.0834	0.014	0.219**	0.029	-0.0186	-0.004
	(1.177)		(2.404)		(-0.539)	
Farm size (in ha)	-0.067***	-0.012	-0.08***	-0.011	0.0115	0.002
	(-2.850)		(-3.702)		(1.384)	
Steep slope (=1)	0.117	0.021	0.119	0.016	-0.717***	-0.171
	(1.098)		(0.857)		(-14.58)	
Moderate slope (=1)	0.0534	0.009	0.0200	0.003	-0.214***	-0.051
	(0.874)		(0.239)		(-7.116)	
Plot size (ha.)	0.685***	0.122	0.681***	0.091	-1.883***	-0.45
	(6.708)		(11.73)		(-20.72)	
Inherited plot (=1)	-0.0946	-0.016	-0.88***	-0.119	0.270***	0.064
	(-1.221)		(-8.376)		(6.379)	
Just moved-in (=1)	0.327	0.058	-2.10***	-0.283	-0.901***	-0.21
	(1.281)		(-4.600)		(-5.112)	
Other methods (=1)	0.251	0.044	0.0267	0.004	0.181*	0.043
	(1.405)		(0.101)		(1.755)	
Wave 2 (=1)	-0.0863	-0.015	0.802***	0.106	0.252***	0.06
	(-1.329)		(9.131)		(8.111)	
Wave 3 (=1)	0.0862	0.015	0.45***	0.057	0.098***	0.023
	(1.172)		(4.526)		(2.740)	
sigma_u			4.627***			
			(37.38)			
sigma_e			3.591***			
			(91.78)			
Constant			-6.89***			
			(-18.07)			
Observations	20,648		48,263		46,145	
Number of hhid	880		3,000		2,134	

z-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The binary outcome variables are estimated by panel logit fixed effect regression and the natural logarithm of chemical fertilizer (in kg) is estimated by panel tobit regression.

The benefits of organic fertilizer might not be fully reaped even if there are terraces if maintenance works are not undertaken continuously due to labor constraint and material costs. But they prefer to use organic fertilizers on certified plots which are fertile and not-exposed to erosion instead of chemical fertilizers to maintain the fertility level sustainably in the future. In sum, the main variables of interest in Table 10 shows that certification of erosion prone parcels enhances chemical fertilizer use whereas the certification of fertile plots (which are often not exposed to erosion) induces organic fertilizer use.

Table 10: Coefficients and average marginal effects from Panel regressions of farm intermediate inputs on numbers of years of plot certification and its interaction with terracing and plot quality

	Improved seed(=1)				Ln(Chemical fertilizer in kg)				Organic fertilizer (=1)			
Variables	**Coef**	**M. Eff**	**Coef**	**M. Eff**	**Coef.**	**M. Eff**	**Coef.**	**M. Eff**	**Coef.**	**M. Eff**	**Coef.**	**M. Eff**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
No. years since the plot was certified	0.025*	0.006	0.012	0.003	0.06***	0.009	0.1***	0.015	0.007	0.006	-0.013*	-0.003
	(1.78)		(0.81)		(4.235)		(6.911)		(1.05)		(-1.84)	
No. years certified*Terrace	0.002	0.000			0.09***	0.014			-0.01**	-0.01		
	(0.166)				(7.27)				(-2.39)			
No. yrs certified*fertile plot			0.03***	0.009			-0.02**	-0.004			0.05***	0.012
			(3.51)				(-2.14)				(9.49)	
Female-Headed (=1)	-0.172	-0.04	-0.195	-0.046	0.477	0.069	0.48	0.069	-0.080	-0.02	-0.09	-0.02
	(-0.39)		(-0.453)		(1.572)		(1.575)		(-0.41)		(-0.467)	
Age of Head (years)	0.0034	0.001	0.00247	0.001	-0.006	-0.001	-0.005	-0.001	-0.005	-0.001	-0.005	-0.00
	(0.286)		(0.204)		(-0.874)		(-0.77)		(-0.93)		(-1.055)	
Never married (=1)	0.87**	0.206	0.845**	0.198	-0.532	-0.07	-0.574	-0.08	-0.12	-0.02	-0.113	-0.02
	(2.38)		(2.290)		(-1.07)		(-1.15)		(-0.59)		(-0.540)	
Divorced (=1)	-0.464	-0.11	-0.495	-0.116	-0.635	-0.09	-0.557	-0.08	0.222	0.043	0.206	0.046
	(-1.12)		(-1.224)		(-1.471)		(-1.28)		(1.07)		(0.996)	
Separated (=1)	0.962	0.226	1.029	0.241	-0.433	-0.06	-0.418	-0.06	-0.073	-0.02	-0.0855	-0.02
	(1.28)		(1.372)		(-0.620)		(-0.59)		(-0.28)		(-0.330)	
Widowed (=1)	-0.317	-0.07	-0.303	-0.071	-0.79**	-0.11	-0.8***	-0.12	-0.134	-0.03	-0.0450	-0.01
	(-1.12)		(-1.070)		(-2.54)		(-2.62)		(-0.91)		(-0.308)	
Literate (=1)	-0.147	-0.03	-0.116	-0.027	0.062	0.009	0.0540	0.008	0.2***	0.043	0.21***	0.048
	(-0.96)		(-0.762)		(0.413)		(0.358)		(2.806)		(2.945)	
Household size	0.040	0.010	0.0413	0.010	0.058	0.008	0.059	0.009	0.005	0.001	0.00556	0.001
	(0.96)		(0.987)		(1.491)		(1.534)		(0.258)		(0.252)	
Credit Access (=1)	0.065	0.015	0.0676	0.016	0.30***	0.043	0.24**	0.035	-0.1***	-0.02	-0.1***	-0.03
	(0.642)		(0.67)		(2.60)		(2.107)		(-2.81)		(-2.605)	

Farm size (in ha)	-0.3***	-0.07	-0.3***	-0.070	-0.1***	-0.01	-0.1***	-0.01	0.05***	0.013	0.05***	0.012
	(-7.36)		(-7.47)		(-3.58)		(-3.79)		(3.19)		(2.93)	
Fair quality plot (=1)	-0.1**	-0.03			0.42***	0.060			-0.3***	-0.07		
	(-2.0)				(4.17)				(-8.87)			
Poor quality plot (=1)	-0.2**	-0.06			0.59***	0.085			-0.7***	-0.15		
	(-2.23)				(4.26)				(-12.4)			
Steep slope (=1)	-0.123	-0.03	-0.127	-0.030	-0.087	-0.01	0.0196	0.003	-0.7***	-0.14	-0.7***	-0.17
	(-0.88		(-0.920)		(-0.53)		(0.120)		(-11.2)		(-12.32)	
Moderate slope (=1)	0.0164	0.004	0.0205	0.005	-0.15	-0.02	-0.0903	-0.01	-0.2***	-0.03	-0.2***	-0.05
	(0.214)		(0.269)		(-1.52)		(-0.92)		(-5.29)		(-6.022)	
Plot size (ha.)	0.9***	0.218	0.93***	0.219	0.60***	0.087	0.6***	0.089	-2.4***	-0.49	-2.5***	-0.56
	(8.01)		(8.105)		(9.49)		(9.64)		(-20.3)		(-20.70)	
Inherited plot (=1)	-0.119	-0.02	-0.106	-0.025	-0.6***	-0.09	-0.6***	-0.09	0.2***	0.056	0.27***	0.062
	(-1.18)		(-1.068)		(-4.83)		(-5.06)		(4.79)		(4.9)	
Just moved-in (=1)	0.0475	0.011	0.0725	0.017	-2.0***	-0.29	-2.0***	-0.29	-0.7***	-0.15	-0.7***	-0.17
	(0.131)		(0.200)		(-3.22)		(-3.23)		(-3.19)		(-3.163)	
Other methods (=1)	-0.139	-0.03	-0.131	-0.031	-0.45	-0.06	-0.440	-0.06	-0.052	-0.01	-0.0613	-0.01
	(-0.33)		(-0.314)		(-1.03)		(-1.02)		(-0.25)		(-0.308)	
Wave 3 (=1)	0.2***	0.054	0.23***	0.054	-0.5***	-0.07	-0.5***	-0.07	-0.1***	-0.03	-0.1***	-0.03
	(3.60)		(3.579)		(-6.65)		(-6.49)		(0.03)		(-4.899)	
Constant					-6.0***		-5.82**					
					(-13.3)		(-12.9)					
Observations	12,112		12,153		33,597		33,697		30,060		30,149	
Number of hhid	714		714		2,898		2,901		1,901		1,902	

z-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The binary outcome variables are estimated by panel logit fixed effect regression and the natural logarithm of chemical fertilizer (in kg) is estimated by panel tobit regression.

4. Conclusion and Policy Lessons

This study investigates the effects of plot certification on farm investments and intermediate input use using three waves of plot level panel data collected from rural Ethiopia as part of the Ethiopia socioeconomic surveys conducted in 2011, 2013, and 2015. Panel logit fixed effect is employed in the estimation of binary outcome variables and panel Tobit in the estimation of the quantity of chemical fertilizer use. The results show that the number of years since the plot was certified has significant positive relationships with plot soil conservations adoptions especially on terracing and tree planting. The effects of certification on terracing are robust to parcel characteristics such as slope and household characteristics. Our findings further show that households mainly undertake soil conservation investments especially terracing on sloppy parcels which are often less fertile due to exposure to erosion over years.

The analyses of intermediate input uses uncovered that the quality of the certified plot is very important determinant of the type of fertilizer to be used by farmers. Farmers tend to use organic fertilizer (instead of chemical fertilizer on their certified plots) and also more likely to adopt improved seeds on their certified fertile plots. The results further show that the induced terrace due to certification increases the quantity of chemical fertilizer but decreases organic fertilizer. The terraced plots are mainly sloppy and less fertile due to exposure to erosion in the past. Moreover, the invested terraces may require regular maintenance works, which are labor and material intensive, to control the erosion effectively. This may be the reason for lack of interest to use organic fertilizer, whose benefit from applied farm plots can extend for several seasons if not eroded during rainy seasons, on terraced plots. Even if erosion also effectiveness of chemical fertilizers, farmers might delay the application until the heavy rainfall passes. In sum, the findings from the soil intermediate input use analyses reveals that farmers have more proclivity for organic fertilizer on certified fertile plots and more tendency to use more chemical fertilizer on certification induced terraced plots.

To recap, this study provides a positive evidence on the relationship of land certification with soil conservation, tree planting, and farm intermediate input uses. Given the direct and indirect effects of the certification program on farm investments and intermediate inputs use, the program should be strengthened to enhance its positive contributions on farm productivity.

An improved extension approach and material support is needed to improve the effectiveness of terraces and to encourage farmers to do maintenance works regularly. These could, in turn, induce farmers to use organic fertilizers on their terraced but less fertile plots to restore the quality sustainably.

Even if chemical fertilizers are effective in raising crop yield in the short run, the have undesirable effects on soil fertility and crop yield in the long-run. This is reflected by farmers choice of organic fertilizer on their certified fertile plots and chemical fertilizer on their certified and terraced plots which are largely non-fertile. To exploit the best out of land certification and the agriculture system, bio fertilizers (which have both organic and chemical fertilizer content) should be promoted. Bio fertilizers are more effective than organic fertilizer in raising crop yield and play a crucial role in improving soil quality by fixing atmospheric nitrogen.

References

Adamie, B. A. (2021). Land property rights and household take-up of development programs: Evidence from land certification program in Ethiopia. World Development, 147, 105626.

Besley, T. (1995). Property rights and investment incentives: Theory and evidence from Ghana. *Journal of political Economy*, 103(5), 903-937.

Cheng, H., Zhang, D., Huang, B., Song, Z., Ren, L., Hao, B., & Cao, A. (2020). Organic fertilizer improves soil fertility and restores the bacterial community after 1, 3-dichloropropene fumigation. Science of The Total Environment, 738, 140345.

Chen, J. H. (2006). The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soil fertility. Proceedings of International workshop on sustained management of the soil-rhizosphere system for efficient crop production and fertilizer use (Vol. 16, No. 20, pp. 1-11). Land Development Department Bangkok Thailand.

Cornia, G. A. (1985). Farm size, land yields and the agricultural production function: An analysis for fifteen developing countries. World development, 13(4), 513-534.

Central Statistical Agency. Ethiopian Socio-economic Survey (ESS) 2011/12, 2013/14, and 2015/16.

De Janvry, A., Emerick, K., Gonzalez-Navarro, M., & Sadoulet, E. (2015). Delinking land rights from land use: Certification and migration in Mexico. American Economic Review, 105(10), 3125-49.

De Soto, H. (2000). The mystery of capital: Why capitalism triumphs in the West and fails everywhere else. Basic books.

Deininger, K., Ali, D. A., & Alemu, T. (2011). Impacts of land certification on tenure security, investment, and land market participation: evidence from Ethiopia. Land Economics, 87(2), 312-334.

Deininger, K., Ali, D. A., Holden, S., & Zevenbergen, J. (2008). Rural land certification in Ethiopia: Process, initial impact, and implications for other African countries. World development, 36(10), 1786-1812.

Fenske, J. (2011). Land Tenure and Investment Incentives: Evidence from West Africa. *Journal of Development Economics*, 95(2): 137–56.

Gebremedhin, B., & Swinton, S. M. (2003). Investment in soil conservation in northern Ethiopia: the role of land tenure security and public programs. Agricultural economics, 29(1), 69-84.

Goldstein, M., Houngbedji, K., Kondylis, F., O'Sullivan, M., & Selod, H. (2018). Formalization without certification? Experimental evidence on property rights and investment. *Journal of Development Economics*, 132, 57-74.

Holden, S. T., Deininger, K., & Ghebru, H. (2011). Tenure insecurity, gender, low-cost land certification and land rental market participation in Ethiopia. *The Journal of Development Studies*, 47(1), 31-47.

Holden, S. T., & Ghebru, H. (2013). Welfare impacts of land certification in Tigray, Ethiopia. In *Land Tenure Reform in Asia and Africa* (pp. 137-161). Palgrave Macmillan, London.

Jacoby, Hanan, G., Guo Li and Scott Rozelle. (2002). Hazards of Expropriation: Tenure Insecurity and Investment in Rural China. American Economic Review, 92(5):1420-1447.

Leifeld, J., & Fuhrer, J. (2010). Organic farming and soil carbon sequestration: what do we really know about the benefits?. AMBIO, a *Journal of Environment and Society*, 39(8), 585-599.

Mishra, D., Rajvir, S., Mishra, U., & Kumar, S. S. (2013). Role of bio-fertilizer in organic agriculture: a review. *Research Journal of Recent Sciences* ISSN, 2277, 2502.

Mekonnen, A., Ghebru, H., Holden, S. T., & Kassie, M. (2013). The impact of land certification on tree growing on private plots of rural households: evidence from Ethiopia. In *Land Tenure Reform in Asia and Africa* (pp. 308-330). Palgrave Macmillan, London.

Melesse, M. B., & Bulte, E. (2015). Does land registration and certification boost farm productivity? Evidence from Ethiopia. Agricultural Economics, 46(6), 757-768.

Nkoa, R. (2014). Agricultural benefits and environmental risks of soil fertilization with anaerobic digestates: a review. Agronomy for Sustainable Development, 34(2), 473-492.

Otsuka, Keijiro; Place, Frank. (2014). Changes in land tenure and agricultural intensification in sub-Saharan Africa, WIDER Working Paper, No. 2014/051, ISBN 978-92-9230-772-1, The United Nations University World Institute for Development Economics Research (UNU-WIDER), Helsinki

Otsuka, K. and Place, F. (eds) (2001). *Land Tenure and Natural Resource Management: A Comparative Study of Agrarian Communities in Asia and Africa*. Baltimore: Johns Hopkins University Press.

Tesfaye, A., Negatu, W., Brouwer, R., & Van der Zaag, P. (2014). Understanding soil conservation decision of farmers in the Gedeb watershed, Ethiopia. Land Degradation & Development, 25(1), 71-79.

Determinants of Adoption of Improved Teff Varieties by Smallholder Farmers: The Case of Kobo District, North Wollo Zone, Amhara Region, Ethiopia

Susie Teshome[1] * and Bosena Tegegne[2]

Abstract

Adoption and wider diffusion of improved teff varieties is playing a vital role in reversing the present situation of food insecurity in many parts of Ethiopia. However, the uses of improved teff varieties are constrained by various factors. Hence, in this study, an attempt was made to examine factors affecting the adoption and intensity of use of improved teff varieties. A multi-stage random sampling technique was employed to select 150 sample households from Kobo district. Double-hurdle model was used to identify factors influencing households' adoption decisions and the intensity of use of improved teff varieties. The result of the double-hurdle model shows that the educational level of household head, participation in crop production demonstration, distance from the nearest market, frequency of extension contact, off/non-farm income, the proportion of cultivated land allocated for teff, livestock holding, improved teff seed availability, and perception on the better yielding capacity of the new varieties over local varieties were found to be significantly influencing households adoption decision, whereas, sex, age, family labor, membership to an organization, off/non-farm income, frequency of extension contact and land allocated for teff were found to be significantly influencing the intensity of use of improved teff varieties. Therefore, the result implies that strengthening the existing extension services, providing good transport facilities for farmers through infrastructural development, improving access to improved seeds, improving farmers' level of education, strengthening farmer's organization, encouraging the use of labour-saving technologies, improving crop-livestock production system and provision of demonstrations of new technologies are areas that need policy attention to enhance adoption and intensity of use of improved teff varieties. Further, high-yielding teff varieties need to be given special priority in teff variety scaling out programs.

Keywords: Adoption, Improved teff Varieties, Double-hurdle Model, Intensity, Kobo, Amhara

[1] Department of Agricultural Economics, Woldia University, Woldia, Ethiopia (**susrvp@gmail.com)**
***** Correspondence Author
[2] Departement of Agricultural Economics, Bahir Dar University, Bahir Dar, Ethiopia **(bosenat@gmail.com)**

1. Introduction

Ethiopia is fundamentally an agrarian country and agriculture is Ethiopia's most important sector, crucial for ensuring the country's food security and the livelihoods of its people. The sector is the largest contributor to the overall economy and is fundamental to Ethiopia's overall development (WB, 2019; Gebissa, 2021). Despite the dominance of traditional smallholder farmers in the sector, increased engagement with mid and large-scale private sector partners has brought new technologies and improved market linkages (ATA, 2017). Although the transformation towards a more manufacturing and industrially oriented economy is well underway, the agriculture sector continues to be the most dominant aspect of the Ethiopian economy, accounting for nearly 40% of GDP, 67.76% of employment, and 80% of foreign export earnings (CSA, 2019; WB, 2019).

Despite its contribution to the national GDP by large, agriculture in Ethiopia is subsistence and most Ethiopians practice mixed agricultural activity. The sector is constrained by climate change, fragmentation and degradation of farmland, unevenly distributed constructions and urbanizations, pests, lack of integration among stakeholders, political instabilities, and its prospects (Gebissa, 2021). Smallholder farmers are cultivating 95% of their farmland using mostly traditional farming practices and inadequate improved technology be found in the low productivity Ethiopian agriculture. Furthermore, the majority of the agriculture sector is made up of smallholder farmers who live on less than 1.17 hectares of land (WB, 2013). This is particularly true for the major food crops grown in the country (CSA, 2020).

Teff is one of the cereals grown in most agroecological zones of Ethiopia and is mainly used for food consumption. It ranks first in area coverage and second after maize in total production. The crop accounted for about 24.11% of the total grain cultivated land (CSA, 2020). It is a multipurpose crop, being utilized in different forms where the grain is used to make the Ethiopian staple food, Injera. It is also valued for its fine straw, which is used for animal feed as well as for reinforcing mud for plastering wooden walls of buildings (Bekabil et al., 2011).

The popularity of teff can be also explained by its high price. It is the highest-priced cereal grown in Ethiopia and is an attractive cash crop for farmers. Combined with the high share of the final price obtained by the farmers, income from teff is much higher than income from other cereals and even 34% higher than income from coffee, the major export crop in Ethiopia (Minten et al., 2013; Worku et al., 2014). In Ethiopia, nearly 25-30 million people are directly dependent on teff production (CSA, 2019). The higher teff price followed by the increasing commercialization of smallholder farmers represents an opportunity to directly increase the living standard of rural communities in Ethiopia (Hauenstein, 2015). Despite its economic importance in Ethiopia, the productivity of teff remains low. For instance, in the 2019/20 production year, teff yield was 18.50 qt/ha, significantly lower than other cereals, such as maize (42.37 qt/ha), sorghum (28.80 qt/ha) and wheat (29.70 qt/ha) (CSA, 2020). Besides compared to other cereals the increase in yield due to the adoption of improved crop varieties is low for teff. For instance, from 2006-2018 the average increase in teff yield is 1.0 metric ton per hectare (MT/ha) which is lower than other cereals such as barley (1.2 MT/ha), wheat (1.9 MT/ha), maize (2.3 MT/ha) and sorghum (1.4 MT/ha) (EBA, 2019). The low teff yield is explained by the limited knowledge about the possible avenues for improving teff productivity, together with the problems inherent to its botany. Moreover, teff yield is low because of lodging, low modern input use, traditional way of sowing, socio-economic factors such as lack of access to market information, post-harvest losses, and lack of high yielding cultivars (Bekabil et al., 2011; Tareke, et al., 2011).

Consequently, in Ethiopia, to increase the productivity of teff several improved varieties were developed and disseminated to farmers along with their optimum management practices (Setotaw, 2013). However, different area-specific pieces of evidence indicate that the intensity and adoption rate of improved teff varieties in the country is low. This low rate of adoption decisions of farmers is usually determined by various factors which can be specific to socio-economic, institutional, demographic, and psychological. In addition, factors such as expensiveness and unavailability of seeds and desired varieties, lack of awareness, and the serious sequence of agronomic practices have commonly been mentioned as the constraints contributing to the low level of improved teff varieties adoption (Tesfaye et al., 2001; Hailu, 2008; ATA, 2012).

The study area is mainly characterized by unreliable rainfall conditions and risk-prone farming systems. As a result, crop production has become highly unpredictable, and subsistence throwing the major proportion of the rural population into a food insecurity situation (SARC, 2015). Apparently, agricultural performance in the area should be improved if the food security of the majority of farmers is to be enhanced. As part of this goal, in the study area improved teff varieties are often introduced in a package program although adopters use part of the package.

Despite such intervention, information concerning the adoption of improved teff varieties on location-specific factors influencing adoption and intensity of adoption of improved teff varieties being promoted in the districts was not empirically studied and documented. Hence, this study was aimed at analyzing factors affecting the adoption and intensity of use of improved teff varieties to draw important conclusions and policy implications for future intervention.

2. Empirical Findings And Analytical Framework

Various factors influence the adoption decision and intensity of use of improved agricultural technologies which can be categorized under characteristics or attributes of technologies; the adopters or farmer, which is the object of change agent; and the socio-economic, institutional, and physical environment in which the technology takes place. Various studies of technology adoption across different locations revealed that a combination of socioeconomic, demographic, institutional, and perception of technology attribute variables determine the adoption and intensity of use of the technologies. Therefore, this sub-section focuses on reviewing relevant studies on adoption around Ethiopia and outside Ethiopia that would give a brief account of the results and explanations behind the findings. The following are some of the results of previous studies on teff and other crops in Ethiopia and other countries respectively.

Debelo (2015) assessed factors influencing the adoption of quncho teff variety in the Wayu Tuqa district of Ethiopia using the logit model. Results of the study revealed that family labor availability, participation of farmers in agricultural training, education level of the household head, livestock holding (TLU), farmer's ability to meet family food consumption, and frequency of extension contact were enhancing the decision to adopt quncho teff while, age of household head, owning oxen and distance from household residence to the market center were found to influence the adoption of quncho teff negatively. In a related study, Tsibuk (2015) analyzed the factors affecting the adoption of quncho teff variety in Medebayzana woreda of Tigray region, Ethiopia using the binary logit model. The result from the econometric regression binary logit model indicated that family labor availability, access to credit service, frequency of contacts with extension agents, participation in training, and mass media exposure are important variables which affect the adoption of quncho teff variety and had a positive and significant influence on both the adoption decision and the extent of adoption. While market distance and perception towards the cost of inputs had a negative and significant influence on both the adoption decision and the extent of adoption.

Regassa et al. (2018) explored the determinants of improved teff varieties adoption in the case of non-traditional teff growing areas of Western Ethiopia. The study applied the Tobit model for analysis. The author founds that the decision to adopt and the intensity of use of improved teff varieties were both positively and significantly affected by plot size, livestock ownership, and poultry ownership; training, and income gained from teff sale, while the adoption decision and intensity of adoption of improved teff varieties were negatively and significantly influenced by the total area under cereal crops other than Teff and dependent family members.

Others like Bayissa (2014) employed a double-hurdle model to estimate the improved teff planting decision and intensity use of households in the Diga district of East Wollega Zone. Results of the double-hurdle model confirmed that both the adoption decisions and intensity use of improved teff were positively and significantly influenced by the sex of the household head, farming experience, participation in crop production training, educational level, yield superiority, and maturity period of new varieties. While the author found that distance to the nearest marketplace had a negative and significant influence on the adoption and intensity of use of improved teff varieties. Similarly, Begashaw (2018) analyzed the adoption of teff row planting technology in Moretna Jiru Woreda, North Shoa Zone of Amhara Region, Ethiopia using the Tobit econometric model. The result of the author's analysis indicated that sex of the household head, level of education, family size, farming experience, off-farm income, contact with extension agents, and participation in farmers field days were found to have a positive and significant influence on the probability of adoption and intensity of use of teff row planting technology.

Different studies are also conducted on the adoption of improved technologies on other crops in Ethiopia. For instance, Berihun et al. (2014) examined the underlying determinants of chemical fertilizer adoption by the rural households in the Raya Azebo and Raya Alamata districts of the Tigray region, Ethiopia. The probit regression result showed that sex of the household head, land ownership right security, irrigation use, access to credit, contact with extension workers, and off-farm participation were found to be positive in determining chemical fertilizer adoption decision. Besides, plot distance from the homestead, distance to the nearest market and TLU were significant while influencing chemical fertilizer adoption decisions negatively. In a nutshell, the difficulty of accessing credit either formally or informally, feelings of non-secured land ownership right, and fear of the damaging effect of technologies on crops grown due to shortage of water were found to be determinants of technology adoption. Furthermore, gender, given that female-headed households were mainly chemical fertilizer non-adopters since they could not be exposed to new and updated agricultural information, great discrepancies have been seen and found.

Yenealem et al. (2013) investigated gender disparities in the adoption of improved maize varieties between male-headed and female headed households in Ethiopia using the binary probit model. The results revealed that the adoption of improved maize variety was biased by gender, where female headed households adopt the improved varieties less. The number of livestock units, extension services, and land size had a significant and positive influence on the adoption decision of improved maize varieties, whereas age and distance to the input market had a negative and significant influence on the adoption decision for male-headed households. The author found that the new maize variety is more likely to be adopted by male-headed households with large farms. Their finding also showed that younger male headed households are more likely to adopt new technology such as the use of improved maize varieties.

Ermias (2013) also analyzes the adoption of improved sorghum varieties and farmers' varietal trait preference in Kobo district of Ethiopia using the Tobit model. The author found that the farmer's adoption decision and intensity of use of improved sorghum varieties were positively and significantly influenced by irrigated farm size, tropical livestock unit, striga infested farm size, farmers' perception of yielding capacity, and a taste preference for improved sorghum varieties while active labor ratio, distance from the farmers training center to home, the proportion of sorghum farm from the total cultivated land and farm size had a negative and significant influence on both the probability and intensity of adopting improved sorghum varieties.

In another study, Solomon et al. (2011) analyzed their paper on agricultural technology adoption, seed access constraints, and commercialization and estimates the causal effect of adopting improved chickpea technologies on smallholder farmers' integration into the output market in rural Ethiopia using a double-hurdle model. Results of the double-hurdle model confirmed that the level of adoption of improved chickpea varieties was strongly related to a range of household wealth indicator variables. Those households with more family labor force, livestock, and land were considerably more likely to allocate extra land for the improved chickpea varieties. Ownership of these assets seems to ease the access of households to improved seed, some of which may be due to its potential effect on accessing credit. Livestock ownership also helps farmers spread some of the risks they face. In a related study, Alemitu (2011) explored the factors affecting the adoption of an improved haricot bean production package using the Tobit model. Results of the model indicated that the probability of adoption of an improved haricot bean production package was positively and significantly affected by participation in the demonstration, sex of the household head, participation in the field day and access to credit for improved haricot bean varieties seed in kind.

There are also empirical studies on agricultural technology adoption conducted in other countries outside Ethiopia and related to this study. For instance in Nigeria Ayinde et al. (2010) and Idrisa et al. (2012) analyzed the adoption of improved maize seed and its effect on household food security using a bivariate probit model. They suggest that factors such as the socio-economic characteristics of farmers, access to credit or cash resources and information from extension and other media influenced the adoption rate of new agricultural technology among farmers. Ghimire (2015) also explored the factors affecting the adoption of improved rice varieties among rural farm households in central Nepal using the probit model. The study reported that seed access, education, farm size, land type, extension service, and perception on the yield potential of new varieties were significant variables which influence the probability of adoption of improved rice varieties.

Rafael (2011) examined the underlying determinants of agricultural technology adoption in Mozambique by using a binary logit model. The major finding can be briefly summarized as access to credit, higher level of education, access to extension advisory service, and members of agricultural associations were more likely to enhance the adoption of new agricultural technologies. In the same study conducted by Kudi et al. (2011) farming experience, farm size, and farmers' awareness had a considerable influence on the rate of adoption of agricultural innovation.

Kapalasa (2014) examined factors influencing farmers' adoption of improved soybean varieties in Malawi using a double-hurdle model. Demographic, socioeconomic, and Institutional factors such as age, access to extension services, and distance to the nearest market of the household significantly influenced farmers' decision to adopt and intensity use of improved soybean varieties. The author also founds that farm-level characteristics such as farm size and variety-specific characteristics like earliness to maturity, higher yielding, and pleasant taste were significant attributes that influence a farmer to adopt improved soybean variety.

As discussed above despite different studies conducted in Ethiopia in different areas on improved teff technologies adoption a location specific based study in the study area is necessary to identify the main factors affecting the probability of adoption and intensity of use of improved teff varieties and accordingly this study tried to identify determinants of adoption of improved teff varieties by smallholder farmers in Kobo district North Wollo Zone of Amhara Region, Ethiopia.

3. Methodology

3.1. Description of the study area

The study was conducted in the Kobo district, the Northeastern escarpment of the Amhara Region. The district town, Kobo is located on the Addis Ababa-Mekele highway, found around 575 kilometers away from Addis Ababa. The landscape of this district is characterized by a broad fertile plain that is separated from the lowlands of the Afar Region by the Zobil Mountains, which are over 2000 m. a. s. l. The mean annual rainfall ranges between 500-800 mm while the temperature varies from a minimum of 19°C to a maximum of 33°C annually (SARC, 2015). The agro-climatic feature of the area is tropical as 7.9%, 37.2% and 54.9% are Dega, Weyina Dega, and Kola respectively. In the district, there are 34 rural and 6 urban Kebele administrations. The total population in the district was estimated to be 239,504, of whom 120,383 were males and 119,121 were females (CSA, 2012)

The agricultural practice in Kobo is mainly characterized by a mixed farming system where nearly 66.5% of the population is engaged in mixed farming whereas 27% and 2% of the population depend only on crop and livestock production respectively. The crop production sub-system in the district is both rain-fed and irrigated. The rain fed crop production is dominated by cereals such as sorghum and teff whereas irrigation crop farming is dominated by vegetables and cereals. Improved teff varieties cultivated in the district are Quncho, Boset, and Zobel. Currently, Quncho and Boset are widely cultivated varieties by farmers (MoANR, 2018; OKARD, 2018).

3.2. Data type, sources, and methods of data collection

The study used data generated from both primary and secondary sources. Cross-sectional data were used which contains both quantitative and qualitative data collected from selected households with a semi-structured questionnaire. The interview was mainly used as a data collection tool. The interview schedules were first pre-tested using non-sample respondents before actual data collection and amendments were made. Accordingly, primary data were collected by interviewing smallholder farmers growing teff during the 2018/19 production season. This contains data on key demographic, institutional and socio-economic factors affecting adoption decisions and intensity of adoption of improved teff varieties, and the perceptions towards improved teff attributes were collected. While, secondary data were collected from books, journals, and other published and unpublished documents, from district agricultural offices, websites, and other related sources to supplement primary data.

3.3. Sampling procedure and sample size

Multi-stage sampling procedure was employed to select representative sample households as this method allows dividing and distributing the target population into stages to make the sampling process more practical and flexible to choose the sample carefully while collecting primary data from a geographically dispersed population. In the first stage, Kobo District from North Wollo Zone was selected purposively based on the maximum cultivated land under teff. In the second stage, 4 Kebeles were selected randomly from 20 teff producing Kebeles of the district. Then, the farmers in each randomly selected Kebeles were stratified into adopter and non-adopter categories giving the relative homogeneity of sample respondents' adoption status. Finally, from each stratum of the randomly selected Kebeles, 150 representative sample respondents were selected randomly by taking probability proportional to the size of teff growing households in each kebeles for both groups.

3.4. Methods of data analysis

The study used both descriptive statistics and an econometric model for analyzing the data. Descriptive statistics such as mean, standard deviation, frequency distribution, and percentage were employed to have a clear picture of the socio-economic, institutional, and demographic characteristics of sample households. The chi-square and independent sample t-test were used to see the presence of a systematic association between those who adopt and those who do not improve teff varieties in terms of hypothesized variables.

Econometric Analysis: Various researchers used different models for analyzing the determinants of technology adoption. In principle, the decisions on whether to adopt and how much to adopt can be made jointly or separately (Berhanu and Swinton, 2013). Several adoption studies have used the Tobit model to estimate adoption relationships with limited dependent variables. Tobit model is, however, statistically restrictive because it assumes that the same set of variables determines both the probability of adoption and intensity level. In this case, the appropriate approach is to use a double-hurdle model. This model assumes farmers faced with two hurdles in any agricultural decision making process (Cragg, 1971). In this study, a double-hurdle model was used since it allows for the distinction between the determinants of improved teff variety adoption and the intensity of use of improved teff varieties through two separate stages. The model estimation involves running a probit regression to identify factors affecting the decision to adopt using all sample households in the first stage and a truncated regression model on the participating households to analyze the intensity of adoption in the second stage.

As already noted, the general form of Cragg's double-hurdle model (probit and truncated models in particular) that was used for this study is specified as follows.

$D^*_i = W_i'\alpha + U_i$ (Adoption Decision Equation) **(1)**

$D_i = 1, if\ D^*_i > 0$, $D_i = 0,$ otherwise

Where, D* is the latent variable describing the household's decision of whether or not to adopt improved teff varieties that takes the value of 1 if the household adopted and 0 otherwise, Di is the observed variable which represents the household's adoption decision, Wi is a vector of explanatory variables, α is a vector of parameters to be estimated and Ui is the error term.

$Y^*_i = X'_i\beta + V_i$ (Intensity Equation) **(2)**

$Y_i = Y^*_i = X_i\beta + V_i\ if\ Y^*_i > 0$ and $D^*_i > 0$, $Y_i = 0,$ otherwise

Where Yi* is the latent variable describing the intensity of adoption of improved teff varieties. Yi is the area of improved teff varieties cultivated in hectares signifying the intensity of adoption. Xi is a vector of explanatory variables influencing how much the household use improved teff varieties, β is a vector of parameters to be estimated and Vi is the error term. If both decisions are made by the individual farmers independently, the error term is assumed to be independently and normally distributed as Ui~N (0, 1) and Vi~N (0, δ2).

The log-likelihood from the Cragg type double-hurdle model is the sum of the log-likelihood from a probit and a truncated regression. Hence, a double-hurdle model is given by:

$$\text{Log } l = \sum_0 \ln\left(1 - \Phi\left(W_i'\alpha\left(\frac{X_i\beta}{\sigma}\right)\right)\right) + \sum_+ \ln\left(\Phi(W_i'\alpha)\frac{1}{\sigma}\phi\left(\frac{Y_i - X_i\beta}{\sigma}\right)\right) \quad \textbf{(3)}$$

Where Φ and ϕ are standard normal cumulative distribution function and density function respectively.

To determine the appropriateness of models, a hypothesis test for the double-hurdle model against the Tobit model was made. The test can be done by separately estimating Tobit, truncated, and probit regression models and then conducting a likelihood ratio test that compares the Tobit with the sum of the log-likelihood functions of the probit and truncated regression models. The LR statistic can be computed using the formula developed by (Greene, 2003) as:

$$\Gamma = -2\left[\ln L_T - (\ln L_P + \ln L_{TR})\right] \sim \chi_k^{\ 2} \qquad \textbf{(4)}$$

Where LT= likelihood for the Tobit model; LP= likelihood for the probit model; LTR= likelihood for the truncated regression model and k is the number of independent variables in the equations.

The test hypothesis is written as: $H_0 : \lambda = \frac{\beta}{\sigma}$ and $H_1 : \lambda \neq \frac{\beta}{\sigma}$

The null hypothesis (H0) that the Tobit model is the best fit model will be rejected on a pre-specified significance level if $\Gamma > \chi_k^{\ 2}$. The test result is given in Appendix Table 1 below:

4. Result and Discussions

4.1. Rate and intensity of improved teff varieties adoption by sample households

In the study area, farmers are commonly cultivating three improved varieties namely, Quncho, Boset, and Zobel. Table 1 below summarizes the adoption status and area covered by improved teff varieties of adopter sample households. The results indicated that, out of the total adopters, 27 (37.5%) of them were practice Quncho, 33 (45.8%) used Boset and it was the most widely adopted variety, and only 12 (16.7%) of the adopters were users of Zobel teff variety. In this study, the adoption intensity measures the extent of adoption expressed in terms of the area of land allocated to improved teff varieties. An average of 0.35 ha of land was found to be allocated for improved teff varieties by adopter sample households. Out of which, on average 0.11, 0.17, and 0.07 ha of land was allocated to Quncho, Boset, and Zobel respectively.

Table 1: Adoption status and area covered by improved teff varieties

Variety	Growers		Average area (ha)
	N	%	
Quncho	27	37.5	0.11
Boset	33	45.8	0.17
Zobel	12	16.7	0.07
All improved varieties	72	100	0.35

Source: own estimate

4.2. Result of descriptive statistics for dummy and continuous explanatory variables

The descriptive statistics of socioeconomic, demographic, and institutional characteristics of sample respondents examined in this study are presented in Tables 2 and 3. Table 2 presents dummy variables whereas Table 3 presents continuous variables. Out of the total sample respondents, 72 (48%) were adopters and 78 (52%) were non-adopters.

Table 2 below shows the result of descriptive statistics for dummy explanatory variables. Totally 150 household heads were considered in this study. Out of these, 134 (89.3%) were male-headed and the remaining 16 (10.7%) were female-headed households. The chi-square test was computed for dummy variables and it was found to be statistically significant for credit access at 5% significance level, for the perception of farmers towards yield, participation in the demonstration, improved teff seed availability, and education level at 1% significance level and for membership to an organization it was found to be statistically significant at 10% significance level.

Table 2: Descriptive statistics for dummy explanatory variables

Variables		Adopters		Non-adopters		Total		χ^2-value
		N	%	N	%	N	%	
Sex of household head	Male	67	93.1	67	85.9	134	89.3	2.01
	Female	5	6.9	11	14.1	16	10.7	
Education level	Illiterate	12	16.7	45	57.7	57	38	42.25***
	Read & write	23	31.9	27	34.6	50	33.3	
	Grade (1-8)	30	41.7	6	7.7	36	24	
	Grade 9 & above	7	9.7	0	0	7	4.7	
Participation on demonstration	Yes	61	84.7	31	39.7	92	61.3	31.94***
	No	11	15.3	47	60.3	58	38.7	
Improved teff seed availability	Yes	71	98.6	57	73.1	128	85.3	19.50***
	No	1	1.4	21	26.9	22	14.7	
Access to credit	Yes	39	54.2	27	34.6	66	44	5.81**
	No	33	45.8	51	65.4	84	56	
Membership to an organization	Yes	61	84.7	57	73.1	118	78.7	3.03*
	No	11	15.3	21	26.9	32	21.3	
Perception on yield capacity	Yes	62	86.1	38	48.7	100	66.7	23.56***
	No	10	13.9	40	51.3	50	33.3	

***,**and *represents the level of significance at 1%, 5% and 10% respectively .
Source: own estimate

Table 3 shows the result of descriptive statistics for continuous variables. As indicated in the table, the t-value was computed for all continuous variables and it was found to be statistically significant for family labor in adult equivalent, livestock holding in TLU, distance from the nearest market, cultivated land size, and proportion of cultivated land allocated for teff at 1% level of significance and for the age of the household head at 10% level of significance. This implies that there was a significant difference in all these variables between the two adoption categories.

Hence results of the descriptive analysis revealed that all explanatory variables except, sex of the household, farming experience, off/non-farm income, and extension contact show a significant difference between adopters and non-adopters.

Table 3: Descriptive statistics for continuous explanatory variables

	Adopters		Non-adopters		Combined		
Variables	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**t-value**
Age of household head	41.93	8.90	44.78	9.80	43.41	9.43	-1.86*
Farming experience	20.00	8.40	18.18	9.46	19.05	8.98	1.24
Family labor	2.75	0.96	2.07	0.84	2.39	0.95	4.61***
Off/non-farm income	5574.2	9895.2	3592.2	9016.1	4543.6	9468.6	1.28
Cultivated land size	0.99	0.36	0.81	0.29	0.89	0.34	3.59***
Livestock holding	3.43	1.61	2.11	1.40	2.74	1.64	5.34***
Extension contact	7.67	4.88	7.03	4.33	7.33	4.59	0.85
Distance from the nearest market	9.39	1.80	11.05	1.62	10.26	1.89	-5.89***
Proportion of cultivated land allocated for teff	0.42	0.19	0.34	0.13	0.38	0.16	3.05***

***and *represents the level of significance at 1% and 10% respectively
Source: own estimate

4.3. Econometric model results

In this section, results and discussions from an econometric model (i.e. double-hurdle model) analyses were presented. A hypothesis test of the Double-hurdle model against the Tobit model was made before any econometric analysis. Accordingly, the Double-hurdle model was chosen over the Tobit model and used to analyze the influence of various demographic, socioeconomic, and institutional variables on the adoption and intensity of use of improved teff varieties. This is done based on the log-likelihood ratio test. The test statistics of the double-hurdle versus the Tobit model indicated the rejection of the Tobit model and acceptance of the double-hurdle model. The test results in Appendix Table 1 revealed that the calculated statistical value of the likelihood ratio was 90.64 which was greater than the tabulated or critical value of $\chi 2$ (16) =32 at 1% level of significance. This result provides an empirical result of farmers' independent decisions making regarding the adoption and intensity of use of improved teff varieties in the study area.

Besides before the estimation of the model parameters, the presence of a multicollinearity problem among the independent variables was checked. For continuous variables, VIF was used to check the multicollinearity problem, and for dummy variables contingency coefficient was used. As a rule of thumb, a VIF value less than 10 is said to be a weak association among explanatory variables.

Accordingly, the VIF values displayed in Appendix Table 2 show that all the continuous explanatory variables had no serious multicollinearity problem. Similarly, the values of the contingency coefficient were low as shown in Appendix Table 3 which is less than the rule of thumb of 0.75 implying a weak degree of association among the variables considered. Therefore, based on the above tests all the hypothesized continuous and dummy explanatory variables were kept in the respective models for further analysis.

4.3.1. Factors Determining the Probability of Adopting Improved Teff Varieties

The results of the probit (first hurdle) model of the double-hurdle revealed that out of sixteen variables included in the model nine were found to be significantly influencing farmers' decision to adopt improved teff varieties. The estimated result is revealed in Table 4 below. Details of significant variables from the probit model are discussed as follows.

The education level of the household head had a significant positive influence on the probability of adoption of improved teff varieties at 1% level of significance. This might be due to relatively literate farmers having more access to information, being capable to interpret and analyze information, and becoming aware of new technology than illiterate farmers and this awareness enhances the adoption of new technologies. The model result indicates that as compared to illiterate farmers the probability of adoption of improved teff varieties for literate farmers would increase by 35.3%. Similarly (Lavison, 2013; Bayissa, 2014; Leake and Adam, 2015) reported that having education increases the probability of adoption of new agricultural technology by farmers.

As the model result indicates, the variable off/non-farm income positively and significantly influenced the likelihood of adoption of improved teff varieties at 5% significance level. Keeping all other variables constant, for each additional 1% increase in off/non-farm income the probability of adopting improved teff varieties increases by 4%. Hence, the result of this study revealed that farmers with relatively higher off/non-farm income are more likely to use improved teff varieties as compared to farmers with lower income. The reason might be off/non-farm income increases the income of the household and might increase the capacity to invest in technology adoption. The result is consistent with other findings by (Hassen et al., 2012; Brkalem, 2015; Regassa et al., 2018).

The proportion of cultivated land allocated for teff had a positive and significant effect on the probability of adoption of improved teff varieties at 5% level of significance. Other variables held constant, the marginal effect showed that an increase in the proportion of cultivated land allocated for teff by 1% would result in 148.8% increase in the probability of adoption of improved teff varieties. This result implied that farmers who allocate a relatively higher proportion of land for teff are more likely to adopt improved teff varieties than farmers who allocate a relatively smaller proportion of land for teff production. The reason might be an increased risk-taking behavior of farmers with an increased proportion of teff area. Consistent with this, (Yu and Nin-Pratt, 2014; Sibanda et al., 2016) found that the higher the share of crop area the more likely to increase the use of improved technologies.

The number of tropical livestock units had affected positively and significantly the probability of adoption of improved teff varieties at 5% probability level. Other variables held constant, as the number of livestock increased by one TLU, the probability of adoption of improved teff varieties increased by 13.4%. The result could be explained as better risk-bearing behavior of those wealthy farmers with better livestock would enable them to try those newly adopted teff varieties. Previous empirical findings by (Regassa et al., 2018; Debelo, 2015) confirms this result.

As hypothesized, the frequency of farmers' extension contact with agricultural extension agents had a positive and significant effect on the probability of adoption of improved teff varieties at 5% level of significance. Other variables held constant, for each additional contact with extension agents the probability of adoption of improved teff varieties increases by 2.8%. The result indicated a higher probability of farmers with more contact with extension agents adopting than farmers with less contact. The possible justification for this is that frequent contacts create awareness and build the necessary knowledge for using the innovation and enhancing the exposure of farmers to the adoption practice of improved technologies. The result is similar to the finding of (Yaregal, 2011; Idrisa et al., 2012).

Households' participation in crop production demonstration positively and significantly influenced the probability of adoption of improved teff varieties at 5% significant level. Other variables held constant, participation in the demonstration would result in 36.7% increase in the probability of adoption of improved teff varieties. The result concerning this variable showed that farmers who have the opportunity to attend a demonstration of improved teff technology are more likely to use improved teff varieties than those farmers who have no similar opportunity. The reason might be participation on demonstration help farmers to create awareness and promote understanding about the merits of the available information by showing the practical applicability of the technology selected to be adopted. This result goes along with the findings of (Alemitu, 2011; Kafle, 2011; Regassa et al., 2018).

Availability of improved teff seed was found to positively and significantly influence the probability of adoption of improved teff varieties at 5% probability level. Other variables held constant, timely availability of improved teff seed brings about 52.5% increase in the probability of adoption of improved teff varieties. The result implied that those farmers who get improved seeds are more likely to adopt improved teff variety than those who do not have access. The possible explanation for this finding could be timely availability of seeds either in the local stores or in the market eases the households to purchase and cultivate new and improved varieties in their fields. The result is consistent with studies by (Ghimire et al., 2015; Verkaart et al., 2016) who found that availability of improved seeds affects the probability of adopting improved varieties.

Distance from the nearest market had a negative and significant influence on the probability of adoption of improved teff varieties at 1% level of significance. Keeping other variables constant, an increase in distance from farmers' residences to market place by a kilometer would result in 14.6% reduction in the likelihood of adoption of improved teff varieties. The result implied that the longer the distance between farmers' residences and the marketplace, the lower will be the probability of adoption of improved teff varieties. The plausible explanation for this result might be farmers nearby the market centers had more access to production inputs, had a higher probability of obtaining up-to-date market information, and hence accessed more information about improved technology that could enable them to try new technologies than those farmers who are in a distant location. The finding of this research is in line with (Hassen, 2014; Debelo, 2015).

Farmers' perception of the better yielding character of improved teff varieties significantly and positively affected the adoption decision of the farm households at 5% level of significance. Other variables held constant, a change in the perception of the farmer on the yield of improved variety to be higher than that of local variety (that is, a change from 0 to 1) brings 33.8% increase in the probability of adoption. The result of this study showed that if farmers perceive that new varieties are superior in terms of yield as compared to the local varieties, they will more likely adopt and widely use them. The possible reason is farmers' interest in maintaining and enhancing teff yield in the production year. The result is similar to the finding of (Ermias, 2013; Bayissa, 2014).

4.3.2. Factors Determining the Intensity of Adopting Improved Teff Varieties

The factors affecting the intensity of the use of improved teff varieties were estimated using a truncated regression model. The model result from Table 4 indicated that from sixteen variables included in the model, seven were found to be significantly affecting the intensity of use of improved teff varieties at different probability levels. Details of significant variables from this model are discussed as follows.

Sex of household heads had a positive and significant effect on the intensity of use of improved teff varieties at 5% level of probability. As compared to female-headed households, the intensity of use of improved teff varieties for male-headed households increased by 14.7%. The result suggests that those male headed households are more likely to allocate larger amounts of land to improved teff varieties than their counterparts, ceteris paribus. This could be attributed to various reasons, which could be the problem of the economic position of female headed households, including shortage of labor, limited access to information on improved varieties, and required production inputs due to social position. Besides teff farming is more labour intensive and it requires more labour from the planting until the harvesting season. Hence female headed households might have additional responsibilities in the household and thus might not have enough time and resources to allocate more hectares of land for teff production. The result is consistent with the findings of (Lavison, 2013; Hassen, 2014; Bayissa, 2014).

Age had a negative and significant influence on the intensity of use of improved teff varieties at 5% probability level. Other variables held constant, as the age of the household increases by a year, the intensity of use of improved teff varieties decreases by 0.5%. The result implied that older household heads are resistant and less likely to adopt improved varieties than young household heads. The possible justification is that as the household heads get old they might reduce trust in new technologies adoption as new technologies need financial investments and intensive field management. The result is in accordance with the findings of (Teklewold et al., 2006; Aman and Tewodros, 2016).

Family labor in adult equivalent was positively and significantly influenced the intensity of using improved teff varieties at 10% probability level. Keeping all other variables constant, a unit increase in family labour, increases the intensity of the use of improved teff varieties by 2.6%. This result indicated that farmers with a high labor force are more likely to allocate more hectares of land to improved teff varieties than those with a low labor force. The possible reason is that teff production is a labor-intensive activity and hence a household with a high working labor force would be in a position to manage the labor-intensive teff production activity. Previous studies by (Solomon et al., 2011; Hassen, 2014; Leake and Adam, 2015) also reported that the more family labour available the better intensity of adoption of agricultural technologies.

Off/non-farm income positively and significantly influenced the intensity of using improved teff varieties at 1% level of significance. Other variables held constant, 1% increase in off/non-farm income increases the intensity of use of improved teff varieties by 0.9%. This result showed that households with relatively higher off/non-farm income are expected to allocate more hectares of land to improved teff varieties than their counterparts. The probable reason for this finding is that additional income earned through participation in off/non-farm activities improves farmers' financial capacity and might increase the ability to acquire improved seeds and associated inputs. This result goes along with the previous studies by (Berihun et al., 2014; Regassa et al., 2018; Brkalem, 2015).

The proportion of cultivated land allocated for teff was found to have a positive and significant influence on the intensity of using improved teff varieties at 5% level of significance. Other variables held constant, each 1% increase in the proportion of cultivated land allocated for teff production would result in 23.4% increase in the intensity of use of the improved teff varieties. As stated by (Yaregal, 2011; Sibanda et al., 2016), farmers who allocate a higher proportion of cultivated land for their crops are more likely to use improved technologies extensively than those farmers with a smaller proportion of cultivated land.

As expected, the frequency of extension contact was found to positively and significantly influence the intensity of adoption of improved teff varieties at 10% probability level. The intensity of adopting improved teff varieties increases by 0.45% as for each additional contact with extension agents. The result implied that frequent contact with extension agents increases the availability of information about improved technologies and makes farmers being aware of new technologies on how they can apply and hence increasing the intensity of use of technologies. The result is consistent with the findings of (Hassen et al., 2012; Idrisa et al., 2012; Leake and Adam, 2015).

The intensity of use of improved teff varieties was positively and significantly influenced by membership of organizations at 1% level of significance. The model result indicates that as compared to non-membership to organizations, membership in organizations would increase the intensity of use of improved teff varieties by 10.6%. Farmers' organizations could serve as a platform for accessing and disseminating new information and improved technologies. Hence, the result of the study implied that farmers belonging to organizations have easy access to information, credit, labor, and inputs such as fertilizer, improved seeds, and chemicals and are expected to allocate more hectares of land to improved varieties. The result is consistent with another previous study by Aman and Tewodros, (2016).

Table 4: Parameter estimates of Cragg's double-hurdle model for adoption decision and intensity of adoption of improved teff varieties

	Adoption decision (probit model)			Intensity of adoption (truncated model)	
Variables	Coef.	Std. Err	Marginal effect	Coef.	Std. Err
Sex of the household head	-0.1249	0.6666	-0.0498	0.1468***	0.0543
Age of the household head	0.0072	0.0281	0.0029	-0.0049**	0.0021
Educational level	0.8851***	0.2481	0.3527	-0.0100	0.0145
Family labor	0.1336	0.2247	0.0532	0.0263*	0.0139
Off/non-farm income	0.1005**	0.0422	0.0400	0.0090***	0.0028
Farming experience	0.0082	0.0278	0.0032	-0.0028	0.0020
Cultivated land size	-0.6307	0.7371	-0.2513	-0.0683	0.0566
Proportion of teff cultivated land	3.7331**	1.8491	1.4875	0.2335**	0.1026
Livestock holding	0.3352**	0.1606	0.1335	0.0041	0.0087
Frequency of extension contact	0.0705**	0.0349	0.0280	0.0045*	0.0025
Participation on demonstration	0.9678**	0.4505	0.3673	0.0389	0.0411
Improved teff seed availability	1.7774**	0.8102	0.5254	-0.0576	0.1060
Distance from the nearest market	-0.3674***	0.1103	-0.1464	0.0023	0.0070
Access to credit	0.4732	0.3697	0.1869	0.0278	0.0248
Membership to an organization	0.3758	0.5125	0.1472	0.1057***	0.0339
Perception on yield capacity	0.8915**	0.4441	0.3380	0.0057	0.0380
_CONS	-4.6099***	1.7801	_	0.1932	0.1534
LR/Wald chi2 (16)	131.22			78.24	
Prob> chi2	0.000			0.000	
Log likelihood	-38.24			70.39	
Pseudo R2	0.63			_	
Number of observations	150			72	

***, ** and * represents the level of significance at 1%, 5% and 10% respectively.

Source: own estimate

5. Summary and Conclusions

The study was initiated to identify factors affecting the probability of adoption and intensity of use of improved teff varieties in kobo district. A double-hurdle econometric model was employed. The study empirically provides that farmers' decision to adopt and the decision concerning the intensity of use of improved teff varieties were made separately. The model results show that level of education, off/non-farm income, the proportion of cultivated land allocated for teff production, frequency of extension contact, livestock holding, participation in the demonstration, improved teff seed availability, and perception of yield were found to positive and significant in the first hurdle while the distance from the nearest market had a negative and significant effect. Whereas, in the second hurdle, sex of household head, age of household head, off/non-farm income, family labor, the proportion of cultivated land allocated for teff, frequency of extension contact, and membership to an organization were found to be significantly influenced households' intensity of use of improved teff varieties. The finding of this study revealed that some of the variables under investigation affecting the probability of adoption decisions were not affecting the level of usage of improved teff varieties and vice-versa.

The use of improved agricultural technologies particularly improved varieties is considered to be the most important input for the achievement of increased agricultural production and productivity of smallholder farmers in Ethiopia. However, in the study area, the performance of farmers in terms of the use of improved teff varieties has not been to the expected levels and the rate of adoption remains low. Hence, concerted efforts should be made to promote the use of improved agricultural technologies in teff farming. Moreover, understanding the factors that hinder the adoption of improved teff varieties is vital in planning and executing technology related programmes for addressing the challenges of production enhancing technology adopted by farmers in Ethiopia, particularly in the study area.

6. Recommendations

In general, based on the empirical findings of the study, the following recommendations are suggested. Since the level of education affected the adoption of improved teff varieties, the diffusion of technology needed to be facilitated through educated farmers to be used as contact farmers so that they can use the available inputs more efficiently under the existing technology. Besides, the district office of education needs to strengthen the adult education programme. In the study area, emphasis needs to be given to increasing the adoption of improved teff varieties by making better access to improved seeds timely. Strengthening extension service is needed to increase farmers' awareness about the benefits of using improved teff technologies including improved teff varieties as it enhances their ability to acquire and use the information required for production.

Improving the existing market center in the study area through the construction of roads and providing good transport facilities for farmers need to be given more attention to enhance the adoption of improved teff varieties. In the study area farmers' organizations also need to be strengthened to reinforce farmer-to-farmer knowledge sharing should go through workshops, training, and pertinent demonstration activities to capacitate their human and financial resources by providing incentives so that they can be the center for agricultural technology transformation. The sex of the household head was positive and significant on the intensity of use of improved teff varieties suggesting that due attention should be provided for promoting and empowering females by addressing the resource and information constraints. Policies should consider the availability of the labour force before introducing labour-intensive technologies.

References

Alemitu Mulugeta. (2011). Factors affecting adoption of improved haricot bean varieties and associated agronomic practice in Dale Woreda, Ethiopia. MSc Thesis, Hawassa University, Hawassa, Ethiopia.

Aman Tufa and Tewodros Tefera. (2016). Determinants of improved barley adoption intensity in Malga District of Sidama Zone, Ethiopia. *International Journal of Agricultural Economics,* 1 (3): 78-83.

ATA (Agricultural Transformation Agency). (2012). Working Strategy for Strengthening Ethiopia's Teff Value Chain Vision, Systemic Challenges, and Prioritized Interventions. Addis Ababa, Ethiopia.

ATA (Agricultural Transformation Agency). (2017). Transforming Agriculture in Ethiopia. Annual Agricultural Report 2017/18. Addis Ababa, Ethiopia.

Ayinde, O.E., Adewumi, M.O., Olatunji, G.B. and Babalola, O.A. (2010). Determinants of adoption of downy mildew resistant maize by Small-Scale Farmers in Kwara State, Nigeria. *Global Journal of Science Frontier Research*, 10(1): 32-35

Bayissa Gedefa. (2014). A double-hurdle approach to modeling of improved teff technologies adoption and intensity use: The case of Diga district of East Wollega Zone, Ethiopia. *Global Journal of Environmental Research*, 8 (3): 41-49.

Begashaw, M. (2018). Determinants of adoption of Teff (Eragrostis tef) row planting technology in Moretna Jiru Woreda. North Shoa Zone of Amhara Regional State.

Bekabil Fufa, Befekadu Behute, Simons, R. and Tareke Berhe. (2011). Strengthening Teff Value Chain in Ethiopia: Teff Diagnostic Report. ATA, Addis Ababa, Ethiopia.

Berhanu Gebremedhin and Swinton, S. M. (2003). Investment in soil conservation in Northern Ethiopia: The role of land tenure security and public programme. *Journal of Agricultural Economics,* 29 (1): 69-84.

Berihun Kassa, Bihon Kassa and Kibrom Aregawi. (2014). Adoption and impact of agricultural technologies on farm income: Evidence from Southern Tigray, Northern Ethiopia. *International Journal of Food and Agricultural Economics*, 2 (4): 91-106

Brkalem Shewatatek. (2015). Econometrics model on determinants of adoption of improved soil and water conservation practices: The case of Boloso-Sore Woreda, Woliata Zone, Ethiopia. *Scholarly Journal of Scientific Research and Essay*, 4 (2): 35-42.

Cragg, J. G. (1971). Some statistical models for limited dependent variables with application to the demand for durable goods. *Journal of the Econometric Society*, 39 (5): 829-844.

CSA (Central Statistical Agency). (2012). Summary and Statistical Report of the Population and Housing Census. Addis Ababa, Ethiopia.

CSA (Central Statistical Agency). (2019). Agricultural Sample Survey: Area and Production of Crops, Main Season. Addis Ababa, Ethiopia.

CSA (Central Statistical Agency). (2020). Agricultural Sample Survey: Area and Production of Crops, Main Season, and VOLUME I. Addis Ababa, Ethiopia.

Debelo Duressa. (2015). Analysis of factors influencing adoption of quncho teff: The Case of Wayu Tuqa District. *International Journal of African and Asian Studies*, 12: 20-28.

EBA (Ethiopia Bellmon Analysis). (2019). The agricultural sector of Ethiopia. Ethiopia Bellmon Analysis 2019/20.

Ermias Tesfaye. (2013). Adoption of improved sorghum varieties and farmers' varietal trait preference: The case of Kobo District, North Wolo Zone, Ethiopia. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Gebissa Yigezu (2021). The challenges and prospects of Ethiopian agriculture, Cogent Food and Agriculture, 7:1.

Ghimire, R., Wen-chi, H. and Shrestha, R. B. (2015). Factors affecting adoption of improved rice varieties among rural farm households in Nepal. Rice Science, 22 (1): 35-43.

Greene, W. H. (2003). *Econometric Analysis*, 5th Edition. Macmillan, New York, USA.

Hailu Beyene. (2008). Adoption of improved teff and wheat production technologies in crop and livestock mixed systems in Northern and Western Shewa Zones of Ethiopia. Doctoral Dissertation, University of Pretoria, South Africa.

Hassen Beshir, Bezabih Emana, Belay Kassa and Jema Haji. (2012). Determinants of chemical fertilizer technology adoption in North Eastern highlands of Ethiopia. *Journal of Research in Economics and International Finance*, 1 (2): 39-49.

Hassen Beshir. (2014). Factors affecting adoption and intensity of use of improved forages in N. East Highlands of Ethiopia. *American Journal of Experimental Agriculture*, 4 (1): 12-27.

Hauenstein, S. (2015). Assessing the resilience of teff value chain in Ethiopia. MSc Thesis, Swiss Federal Institute of Technology, Zurich, Swisserland.

Idrisa, Y. L., Shehu, H. and Ngamdu, M. B. (2012). Effects of adoption of improved maize seed on household food security in Gwoza local government area of Borno State, Nigeria. *Global Journal of Science Frontier Research*, 12: 5-12.

Kafle, B. (2011). Factors affecting the adoption of organic vegetable farming in Chitwan District, Nepal. *World Journal of Agricultural Sciences*, 7 (5): 604-606

Kapalasa, G.E. (2014). Assessing factors influencing farmers' adoption of improved soybean varieties in Malawi. *Scholarly Journal of Agricultural Science*, 4(6):339-349.

Kudi, T.M., Bolaji, M., Akinola, M.O. and Nasa, I.D. (2011). Analysis of adoption of improved maize varieties among farmers in Kwara State, Nigeria. *International Journal of Peace and Development Studies*, 1(3): 8-12.

Lavison, R. (2013). Factors influencing the adoption of organic fertilizers in vegetable production in Accra. MSc Thesis, Accra, Ghana.

Leake Gebreselassie and Adam Bekele. (2015). Factors determining the allocation of land for improved wheat variety by smallholder farmers of northern Ethiopia. *Journal of Development and Agricultural Economics*, 7 (3): 105-112.

Minten, B., Seneshaw Tamru, Ermias Engida, and Tadesse Kuma. (2013). Ethiopia's Value Chains on the Move: The Case of Teff. ESSP II Working Paper 52. International Food Policy Research Institute (IFPRI). Addis Ababa, Ethiopia.

MoANR (Ministry of Agriculture and Natural Resource). (2018). Plant variety release, protection, and seed quality control directorate. Addis Ababa, Ethiopia. Crop Variety Register. 19: 1–450

OKARD (Office of Kobo Agricultural and Rural Development). (2018). Socio-economic Profile Description of Kobo District of Amhara Region, Ethiopia.

Rafael, N. (2011). Determinants of agricultural technology adoption in Mozambique. Post-Doctoral Research Fellow. IFPRI, Maputo, Mozambique.

Regasa Dibaba, Afework Hagos, Chilot Yirga and Endeshaw Habte. (2018). Determinants of improved teff varieties adoption and its impact on productivity: The case of non-traditional teff growing areas of Western Ethiopia. *Journal of Natural Sciences*, 22(8): 2224-3186.

SARC (Sirinka Agricultural Research Center). (2015). Annual report,. Sirinka, Ethiopia.

Setotaw Ferede. (2013). Technological Change and Economic Viability in Teff Production. pp. 255-273. In: Kebebew, A., Solomon, C. and Zerihun, T. (eds.), Proceeding of the 2nd International Workshop, Achievements and Prospects of Teff Improvement, 7-9 November 2011. Debre Zeit, Ethiopia.

Sibanda, M., Mushunje, A. and Mutengwa, C. S. (2016). Factors influencing the demand for improved maize open pollinated varieties (OPVs) by smallholder farmers in the Eastern Cape Province, South Africa. *Journal of Cereals and Oilseeds*, 7 (2): 14-26.

Solomon Asfaw, Bekele Shiferaw, Simtowe, F. and Messia Hagos. (2011). Agricultural technology adoption, seed access constraints and commercialization. Evidence from chickpea technologies in Ethiopia. *Journal of Development and Agricultural Economics*, 3 (9): 436-447.

Tadesse Adgo. (2008). Farmers evaluation and adoption of improved onion production package in Fogera district, Northern Ethiopia. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Tareke Berhe, Zewdie Gebretsadik, Edwards, S. and Hailu Araya. (2011). Boosting Teff Productivity Using Improved Agronomic Practices and Appropriate Fertilizer. Pp. 133–140. In: Kebebew, A., Solomon, T. and Chanyalew, Z. (eds.), Proceedings of the 2nd International Workshop in Achievements and Prospects of Teff Improvement, November 7-9, 2011, Debre Zeit, Ethiopia.

Teklewold Hailemaiam, Legesse Dadi, Alemu Yami and Dana, N. (2006). Determinants of adoption of poultry technology: Livestock Research for Rural Development, 18 (3).

Tesfaye Teklu, Fassil Kelemework, Abera Deresa, Elias Zerfu, Kiflu Bedane and Legesse Dadi. (2001). Teff Technology Transfer and Adoption. Pp 255-264. In: Hailu Tefera, Getachew Belay, and Sorrells, M. (eds.), Proceedings of the International Workshop on Teff Genetics and Improvement, 16-19 October 2000. Addis Ababa, Ethiopia.

Tsibuk Berhe. (2015). Factors affecting adoption of quncho teff variety: The case of Medebayzana Woreda, North-Western Administrative Zone of Tigray Region, Ethiopia. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Verkaart, S., Bernard, G., Mausch, K. and Jeffrey, D. (2016). Welfare impact of improved chickpea adoption in Ethiopia. Food policy, 66 (2): 50-61

WB (World Bank). (2013). Ethiopia Rural Socioeconomic Report. Addis Ababa, Ethiopia.

WB (World Bank). (2019). Agriculture, forestry, and fishing, value added (% of GDP), Ethiopia

WB (World Bank). (2019). Enabling the Business of Agriculture and Improving Food security in Ethiopia

Worku, I., Dereje, M., Berhane, G., Minten, B. and Taffesse, A. (2014). Teff and its Role in the Agricultural and Food Economy. Ethiopian Research Institute. (Unpublished).

Yaregal Mulu. (2011). Adoption of improved varieties of maize: The case of Dilla Zuria Woreda, SNNPR, Ethiopia. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Yenealem Kassa, Ranjan, S. and Belaineh Legesse. (2013). Determinants of adoption of improved maize varieties for male headed and female headed households in West Harerghe Zone, Ethiopia. *International Journal of Economic Behavior and Organization*, 1(4): 33-38.

Yu, B. and Nin-Pratt, A. (2014). Fertilizer adoption in Ethiopia's cereal production. *Journal of Development and Agricultural Economics*, 6 (7): 318-337.

Appendices

Appendix Table 1: Test statistics for comparison of double-hurdle with Tobit Model

	Tobit	Double hurdle	
		Probit	**Truncated**
Wald/LR χ^2	143.61	131.22	78.24
Prob > χ^2	0.000	0.000	0.000
LOG-L	-13.17	-38.24	70.39
Number of observations (N)	150	150	72
Log likelihood ratio statistics	Γ= 90.64 > χ^2 (16) = 32 at 1% level of significance		

Source: Own estimate

Appendix Table 2: Multicollinearity test results for the continuous explanatory variables

Variables	Co-linearity Statistics	
	VIF	**1/VIF**
Age of the household head	1.98	0.506
Family labor in adult equivalent	1.40	0.714
Off/non-farm income	1.05	0.956
Farming experience	2.05	0.488
Cultivated land size	2.39	0.418
Proportion of teff cultivated land	1.95	0.512
Livestock holding in TLU	1.42	0.704
Frequency of extension contact	1.02	0.979
Distance from the nearest market	1.20	0.830
Mean VIF	1.61	

Source: Own estimate

Appendix Table 3: Multicollinearity test results for dummy explanatory variables

Variables	Sex	Education	Demonstration Participation	Seed availability	Credit	Organization member	Yield
Sex	1	0.033	0.022	0.003	-0.205	0.016	-0.111
Education		1	-0.276	-0.132	0.011	0.083	-0.294
Demonstration Participation			1	0.262	-0.032	0.195	0.102
Seed availability				1	0.039	-0.254	0.002
Credit					1	0.090	-0.102
Organization member						1	0.147
Yield							1

Source: Own estimate

Analysis of the Technical Efficiency of Wood and Metal Manufacturing Enterprise in Bahir Dar City of Amhara Region, Ethiopia

Dejene Fikadie[1]

Abstract

This study investigates technical efficiency of wood and metal manufacturing enterprise in Bahir Dar city, Ethiopian, using cross sectional data collected from 220 manufacturing enterprise. The stochastic frontier approach estimated to obtain elasticity technical inefficiency score. The results indicate there is technical inefficiency both in wood and metal micro and small manufacturing enterprise. The production function indicates that labor and cost of input have positive relationship. However, capita have negative relationship on wood manufacturing but it is not significant in metal manufacturing enterprise. The mean inefficiency equals 0.185 and 0.317 wood and metal manufacturing. This study used Tobit model to identify the determinates of technical efficiency. The result indicated that age of business owner, experiences, age of enterprise, credit, vertical linkage and availability of current financial capital affect efficiency level of metal manufacturing enterprise. With respect to wood manufacturing enterprise work experiences, training, enterprise age and ownership have significantly relationship with technical inefficiency. Enterprise age found positively related their technical inefficiency level of both wood and metal manufacturing. The productions of both manufacturing enterprises exhibit decreasing return to scale. Government policy and strategy addressed to wards on enterprise and enterprise characteristics to improve technical efficiency of enterprise.

Keywords: Wood; Metal; Manufacturing, Stochastic Frontier Approach, and Technical Efficiency.

[1] Department of Economics, Debre Tabor University, Ethiopia
Email: dejenfikadu23@gmail.com

1. Introduction

Micro and small manufacturing development gives priority attention in growth and transformation plan period in Ethiopia. Also strategy formulated since 1997 and revised in 2011 with a systematic approach for promoting growth and development of enterprise in different sector. Facilitating economic growth creates long term job opportunity; promoting export and import substitution are the vital role of transformation plan one and two. Five sector identified for micro and small enterprise such as construction, urban agriculture, trade, services and manufacturing sector were identified more priority gives for manufacturing sector such as textile ,garment ,woodworking, metal working, agro processing, food and beverage processing by accelerating the developments of micro and small enterprise the contribution of manufacturing sector will be increase for total national output. More than 10,000 new medium will get a manufacturing location from industrial zone by selecting 16 export products which have high value chine maximizing their benefits 50.2 billion birr from local market, $1 billion from international (Growth and Transformation Plan Annual Progress Report, 2014).

Majority of micro and small enterprise in developing countries does not follow the efficient technique of production as well it influence growth and productivity of enterprise (International Labour Office, 2015). In Ethiopia, also as compare to large enterprise micro and small enterprise highly inefficient and high input wastage during production. It has been contributed low performances of enterprise efficiency (Bultum, 2017). But, there is potential possibility rise growth and productivity by improving efficiency without increasing new technology and input. Inefficiency is the result of using excessive inputs at a given level of output or low output at given level of input (Kuma et al ., 2016).

Technical efficiency of micro and small enterprise is an ability of to produces the maximum output by using a set of input or minimizing the level of inputs for certain level of output Enterprise operating it efficient ways of production systems and identifying the determinates factor for efficient ways of production plays crucial role on sustainability of enterprise (Kotane & Kuzmina-merlino, 2017). For instances, the measurement of efficiency in production unit and the identification of the sources of inefficiency it is one of the most important condition for the improvement of the productivity in competitive world. Technical efficiency mean that minimize input at given level of output or maximize an output at given level of input and technology during production. There are two major methods for estimations of technical efficiency frontier parametric and non-parametric method of estimation (Vincova, 2005)

According to Porcelli (2009) the parametric method technical efficiency use econometrics techniques by applying the stochastic frontier production function , which assumes that the error terms is composed of two elements it is the statically notices which represents the randomness the second represents technical inefficiency when one side distribution. The production function can be Cobb-Douglas or translog production function. The second method of technical efficiency is non-parametric methods of estimation. Unlike, the parametric method there is no need to estimate production function to measure technical efficiency. However, Data envelopment analysis is methods of non-parametric technical efficiency with mathematical linear programming model. Although in this method the inefficiency scores are very sensitive to measurement error related to this method from input or output variable and without assuming the error term.

Alvarez et al (2003) examined study in Nigeria microenterprise technical efficiency analysis by incorporated with cross sectional data. Education has positive significant effect on technical efficiency of enterprise. Increase the age of entrepreneur declines the technical efficiency of micro enterprise. An empirical study conduct by Tingum & Ofeh (2017) on technical efficiency of Cameron micro and small manufacturing enterprise by using stochastic production frontier. Through cross sectional data from different manufacturing enterprise the result confirmed that most firm were technical inefficient. Firm size most important variables affect for technical efficiency of firm production processes. Large enterprise are less technical efficient than efficient than small firm based on production. The age of firm plays a significant effect on the technical efficiency of firm, when the ages of firm increases it leads to reduction of efficiency of manufacturing.

Harvie (2010) examined the levels of technical efficiency among micro and small enterprise in Vietnam by using a Cobb-Douglas production function frontier. The results from manufacturing firm technical efficiency show that relatively high average technical efficiency range from 84.2% to 92.5%. Factor affecting efficiency levels are firm age, location, and government assistances are significantly affect technical efficiency of firm.

Bultum (2017) explored performances of micro and small enterprise block making, metal work and wood work in Adama by using data envelopment analysis without estimated a production function and identified determinate of technical efficiency. The result established that they are high technical inefficient as compared to large enterprise in Ethiopia. Problems faced enterprises are market linkage, corruption and work place in manufacturing are the main problem.

According to Archive, & Zulfiqar (2013) by estimated stochastic frontier to measure technical efficiency medium and small enterprise in manufacturing sector. Cobb-Douglas production function applied variables output levels of enterprise are labor female and male, local and import raw material. Except female labor all other variables have positive relationship with output levels of Pakistan Micro and small enterprise in manufacturing enterprise. Micro and small enterprise operated by female less technical efficient as compare to male. .

Crespi & Alvarez (2003) used non parametric deterministic frontier methodology for evaluating technical efficiency level of Chilean manufacturing firm. Education, experiences and training of entrepreneur were the determinate of technical efficiency. The result show that experiences and efficiency found positive relationship but education and training don't have significant effect of technical efficiency. In another study Sekwati & Harvie (2014) shown that experience have positive significant relationship on technical inefficiency micro and small enterprise in Botswana. Noor (2014) worked out to confirm training and technical efficiency relationship by using stochastic frontier method in Malaysia enterprise. Training has positive relationship with technical efficiency level. Coast & Bhasi (2001) conducted a study on technical efficiency level of manufacturing enterprise with stochastic frontier Cobb-Douglas production function method.

Natarajan & Raj (2008) selected informal manufacturing enterprise in Indian for measuring technical efficiency level. They used stochastic frontier production function. The results show that there was high level of technical inefficiency. The study analyzed positive relationship between subcontracting and credit with technical efficiency level.

An empirical Study conducted in Ethiopian by Kuma et al ., 2016; Bultum, (2017) has shown that micro and small enterprise are highly technical inefficient level in Adama and Wolaita through Data Envelopment Analysis. However, the finding of the above studies may not be applicable in the case of Bahir Dar city due to diversity of enterprises characteristics. Therefore, it is possible to show input-output relationship both wood and metal manufacturing enterprise by estimate production function. Thus, the main objectives of this study is to analyze technical efficiency of wood and metal manufacturing enterprise in Bahir Dar city of Amhara region, Ethiopia.

2. Research Methodology

2.1. Description of study area

Bahir Dar is the capital city of Amhara National Regional State. It is located in the northwestern highlands of Ethiopia at 37° 10′ E longitude and 11° 38′ N latitude and its average altitude is 1830 m above sea level . Topographically, the city lies on a flat surface with almost no slope gradient except for small increases in elevation in the eastern and western peripheries. Based on the simplified traditional agro-climatic classification system, Bahir Dar falls within the Woina-Dega climatic condition. In Bahir Dar city, the micro an small enterprise is highly characterized as employment and income generation sector for a substantial segment of the city's population.

2.2. Sampling design

In order to collect data the number of sample needs to determine initially. The level of precision, level of confidences interval and degree of variability needs to specify during sample size determination (Israel, 1992). This study focused only 493; micro and small manufacturing in Bahir Dar city are which involved into wood and metal manufacturing sector. The total number of wood micro and small manufacturing enterprise are 269 others 224 are metal manufacturing sector are the target population of this study. At 95% confidences interval and 5% precision level the number of sample size needs from 493 totals micro and small enterprise in wood and metal manufacturing was 220. This study applied a simplified formula provided by Yamane (1967) to determine the required sample size at 95% confidence level and level of precision =5%.

$$n = \frac{N}{1 + \mathrm{N(e)2}}$$

$$n = \frac{493}{1 + 493(0.05)2} = 220$$

Where n is the sample size, N is the population size (equal to 493) and e is the level of precision (equal to 5%). The above formula required a minimum of 220 respondents and this study was carried out on 220 respondents. Micro and small enterprise were stratified in to nine non overlapping strata that are relatively homogenous based on the location. Such stratification was appropriate because the number and characteristics enterprise significantly varies by location. After the stratification of enterprise done by location, next the sampling enterprise stratified by sector into wood and metal within micro and small. Then, a random sample from each sector of these strata were selected independently in a number proportional to each sector of the strata size by comparing to the total population. After that, 120 and 100 micro and small enterprise were randomly selected from wood and metal manufacturing sector respectively. Finally, the respondent was randomly selected from each sector of nine sub cities with the help of simple random sampling in lottery method based on an equal probability system in each sector from nine sub cities.

2.3. Data type, sources and methods of collection

This study was depending on both primary and secondary data. The primary data were collected through structured questionnaires. In order to realize the objective the study detail information were collected such as characteristics of the operates of micro and small enterprise including age, education level, work experiences, and including the profile of enterprise years of establishment, initial capital, current capital, numbers of employees at starting and current, access to training, credit, linkage and other related information important for analysis were collected. The structured questionnaires were arranged both in Amharic and English language. Secondary data were obtained from Bahir Dar city micro and small enterprise development offices including list of enterprise. The objectives of the research have been informed to the owner or manager of enterprise in order to get reliable data.

2.4. Technical efficiency analysis model

The technical efficiency model of micro and small manufacturing enterprise was estimated by using cross sectional data with parametric approach of stochastic frontier model through production function. The common production functions in stochastic frontier technical efficiency analysis is Cobb-Douglas production function (Asied et al , 2012). Battese and Coelli (1995) proposed model for technical efficiency with Cobb-Douglas production function looks like below.

$$lnYi = \beta o + \beta lnXi + \varepsilon i \quad \textbf{(2)}$$

Where εi is an error term $\quad \varepsilon i = vi - ui \quad$ **(3)**

$$lnYi = \beta o + \beta lnXi + vi - ui \quad \textbf{(4)}$$

The economic reason behind this specification is that the production process is subject to two economically obvious random disturbances. Statistical noise represented by vi and technical inefficiency represented by ui. vi, represent the random error term which is statistical noise with zero mean it has independently identical distribution N(0, σ2v). ui, the one side error term assume to be non negative variables with half normal distribution (0, σ2u) and it is the technical inefficiency term drive from Cobb-Douglas estimated frontier. The subscript i represent enterprise. β is a scalar vector of unknown parameters β0 represents the intercept terms other represent input coefficient.

$$lnYi = \beta 0 + \beta 1 lnKi + \beta 2 lnLi + \beta 3 lnMi + Vi - Ui \quad \textbf{(5)}$$

Where, yi the output enterprise proxy by sale revenue of enterprise per monthly in birr Ki , represent the net capital asset in birr , Li number of labor hours worker per month , Mi represents the cost of intermediate input in birr.

The technical inefficiency model specifies below, there are different factor affecting technical efficiency of enterprise identified from the literature. The choice of variables used to estimation inefficiency scores and determinants of efficiency was guided by literature. The variables that have been frequently hypothesized as relevant for efficient outcomes in production theory, and those which have been empirically applied used also in this study. These are variables which are factors affecting to the technical inefficiency of micro and small manufacturing, grouped in to three, enterprise characteristics, entrepreneur characteristics and enterprise linkage. Estimation of technical inefficiency function specify below.

$$Ui = \Theta o + \theta 1 ageow + \Theta 2 gendr + \Theta 3 worke + \Theta 4 tranig + \Theta 5 eduction + \Theta 6 Eage + \Theta 7 lncrrtc + \theta 8 credit + \theta 9 ownership + \theta 10 location + \theta 11 vrti + \beta 12 horz + \acute{\omega} i \quad \textbf{(6)}$$

Where, Ɵ represent the scalar vector of unknown coefficient to be estimate. The maximum likelihood estimation of equation (3.5) yields consistent estimator for β, σ2, λ. ($0 \leq \lambda \leq \infty$) the variances of parameters are expressed in terms of σ2 = σ2u + σ2v and $\lambda = \frac{\sigma u}{\sigma v}$. Where σ^2 is the total variance of the model and the term λ, representing the ratio of the standard error of inefficiency to the standard error of statically noise . The above equation 3.6 estimated by OLS and Tobit model (Crespi, & Alvarez, 2003; Sekwati & Harvie, 2014)

Table 1: Description of variables used in econometrics model

Variable name	Type	Definition
Output of enterprise (lnYi):	Continuous	The output wood and metal manufacturing enterprise measured monthly sale volume in terms of birr.
Fixed Capital (lnKi):	Continuous	Capital input is measured as the net value of fixed assets after deducting accumulated depreciation at the end of the year
Labor (lnLi):	Continuous	Labor is one of the inputs for manufacturing enterprise measured in number of hours work per day. Convert in to total number of monthly worked hours in for the selected enterprise
Cost of raw materials (lnMi)	Continuous	This includes all cost of inputs in the production process measure in birr per month. The combination of all cost of inputs during the life cycle of an item intended to produces an output in terms of monetary value in birr per month
Age	Continuous	It is the ages of entrepreneur in years
Experiences	Continuous	The number of years spending related to this business including past experiences.
Training	Dummy	An entrepreneur of enterprise access to training related to business activity. It takes dummy value 1 yes 0 otherwise
Education	Continuous	It measure in year of schooling of owner of enterprise.
Enterprise age	Continuous	Age of enterprise measured in number of years since the startup of business
Esize	Continuous	The size of enterprise measures in terms of the number of labor employed in manufacturing enterprise when enterprises established.
Sector	Dummy	There are two sector wood and metal manufacturing 1 for metal 0 otherwise
lnCintial	Continuous	The amount financial capital when enterprises start up to practice working activity.

lnCurrtc	Continuous	The amount of total financial capital current available for enterprises to continue business.
Credit	Dummy	When enterprises access to finances to run their enterprise. it takes dummy value 1 yes access credit 0 otherwise
Workplace	Dummy	It takes dummy value 1 if it have own working places, 0 otherwise
Ownership	Dummy	It takes dummy value 1 for sole proprietorship 0 otherwise
Location	Dummy	It takes dummy value 1 working in close to in front of road 0 otherwise
Vertical linkage	Dummy	It has dummy value 1 if enterprise has vertical linkage 0 otherwise
Horizontal linkage	Dummy	It takes dummy value 1 if enterprise has horizontal linkage 0 otherwise.

3. Result and Discussion

3.1 The descriptive statistics of variable used in production function

Table 2 shows that monthly major input-output of wood and metal manufacturing enterprise except labor three other variables from the table values in terms of Birr. From the above summery statistics shows, variables used to the analysis for technical inefficiency of metal and wood manufacturing enterprise. Table 1 shows that a sample wood manufacturing monthly average sale volume equals 64,953 birr. In addition, other input variables average working labor hour per month equal 1371.675 hour. The average value of capital and cost of production in wood manufacturing were equal to 38,089 and 47,254 birr.

Metal manufacturing enterprise has monthly sale volume equals with 46,226.65 birr. The sampled micro and small metal manufacturing enterprise have 1,383.02 working hour per month. The cost of intermediate input in one month equals an average of 35,869 birr. Regarding to asset value machinery and equipment capital in metal manufacturing enterprise has an average value of 13,057 birr.

Table 2: Summary statistics of continuous variables in production function

Variables	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Capital (machinery and equipments)	120	38089.71	6401.766	20283.19	55822.73
Labor input (working hour)	120	1371.675	583.3979	208	3432
Cost of production	120	47254.85	11092.68	26650	82375
Sale volume	120	64953.57	19885.26	25000	133050
Metal manufacturing					
Capital (machinery and equipments)	100	13057.71	11092.68	5919.13	25651.23
Labor input (working hour)	100	1383.02	450.3998	440	2520
Cost of production	100	35869.84	11015.32	14150	61750
Sale volume(output)	100	46226.65	14731.5	18000	79000

Sources: survey result

3.2. Estimates of Stochastic Frontier Model

The maximum likelihood estimation of the stochastic frontier production function was obtained. The stochastic frontier estimates of metal and wood manufacturing enterprise in Cobb-Douglas production functions were statistically significant. In the Cobb-Douglas production function the parameter estimated βs represent the elasticity of output with respect to different input. The coefficient of labor and cost of intermediate input are positive related and statistically significant to the level output elasticity both in metal and wood manufacturing enterprises.

However, capital input only significant in wood manufacturing enterprise also has negative relationship. This finding may indicates that capital have insignificant and negative relationship were due to labor intensive technology rather that capital intensive require in metal and wood manufacturing enterprises. The coefficient of input variables shows that both enterprise operating decreasing return to scale. The sum of the coefficient all input less than unity both in wood and metal manufacturing enterprise.

Table 3: Maximum likelihood estimates of the Stochastic Frontier Production Function

Variables	Metal	Wood
	Coefficient	**Coefficient**
Constant	6.889***	4.281***
	(0.000)	(0.003)
Lnlabor	0.135*	0.0690*
	(0.055)	(0.098)
lncapital	0.0178	-0.380***
	(0.815)	(0.001)
Lncost	0.288***	0.973***
	(0.000)	(0.000)
Σv	.12895	.1474254
σu	.3977733	.2348914
σ2	.1748517	.0769082
$\lambda = \frac{\sigma u}{\sigma v}$	3.084709	1.59329
Observations	100	120

P-Value in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Sources: Computed from filed survey data

3.3. Descriptive statistics of technical inefficiency

The technical inefficiency score ranged from 0.035 to 0.822 and 0.046 to 0.939 in the wood and metal manufacturing. The mean inefficiency of enterprise equals 0.185 and 0.317 to wood and metal manufacturing enterprise. Metal manufacturing enterprises have higher mean technical inefficiency score than wood manufacturing. There is an opportunity to minimize technical inefficiency from current technology and input both sector.

Table 4: Summary statistics of technical inefficiency score by sector

Statistics	Wood	Metal
Mean	.185	.317
S. dev	.105	.214
Minimum	.0350	.046
Maximum	.822	.939

Sources: Computed from filed survey data

3.4. The determinate of technical inefficiency

To identify the determinate of technical inefficiency of wood and metal manufacturing enterprises Tobit models were applied. Technical inefficiency score dependent variable and some entrepreneur and enterprises characteristics are independent variables. Tobit regression econometric model were applied to identify the relationship between of technical inefficiency with entrepreneur and enterprises characteristics. Technical inefficiency score censored at maximum and minimum value in Tobit regression model. The stochastic frontier estimation shows that there is technical inefficiency both wood metal manufacturing enterprises. Before estimation of econometrics model the determinate technical inefficiency model normality of disturbances term was tested by Shapiro-Wilk tests.

The model satisfied the normal distribution assumption of the disturbances term but suffer from Heteroscedasticity problem. Therefore, the robust regression applied on Tobit model. The estimated coefficient with technical inefficiency model of wood and metal manufacturing enterprise Tobit regression result presented Table 5 below.

In wood manufacturing, the significant variables were experiences; training, age of enterprise and ownership are significant relationship with technical inefficiency. Except the age of enterprise, experiences, training and ownership have negative coefficient in wood manufacturing enterprise technical inefficiency model. Thus a negative coefficient means that increases in technical efficiency level and positive effect on output level. The sign and coefficient of technical inefficiency model are interpreted in opposite way; a negative coefficient variables means increase technical efficiency.

In metal manufacturing, the significant variables were age of entrepreneur, experiences, age of enterprise, credit, vertical linkage, current financial capital. Except credit and age of enterprises other variables have negative relationship with technical inefficiency level of metal manufacturing enterprise at 1% ,5% and 10% level of significances.

Age of entrepreneur has a negative coefficient and statistically significant only in metal manufacturing. The marginal effects of age on technical efficiency imply an additional one year age of an entrepreneur would increase technical efficiency by 0.0705% in metal manufacturing enterprise. Therefore, the older the age of owner of enterprise they are less technical inefficiency in the study area. This result contradicts with Alvarez et al. (2003) who found positive relationship between age owner and technical inefficiency. A possible reason for this result would be the older the age of entrepreneur have accumulated working experience enhanced to management enterprise efficiency. One of another possible explanation would be the older age of entrepreneur have request different skill and capacity to make it enterprise efficient in production.

Working experiences of an entrepreneur has negatively related with wood and metal manufacturing technical inefficiency at 10% and 1% level of significance. The marginal effect indicted that a unit change in working experiences would increase the probability of technically efficiency both wood and metal enterprise by 0.9% and 0.8% respectively while keeping all other variables remain constant. The interpretations of this result suggest that more working experiences entrepreneur has technical efficient by acquiring different production skill. This finding contradicts with (Sekwati & Harvie, 2014) finding technical inefficiency and the entrepreneur's years of experience have positive relationship. But, this result in line with Crespi, & Alvarez (2003) finding negative relationship between experiences and technical inefficiency.

Accessed to training has negative significant relation on technical inefficiency level in wood manufacturing enterprise and statistically significant at 1% level of significances. The marginal effect indicted that a unit change in acquisition of training would increase the probability of wood manufacturing technical efficient by 4.83% while assuming all other factors remain constant. This implies that entrepreneur participation in training related to current working activity has positive effect on technical efficiency level of enterprise. Similar result were observed by Coast, & Bhasi (2003) ; Noor (2014) training plays a key function on modifying and adopting new technology and design new methods of production in wood manufacturing enterprise.

The age enterprise is also the determinate of manufacturing enterprise technical inefficiency both wood and metal manufacturing statistically significant at 10%. The computed marginal effect result shows that a one-year increase in the age of enterprise would increase the probability of a wood and metal enterprises being technically efficient by 1.04%and 1.56% respectively. The effect of age on technical inefficiency has not clear empirical result. Some researchers found positive relationship due to learning by doing benefit, but other studies found negative relationship young enterprises adopt new technology and produces efficiently. This result is consistent with the finding of Tingum & Ofeh, (2017); Asiedu, et al. , (2012) the older the age of enterprise may not be have motivation to recognize the new technology due to financial constraints. The young enterprise are more technical efficient that old enterprise. The age of enterprise increase technical inefficiency level. The reason for old enterprises are less efficient may be using old production technology whereas younger enterprise engaged in new advanced method of production technology. An additional, possible reason old manufacturing enterprise technical inefficient may due to diminishing marginal return to scale of production make them more inefficient.

Another variable the determinate of wood manufacturing enterprise technical inefficiency level was ownership structure of enterprise. The marginal effect of ownership on technical efficiency indicates that enterprise who managed by individual were 5.48% more efficient than those enterprises are cooperative. Single owner wood manufacturing enterprise have more technical efficient than cooperative owner enterprise. The implication of this result could be single owner enterprise tend to manage his business decision easily to ensure efficiency. In cooperative enterprise employees may be lacking working incentives and supervision also it is difficult to make decision alone without members. Another reason may be group member may have different motivation to re-invest profit in cooperative rather than argue to distribute. This eventually leads to production inefficiency. So that, cooperative enterprise members may have less internal motivation to make long term investment. The result confirm with the finding of other studies Asiedu et al. (2012) in Ghana.

The estimated coefficient of accessed to credit and the level of technical inefficiency have positively related in metal manufacturing at 5% level of significant. The marginal effect of credit on efficiency indicates enterprises who have access to credit services were 10.8% more efficient than those enterprises that do not have access to credit. The result of the study revealed that metal manufacturing enterprise that have no access to credit are technical efficient than those enterprise access to credit. This might be due to metal manufacturing enterprises not using credit appropriately for intended purpose. This result contradict with Natarajan & Raj (2008) finding negative relation between credit and technical inefficiency.

In this study, vertical linkages measured through the relationship between input supplier with subcontracting form both in wood and metal manufacturing enterprise. However, the result indicates only statistically significant in metal manufacturing at 5% level. The marginal effect of indicates that technical efficiency of non-vertical integration enterprises reduced by 10.3% enterprise that have vertical integration This indicates that enterprises have subcontracting from input supplier experience negative relationship in technical inefficiency also similar result reported by (Natarajan & Raj, 2008) .

Table 5: Technical inefficiency model of wood and metal manufacturing enterprise in tobit model

Variables	Metal Manufacturing		Wood Manufacturing	
	Coefficient	Marginal eff dy/dx	Coefficient	Marginal eff dy/dx
Sex	-0.0700(0.471)	-0.0700(0.469)	-0.00239(0.931)	-0.00239(0.931)
Age	-0.0706**(0.021)	-0.0705**(0.019)	0.00117 (0.464)	0.00116(0.464)
Education level	-0.00903(0.189)	-0.00903(0.185)	0.00143(0.538)	0.00141(0.536)
Experiences	-0.0093*(0.071)	-0.0091*(0.068)	-0.0085***(0.001)	-0.008***(0.000)
Training	-0.00119(0.976)	-0.00119(0.976)	-0.0485***(0.004)	-0.0483***(0.004)
Age of enterprise	0.0158*(0.059)	0.0156*(0.056)	0.0105*(0.096)	0.0104*(0.093)
Ownership	-0.0473(0.198)	-0.0473(0.195)	-0.0549***(0.009)	-0.0548***(0.008)
Credit	0.109**(0.010)	0.108**(0.009)	0.0101(0.547)	0.0101(0.546)
Location	-0.0178(0.646)	-0.0178(0.645)	0.0158(0.386)	0.0158(0.384)
Vertical linkage	-0.105**(0.025)	-0.103**(0.022)	0.00564(0.768)	0.00563(0.767)
Horizontal linkage	0.00831(0.823)	0.00831(0.823)	-0.00434(0.789)	-0.00432(0.788)
Lncurrent capital	-0.154*(0.079)	-0.152*(0.076)	0.00355(0.786)	0.00355(0.786)
Constant	2.451**(0.013)		0.158(0.255)	
Observations	100		120	

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

The amount of current financial capital in birr was negatively and statistically significant relation on technical inefficiency model of metal manufacturing at 10% level of significances. The marginal effect indicated that a one Birr increase of enterprises in current financial capital would increase the probability of technical efficiency by 15.2% while keeping all others variables remains constant. This might be a negative relationship between technical inefficiency and current financial capital, due to enterprises require to purchased input in order maximize output desires financial capital also an essential. In other words, the result shows that the availability of more working financial capital would allow enterprises to applied investment in modern technology, employed skilled labor also positive effect on technical efficiency.

3. Conclusions and Policy Recommendations

This study estimates the technical inefficiency level of wood and metal manufacturing enterprises of Bahir Dar city using parametric approach with Cobb-Douglas stochastic frontier techniques. The result of Cobb-Douglas production function estimation show that all input capital, labor and cost of intermediate input in wood manufacturing significant but capital were not significant in metal manufacturing enterprises. This shows that metal manufacturing enterprises are labor intensive rather than capital-intensive production technology require. Maximum likelihood estimation of Cobb-Douglas stochastic frontier model result show that technical inefficiency presented both manufacturing enterprise because, the estimated value of lambda different from zero $\lambda = 3.084$ and 1.593. The empirical result showed that micro and small manufacturing enterprise in Bahir Dar city are not using a given resources and technology efficiently. This means that more output can be obtained by improvement technical efficiency without added another input and technology. The predicated mean value of technical inefficiency of wood and metal manufacturing estimated to be 0.18 and 0.31.

The estimates of Tobit regression regarding to the determinates of technical inefficiency in wood and metal manufacturing in the study area age of owner, training, work experiences, enterprise age, ownership, credit, vertical linkage and amount of current financial capital are statistically significant. However, this study found no significant relationship between sex, age entrepreneur, education, credit, horizontal linkage, vertical linkage, location and current financial capital in wood manufacturing. In metal manufacturing also sex, education, training, ownership, location, and horizontal linkage are not significant in relation to technical inefficiency.

The age of enterprise play important role in determining technical inefficiency level of wood and metal manufacturing. This may be happen older enterprise applied old technology while young enterprise use advanced technology. Working experiences of entrepreneur have negative significant relationship both wood and metal manufacturing enterprise technical inefficiency level. Training and ownership of enterprise have negative significant relationship with only wood manufacturing technical inefficiency. This finding indicates that accessed training related to current working activity and sole proprietorship ownership structure improved technical efficiency level of wood manufacturing. At the same time, accesses to credit, vertical linkage and age of entrepreneur have significant relationship only metal manufacturing technical inefficiency level.

The finding shows that older enterprise could needs to assistance the concerned body should be give training for older enterprise to adopt new technology to improve efficiency. With respect technical inefficiency model, the findings of wood and metal manufacturing enterprise are not operating efficiently due to less utilization of given input. To minimize technical inefficiency enterprise should focus on efficient use of current input and technology. The study also recommends for wood and metal manufacturing enterprise should increases amount of labor working hour in order to improve output. Enterprise age has positive relationship with technical inefficiency level of wood and metal manufacturing enterprise. This suggests that older enterprise technology should be replaced by new technology in order to improve efficiency. The concerned by should create awareness to old enterprise use modern technology both in wood and metal manufacturing.

Training and sharing of experiences should be provided to wood manufacturing enterprise to enable them technical efficient. Providing training to entrepreneur should be practical to apply directly to their business engagement. Particularly, in quality control, design, market linkage and technology enhancement are important on technical efficiency level improvement. A cooperative micro and small wood manufacturing are not attractive on technical efficiency. So that, possible solution may be creating work incentive among the members and have long term objective. The preference of members should be first recognize an essential condition for creating them. Members who consider that his capacity greater than other unwilling to join the cooperative rather need to redistributed the cooperative resources so the concerned body should consider this problem at the beginning.

In metal manufacturing accessed to credit affect technical efficiency negatively. So that, emphasis should be properly monitored better creation of awareness how to manage credit to improve technical efficiency. There should be better encouragement of vertical linkage in metal manufacturing enterprises enterprise from input supplier by means of subcontracting. Enterprise should be reduces input related problem by making subcontracting from input supplier. Enterprises creating strong linkage from input supplier should expend. The negative result of current financial capital on technical inefficiency of metal manufacturing showed that effort should be given to increase working financial capital intended for improve technical efficiency.

References

Alvarez, R., Crespi, G., & Alvarez, R. (2003). Determinants of Technical Efficiency in Small Firms, 233–244.

Asiedu, K. F., Onumah, E. E., & Kuwornu, J. K. M. (2012). Ownership, Governance and Enterprise Efficiency: Evidence from Ghana Ownership, Governance and Enterprise Efficiency: Evidence from Ghana, 2012.

Bahir Dar city. (2010). Micro and Small Enterprise Offices Data

Battese, G. E. and Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic Frontier production functions for panel data. Empirical Economics 20, 325–332

Berhanu Kuma et. (2017). Determinants of employment growth of micro and small enterprises (January).

Bowale, K. E., & Ilesanmi, A. O. (2014). Determinants of Factors Influencing Capacity of Small and Medium Enterprises (SMEs) in Employment Creation in Lagos State , Nigeria, 5(2). https://doi.org/10.5430/ijfr.v5n2p133

Bultum, N. D. (2017). Performance of Micro and Small-Scale Enterprises : The case of Adama , Oromia, 3(1), 46–51

Cherkos, T., Zegeye, M., Tilahun, S., & Avvari, M. (2017). Examining significant factors in micro and small enterprises performance : case study in Amhara region , Ethiopia. *Journal of Industrial Engineering International*. https://doi.org/10.1007/s40092-017-0221-y

Coast, C., & Bhasin, V. K. (2002). IFLIP Research Paper 01-5, Impact Of Micro-Finance Enterprises On The Efficiency November 2001.

Edjigu, H. T. (2016). Firm Growth and Technical Efficiency in Ethiopia : The Role of Firm Size and Finance, 8(10), 1–13. https://doi.org/10.5539/ijef.v8n10p1

Egziabher, T. G., & Demeke, M. (2007). Micro and small entepries in Small towns, Amhara Region, Ethiopia, (January 2007), 79–111.

Greene. (2002). *Econometric analysis.*

Growth and Transformation Plan Annual Progress Report. (2014). Federal Democratic Republic

of Ethiopia Growth and Transformation Plan Annual Progress Report for F . Y . 2012 / 13,

Harvie, C., & Harvie, C. (2010). Firm performance in Vietnam : evidence from manufacturing small and medium enterprises University of Wollongong Firm Performance in Vietnam

International Labour Office. (2015). Small and medium-sized enterprises and decent and productive employment creation. In International Labour Conference; Report IV. http://www.ilo.org/wcmsp5/groups/public/@ed_norm/@relconf/documents/meetingdocument/wcms_358294.pdf

Israel, G. D. (1992). Determining Sample Size 1, (November), 1–5.

Kotane, I., & Kuzmina-merlino, I. (2017). Analysis of Small and Medium Sized Enterprises' Business Performance Evaluation Practice at Transportation and Storage Services Sector in Latvia. Procedia Engineering, 178, 182–191. https://doi.org/10.1016/j.proeng.2017.01.093

Kuma, T. L. S. R. B. (2016). Determinant of Technical Efficiencies of Micro and Small Enterprises in Wolaita Zone , Ethiopia, 7(21), 70–81.

Maziku, A., & Robert, G. (2014). The Effects of Socio-Cultural Factors on the Performance of Women Small and Medium Enterprises in Tanzania, 5(21), 51–63

Njoroge, C. W. (2013). The effect of entrepreneurial education and training on development of small and medium size enterprises in githunguri district- kenya, 1(8), 1–22.

Noor, Z. M. (2014). Technical Efficiency of Malaysian Manufacturing Small and Medium Enterprises, 9, 676–688

Personal, M., Archive, R., Natarajan, S., & Raj, R. (2008). Technical Efficiency in the Informal Manufacturing Enterprises: Firm level evidence from an Indian state, (7816).

Porcelli, F. (2009). Measurement of Technical Efficiency . A brief survey on parametric and non-parametric techniques, (January), 1–27.

Sekwati, L., & Harvie, C. (2014). Investigating determinants of the technical efficiency of SMEs in Botswana : (2007), 1–21.

Sherifat, Y. O. (n.d.). Gender differentials in factors affecting performance of small-scale enterprises in lagos state – Nigeria, 6(2).

Tingum, E. N., & Ofeh, M. A. (2017). Technical Efficiency of Manufacturing Firms in Cameroon : Sources and Determinants, 8(3), 172–186. https://doi.org/10.5430/ijfr.v8n3p172

Vincová, I. K. (2005). Using DEA models to measure using dea models to measure efficiency 1, (1), 24–28.

Worku, E. B. (2008). Efficiency and Social Capital in Micro , Small and Medium Enterprises : The Case of Ethiopia Key words :, (May).

Yamane, T. (1967). *Statistics: An Introductory Analysis* (2nd ed.). New York: Harper and Row.

Estimation of Technical Efficiency for Selected Commercial Banks in Ethiopia

Kefyalew Tadesse Sendo[1]

Abstract

The study aims at estimating technical efficiency of selected commercial banks in Ethiopia. To achieve this, explanatory research design has been used taking seven commercial banks on the basis of the inclusion criterion that a bank having annual financial reports starting from 2000 till 2017would be sampled with ultimate goal of obtaining maximum number of observation for empirical analysis. Stochastic Frontier Approach (SFA), an econometric estimation model has been followed to disentangle the variation that is attributed to technical inefficiency. Earning asset, proxy of banking investment is the outcome variable and total deposit, proxy of funds used; total employee salary, benefit and general expenses incurred, proxy of labor and total fixed asset, proxy of capital are taken as input variables in estimating technical efficiency. The finding of the study shows that deposit has positive and significant effect on the outcome variable at z-value of 1% (β= 0.616 and p=0.000); capital has positive and significant effect on outcome variable (β= 0.18 and p=0.000); year as a trend variable has positive and significant effect (β= 0.017 and p=0.000), on the output variable. However, labor has negative and significant effect on output variable (β= -0.215 and p=0.000). Therefore, it could be inferred that an increase in technical efficiency is attributed to an increase in deposit, capital and trend variable (technological progress). However commercial bank in Ethiopia experience technical inefficiency owing to labor inefficiency. Commercial banks in Ethiopia have to cut unnecessary labor costs through full utilization of staff capacity and reduction of idle time; in addition, they have to enhance investment in earnings assets as outcome of technical efficiency.

Key Words: Technical efficiency; investment; labor; capital; stochastic frontier approach

---

[1] PhD, E-mail: kefyalewtadesse15@gmail.com or ilmayad@yahoo.com
Tel: 0911763234

1. Introduction

Efficiency of banking industry broadly comprises three different efficiency measures, viz. scope efficiency, scale efficiency, and X- efficiency. X-efficiency can be further categorized into technical efficiency and allocative efficiency (Berger, Hunter, et al., 1993;Chen, Skully, & Brown, 2005; Farrell, 1957). Different scholars define these efficiencies on the basis of their own way to analyze the unique context and objectives.

A firm is said to be technically efficient if it could attain the maximum possible level of output with a given set of input or achieve a certain level of output with lesser amount of a given set of inputs. In other words, Technically Efficient firms have the ability to generate the outputs to the fullest extent from a given level of inputs (known as the output-orientated). In the same manner, a firm is said to be technically efficient if it has the capability to utilize the least possible amount of inputs for a certain level of output (known as input-orientated). Particularly, an input-oriented measure of TE shows the degree to which a bank can reduce its inputs usage to the minimum level in the production of the same level of outputs (Kumbhaker, Lovell 2000 and Lovell, 1993).

As banks play a fundamental role in fostering economic growth, studying efficiency is the most imperative issue in the area (Bumann, Hermes, & Lensink, 2013; Pagano, 1993).. Moreover the need for studying efficiency has increased from time to time which enables policy makers get informed. That is why a number of countries are regulating their banking system to achieve efficiency gains.

Efficient banks are more influential to compete because of their lower cost structure and ability to take business away from less efficient banks. By and large, the efficiency of banking system is always a matter of great concern for different stakeholders(Kumar & Gulati, 2008).

The increased interest of studying banking efficiency is motivated by different methodological issues. Although the production theory explicitly explains whether a decision unit is efficient or not, there are controversial results in many empirical studies in answering the questions, ‘which one is the best banking frontier and how could it be appropriately explained?’ as they are unanswered questions conclusively (Aiello & Bonanno, 2016). This is due to the fact that on one hand, the frontier is not known properly; on the other hand approaches of estimation vary from one another in different ways, as there is no general consensus on the advantage of one method as compared to the others (Berger, Hancock, et al., 1993; Coelli & Perelman, 1999;Fethi & Pasiouras, 2010).

Expansion of empirical literature and correspondingly heterogeneity of the results are the major causes for the increased interest in the study of efficiency in banking sector. The fact that the results are mixed entails that there are varieties of study models which could be classified as parametric and nonparametric methods; stochastic and deterministic approaches; functional forms of frontiers, and distributions for errors and efficiency. Moreover, the difference is further attributed to the econometric model, the size of the sample and the inputs/outputs taken into account. Furthermore, the other point of differences is associated with the time period covered in the study. Even though the above points are all relevant for any kind of efficiency, particularly there are source of heterogeneity in relation to banking literature. This considers how deposits are treated: as output or as input. Because some regard deposit as an output while others consider it as input. By and large, it is not uncommon that all of these heterogeneities in the empirical settings of studies result into heterogeneity in efficiency indices(Aiello & Bonanno, 2016).

These arguments therefore require a better understanding of the responsiveness of results to the preference of methods and specifications of the models. The different options of efficiency measurement models in a banking industry are unique in terms of construct, approach and hence could give different results(Kumar & Arora, 2010). The variation in the results could be significant in the case of banking sector particularly in emerging economies. Highly elaborative descriptions of how efficiency results are sensitive to estimation methods are provided by Beccalli, Casu, and Girardone(2006);Casu and Molyneux(2003);Goddard, Molyneux, and Williams (2014); Huang & Wang(2002); Mobarek & Kalonov (2014); Semih Yildirim & Philippatos (2007).Other scholar, Berger(2007)reviewed the literature and have come up with highly important and comprehensive arguments of why findings differ even though still no one quantifies the effect of methodological choices on variation of efficiency scores.

In this study, technical efficiency is estimated using investment in earning assets and net loans to customers each separately as output variable in two different models specified. Thus, the first models takes investment as output variable and the second method takes net loans as output variable in technical efficiency estimation. As suggested by Greene (2005), true fixed effect is used as it allows to disentangle time varying inefficiency from firm specific time invariant component. The input variables are deposits, labor and capital and the approach used is Stochastic Frontier Approach (SFA) as it assumes that the variation of actual efficiency from the maximum possible efficiency is not only attributed to inefficiency of the firms but also to the random variations.

2. Literature Review

2.1 Theoretical literature

Technical efficiency represents the productivity with which a bank achieves its output and tries to show the efficiency differences that exists among the banks. It is measured by comparing observed value and optimal values of costs, revenues, profits, or all as appropriate as per the focus of the study or as its objective (Aiello & Bonanno, 2016).

As far as the study of banking technical efficiency is concerned, there are two alternative approaches which are mostly used parallel to each other. These are Data Envelopment Analysis (DEA) and Stochastic Frontier Approach (SFA). Among several authors, Coelli & Perelman(1999) come up with the review of approaches used in the measurement of efficiency, including strengths, their limitations and applications.

DEA is one of the non-parametric techniques with principal strength that it does not follow a specified production function and efficiency is gauged in relation to the maximum performance observed as compared to some average. Moreover, DEA exclusively involve an inefficiency term. However, as DEA is deterministic in nature and associates all the variation from the frontier to inefficiencies. Therefore, a frontier estimated by DEA is likely to inflate the inefficiency and tend to obscure the measurement errors or other disturbance terms in the data (Ibid.).

SFA is one of the parametric techniques whose major strengths are that it addresses stochastic error term and also permits statistical hypotheses tests about the structure of production and extent of inefficiency. SFA uses a composed error model whereby: the first component is the random variations that might occur due to short term chances which puts some individual banks in comparatively higher or lower cost structures and measurement error due to excluded explanatory variables etc; the second one is the variation that is attributed to inefficiency (Kumbhakar and Lovell, 2000).

The stochastic production frontier Approach was initially suggested independently by Aigner, Lovell, & Schmidt(1977),Meeusen & van Den Broeck (1977) and for the first time applied by Battese & Corra (1977). In order to properly explain the SFA, it is important to refer back to the neoclassical production theory. Accordingly, the production function is given by $m(x_i ; \beta)$, where x_i is the input vector for a producer i, and is defined as the maximum possible output that can be obtained, i.e. $m(x_i ; \beta)$ is the technical maximum (potential).

The general set up of SFA model is

$$y_i = m(x_i ; \beta) - u_i + v_i = m(x_i; \beta) + \varepsilon_i \qquad \textbf{(1)}$$

where the major difference between this model and the conventional production functional form lies on the fact that the two error terms were separately presented in the model, in which the u_i terms indicate inefficiency, i.e., departure from maximum level of possible output obtained by the production function, $m(x_i; \beta)$, whereas the v_i terms captures the random error that affect the producer which attributed to external factors and are beyond the control of the firm. This view was novel at the time it was suggested. The prior approaches just ignored the v_i component and attributed the total variation to the inefficiency. As a result, the model lacked proper statistical characteristics (Parmeter & Kumbhakar, 2014).

To stress the word maximum, we call $m(x_i; \beta)$ the production frontier function. Here not every firm can achieve the maximum possible output, regardless of whether the inputs were equally provided for all of them or not. Therefore, $y_i \leq m(x_i;\beta)$ and the ratio $y_i/(m(x_i; \beta)) \leq 1$. Accordingly, $(0 \leq TE \leq 1)$,and if y is the actual output produced, customarily we define technical inefficiency ($TI = 1 - TE$) as variation of output from its maximum level, given the inputs. Thus, substituting the values, $TI = (m(x_i ;\beta))-y)/m(x_i ; \beta) \geq 0$. The inequality $y \leq m(x_i; \beta)$ is converted into equality by the reduction of the variation attributed to inefficiency from the maximum output that can be achieved and is re-expressed as $\ln y_i = \ln m(x_i; \beta) - u_i$, where $u_i \geq 0$ and is interpreted as technical inefficiency .

It should be noted that the preceding explanation of inefficiency fits into the situation where random errors which are unforeseen/uncontrollable factors are disregarded. In reality, however,randomness is part of econometric approach for clear reasons as there are countless uncontrollable factors that affect output provided the controllable inputs, x_i. Therefore, to capture the randomness, which is (v_i), it is imperative to assume the stochastic production frontier and write it as $\ln y_i = \ln m(x_i; \beta) - u_i + v_i$. Therefore, the SFA assumes thatthe study of efficiency has gone beyond conventional application of frontier model.

A SFA model in which output oriented technical inefficiency is taken into account can be specified as:

$$\ln y_i = \ln y_i^* - u_i, \; u_i \geq 0, \qquad \textbf{(2)}$$

$$\ln y_i^* = f(x_i; \beta) + v_i, \qquad \textbf{(3)}$$

where, the subscript 'i' stands for the firms or individuals, yiis observed output, xi is a Jx1 vector of inputs, β is a J×1 vector of the respective coefficient vector, vi is random error which is assumed to have a zero-mean and ui ≥ 0 is the measure of inefficiency. Equation 3represents the stochastic production function. Given x, the frontier provides the maximum possible output level and it is designated to be stochastic because of the random error, vi associated to it. Provided that ui ≥ 0, actual output (yi) is expected to fall below the frontier output level (y∗i).

The term ui specified in equation 2 is just the log deviation between the maximum possible output and the observed output (i.e., ui = lny∗i −lnyi), thus ui is the percentage by which actual output could be increased to a fully efficient level of production with the same level of inputs. In other way of saying it is the percentage of output lost because of technical inefficiency. The estimated value of uiis known as the output-oriented technical inefficiency. As the value approaches 0, it means that the firm is almost attaining full efficiency (Parmeter & Kumbhakar, 2014). Rearranging equation 2,we will have

$$\exp(-ui) = \frac{y_i}{y*_i} \quad \textbf{(4)}$$

There are problems that are related to the assumption underlying cross sectional analysis. The first one is that technical inefficiencies are not dependent on the inputs. The other one is related to the assumptions of the forms of technical inefficiency and random error distribution. These two problems could be resolved by the use of panel data. Particularly panel data allows relaxation of independence and distribution assumptions. Moreover, under panel data, it is possible to estimate the efficiency levels of each firm as the number of observations per firm increases. This implies that inefficiency can be estimated more precisely using panel model(Mastromarco, 2008).

2.2. Empirical literature

In estimating Technical efficiency, many scholars contended that the input side of estimating efficiency of cost has been focused mostly Berger, Hunter, et al.(1993); Resti (1997). Only few studies have taken into consideration the output side examining revenue and profit efficiency. Nonetheless, evaluating efficiency of financial institutions both sides are more relevant than focusing on only one.

Any variation of a bank's efficiency from the frontier shows the extent of the bank's inefficiency to achieve maximum output from its given combination of inputs and hence indicates the extent of technical inefficiency (Battese, Rao, & O'donnell, 2004; Coelli, Rao & Battese, 2005).

Andries (2011) in line with the argument of Drake (2001) contends that the higher the bank size, measured by total assets, the higher will be the technical efficiency though the optimum size is a matter of argument. In fact, the bank size-efficiency nexus is subject to unresolved arguments as the empirical results are mixed with this regard and even there seems to be no consensus concerning the association between bank size, bank risk or bank efficiency.

In relation to bank size, Bautista Mesa, Molina Sánchez, & Ramírez Sobrino (2014) suggest that there exists a positive relationship between banking efficiency and the size of the bank, only for small and medium-sized banks and the relationship is insignificant for large banks. A traditional argument used also justifies that the bank with higher concentration are supposed to show greater efficiency.

Apparently, a strong capital base is associated positively to bank efficiency. Equity to total assets is normally used as a proxy to measure the strength of capital base of a bank (Sufian, 2009). The basic argument which favors this contention assumes that strong capital base is a safety margin for banks against unstable macroeconomic circumstances and to provide protection for their depositors(Athanasoglou, Brissimis, & Delis, 2008; Angbazo, 1997; Demirgüç-Kunt & Huizinga, 1999; Kosmidou, 2008). Moreover, from the view point of accounting, the capital ratio directly affects cost of funds since interest expense contributes towards less profitability in the income statement (Berger & Mester, 1997). In similar way, Fiordelisi, Marques-Ibanez, & Molyneux (2011) argue that higher capital base has a positive effect on the level of efficiency.

Sangeetha and Jain (2013) studied the TE of public sector banks in India using Data Envelopment Analysis (DEA) or using interest expense and operating expense as input variables and interest income and other income as output variables. The study found out that the Corporative Bank and the State Bank of India consistently achieved efficiency in all the years under consideration.

Raphael (2013) also examined the efficiency of commercial banks in East Africa (Tanzania, Kenya, Uganda, Rwanda and Burundi, excluding Ethiopia) using a non- parametric approach, DEA, over the period from 2008 to 2011. Applying DEA on input variables (capital and labour) and output variables (deposits and loan accounts) the study indicated that banks recorded a sharp decline.

In the Ethiopian context, there are studies carried out regarding the issue under consideration. For instance, Tesfay and Tesfay (2013) studied relative efficiency of Saving and Credit Cooperatives (SACCOs) using data envelopment analysis and found out that the average TE score was only 21.3% and the technical efficiency varied across the geographical location and the scale operations. Furthermore, Gebremichael and Rani (2012) carried out a study on the total factor productivity change of Ethiopian microfinance institutions (MFIs) using a Malmquist productivity index approach (MPI) and revealed that the main source of the total factor productivity (TFP) growth for the MFIs was attributed to the TE change.

This literature review shows that technical efficiency measurement is mostly based on the nonparametric approach, particularly the Data Envelopment Analysis (DEA). It assumes that the difference between the actual level of efficiency and the maximum possible level of efficiency (efficiency level on the frontier curve) is attributed to the technical inefficiency and has no provision for the random error.
Thus, in this study, the Stochastic Frontier Approach (SFA) has been applied. This model assumes that the variation between the actual and maximum output is attributed both to technical inefficiency and the random errors, which are beyond the control of firms under consideration. This enables to identify the specific level of inefficiency for which the firms are responsible.

3. Methodology

There are 17 commercial banks in Ethiopia out of which 16 are privately owned and one is government owned commercial bank, which is commercial bank of Ethiopia. For this study purpose, there was an inclusion criterion for selecting banks to obtain sufficient number of observation for appropriate empirical analysis. Accordingly, seven commercial banks were selected as a sample based on their number of annual reports, whereby banks having longer period of annual financial reports or longer timesince they were established. More specifically, in order to obtain data set of longer time period and balanced panel data, i.e., equal number of observation for each of the banks considered, banks having a consecutive of 18 years data were selected and included as samples so as to consistently estimate financial intermediation, technical efficiency and competition of one bank with another bank.

The explanatory research design is used in this study setting as the data were obtained from financial reports, which are numerical and objective in nature.

Particularly, panel data was used as both cross sectional units (7 banks) and time series (18 years) were combined in order to estimate the technical efficiency of banks.

The banks selected for this study purpose include Commercial Bank of Ethiopia [CBE], Dashen Bank[DB], United Bank[UB], Awash Bank[AB], Wegagen Bank[WB],Bank of Abyssinia[BOA] and Nib Bank[NIB]

The data were then processed using statistical software packages. In order to efficiently organize the data and facilitate statistical runs, STATA version 12 software package was employed. This software package is used to obtain estimation outputs under Stochastic Frontier Analysis, model for estimating technical efficiency; panel data linear regression analysis and correlation analysis.

As described in the preceding sections, one of the frontier approaches that consider the two components of the total variation is the stochastic frontier approach. On the basis of the suggestion by Parmeter & Kumbhakar(2014), empirical procedure involving Stochastic Frontier Approach (SFA) has been thoroughly followed to come up with the unbiased estimate of the technical efficiency result of the selected banks in Ethiopia.

3.1. The model specification

$$lnInvt_{it}=\alpha+ \beta_1 lndp_{it}+\beta_2 lnlab_{it}+\beta_3 lncap3_{it}+(\beta' lnz_{it})+V_{it}-U_{it} \quad \textbf{(5)}$$

Where, ln=naturallogarithm, base

i= banksunder consideration (which is 7 banks in number, 1,2,3…..7, in this study)

t= time under consideration (2000-2017)

Invt= total investment in Earning asset

β_0=constant term

β_1, β_2&β_3= parameters to be estimated for x1, x2 and x3 respectively

V_{it}= asymmetric random error

U_{it}= error term attributed to inefficiency

Here the assumption is that the U_{it} and the V_{it} are distributed independently for t= 1,2,…,T and bank i= 1,2,…,N.

Table 1: Description of variables used in the model

Variable name	Variable category	Symbol	Description of the corresponding proxy
Technical Efficiency	Dependent Variable	Ivtit	Total earning assets as proxy of investment of bank i in time t
Funds used	Independent	dp it	total deposit of bank i in time t period
Labor	Independent	Lbit	Total employee salary, benefit and general expenses incurred by bank i in time t period
Capital	Independent	Capit	The total fixed asset of bank i in time t
Exogenous variables	Control	lnzit	Variables affecting the technical efficiency and distributions for bank i in time t

Source: Review of Literature by researcher

Now, the technical inefficiency, Uit is given as

$$Uit=\{\exp(-\eta(t-T))\}Uit \qquad \textbf{(6)}$$

Where, η is a parameter that is unknown and to be estimated and helps to determine whether inefficiencies are time varying or not. If η is positive, then it suggests that the technical inefficiencies of banks decrease over time. If η is zero, then the technical inefficiencies remain constant. However, if η is negative, then the technical inefficiencies of the firms increase over time. Ui , i= 1,2,…,N are independent distributed with unknown mean and unknown variance.

Therefore, the technical efficiency for the ith bank during the tth year in the context of stochastic frontier model is defined as follows

$$TEit = \{\exp(-Uit)\}$$

Thus, given the Cobb-Douglas stochastic frontier function, as introduced by Battese and Coelli (1993), the technical efficiency of the ith bank in the tth time is defined by:

$$TE_{it} = \frac{Observedoutput}{potentialmaximumoutput} = \frac{Y_{it}}{Y^{*}_{it}} = \frac{\exp(x_{it}\beta + v_{it} - u_{it}}{\exp(x_{it}\beta)} = \exp(-uit) \qquad \textbf{(7)}$$

The technical efficiency score is expected to be between zero and one. The higher efficiency score, the more efficient is the bank.

3.2. Technical efficiency estimation using SFA: Investment as output variable

In this sub section, investment is taken as output variable in estimating technical efficiency of Ethiopian banking industry and the three variables, namely, deposit, labor and capital are taken as input factors. Accordingly, Cobb-Douglas stochastic frontier functions as well as translog production function are provided in subsequent sections with their corresponding as functional forms.

Based on the Greene (2005) specification of SFA panel model, the true fixed effect and true random effect models have been taken into account as they enable to disentangle time varying inefficiency from time invariant unobserved firm specific heterogeneity.

3.3. Cobb Douglas Production Function

$$lnInvtit=\alpha+\beta1lndpit+\beta2lnlabit+\beta3lncap3it+(\beta' lnzit)+Vit-Uit \qquad \textbf{(8)}$$

Where, ln=naturallogarithm, base
i= banksunder consideration (which is 7 banks in number, 1,2,3…..7, in this study)
t= time under consideration (2000-2017)
Invt= totalinvestments in different securities made by banks that earn return and is used as output variable
dpit= total deposit of bank i in time t period
labit= labor, whose proxy is employee salary, benefit and general expenses incurred by bank i in time t period
capit= capital, whose proxy is the total fixed asset of bank i in time t period
lnzit= exogenous variables of i bank in t-time that affect the technical efficiency and distributions
β0=constant term
β1, β2&β3= parameters to be estimated for x1, x2 and x3 respectively
Vit= asymmetric random error
Uit= error term attributed to inefficiency

3.4. Translog Production Function

The general equation for translog function is provided by Equation 9

$$\log y = \beta 0 + \sum_{i=1}^{n} \beta i \ logxi + \frac{1}{2} \sum_{i=1}^{n} . \sum_{j=1}^{n} \gamma ij \ logxi \ logxj \qquad \textbf{(9)}$$

Where β0 is efficiency parameter, βi is output elasticity of input and γij is the measure of complementariness between xiand xj, where xi and xj are the inputvariables used.

A more elaborated translog function for the study underconsideration is provided as indicated in equation 9.

lnInvtit=α +β1lndpit+β2lnlabit+β3lncap3it + ½βDDlndp2it + ½βLLlnlb2it ½βCClncap2it +βDLlndp*lnlab + βDClndp*lncap + βLClnlab*lncap (β'lnzit)+Vit-Uit **(10)**

where dp, lab and cap are the first derivatives of deposit, labor and capital respectively; DD,LL and CC are the second derivatives of deposit, labor and capital respectively and DL,DC and LC are cross second derivatives of deposit, labor and capital respectively.

4. Results and Discussion

4.1. Descriptive statistics

There are 126 total observations for seven banks each having 18 years of observations. The summary statistics in Table 1 shows the mean value, standard deviation and the minimum and the maximum values of each variable used in the technical efficiency determination.

In the Table 2 values corresponding to each variable are in millions of Ethiopian Birr except the total equity to total asset (TETA) ratio, which is relative measure.

Accordingly, mean total investment of selected commercial banks is about 1.3 billion Ethiopian Birr on average and the minimum and maximum value is 19 million and 238.5 billion Ethiopian birr. This shows that there is a huge gap between the minimum and the maximum value that could be attributed to both within the between. Particularly, as standard deviation between banks (4.44) is slightly more than that of within year (4.35) the variability of investment is higher over time than among banks.

Total deposits shows that its overall mean is 4.7 billion with the minimum and maximum value of 76 million and 364 billion Ethiopian Birr respectively. This huge gap is again attributed to both within and between banks variation, whereby the within years variation is higher than that of between banks variation.

Table 2: Descriptive statistics investment as output variable

Variable		Mean	Std. Dev.	Min	Max	Observations	
Invt	overall	1294.05	7.55	19.00	238463.13	N =	126
	between		4.44	527.47	33767.36	n =	7
	within		4.35	46.52	14558.03	T =	18
dp	overall	4703.46	5.28	76.00	364098.60	N =	126
	between		3.19	1934.22	56545.45	n =	7
	within		3.55	170.56	40135.64	T =	18
lab	overall	69.82	5.93	1.00	49881.73	N =	126
	between		2.58	33.14	527.03	n =	7
	within		4.70	2.11	6607.83	T =	18
cap	overall	93.20	5.69	0.45	6394.52	N =	126
	between		2.62	39.39	579.50	n =	7
	within		4.44	0.79	2186.43	T =	18
TETA	overall	0.11	1.52	0.04	0.29	N =	126
	between		1.45	0.05	0.16	n =	7
	within		1.26	0.08	0.23	T =	18
TA	overall	6187.60	5.11	143.00	476312.77	N =	126
	between		3.12	2659.51	73050.77	n =	7
	within		3.46	313.79	50959.17	T =	18

Source: Own computation, 2021

The labor that is total expenditure on employees, the overall mean value is about 70 million Ethiopian Birr, with the minimum and maximum value of 1 million Birr and about 50 billion Birr respectively. The degree of variation is again higher within years than between banks. When we come to the capital, the overall mean value is about 93 million Birr with the minimum and maximum of 0.45 million and about 6.4 billion Birr respectively. In similar manner, the within years variation is higher than that of the between banks variation.

The exogenous variable, total equity to total asset ratio has an average of 11%, where the minimum and maximum values are 4% and 29% respectively. This means that on average a typical bank contributes 11% of the total assets to finance its business and borrows the remaining 89% from external sources, whereas the most leveraged bank (a bank with minimum TE to TA ratio) contributes only 4% internally to finance the business. The maximum TE to TA ratio is 29% implies that the rest of 71% of financing comes from external sources. The other variable that is regarded as exogenous variable is total asset (TA), which is used as proxy of bank size. The overall mean of total asset of the selected commercial banks is about 6.2 billion Birr, with the minimum and maximum value of 143 million and about 476 billion birr respectively. Standard deviation value shows that across years variation is higher than the between banks variation.

4.2. Testing hypotheses

In statistical procedures of efficiency analysis, testing hypotheses involves checking whether there is significant technical inefficiency; whether Cobb Douglas or Translog is more appropriate and whether half normal or exponential distributional assumption is preferred.

Hypothesis test for significance of technical inefficiency

To begin with, here, the null hypothesis and alternate hypothesis are provided as follows:

H0: γ=0 and H1: γ>0

$\sigma 2 = \sigma u2 + \sigma v2$

Where $\sigma 2$ is total variance, $\sigma u2$is the technical inefficiency component and $\sigma v2$ is random error component and $\gamma = \sigma 2u/\sigma 2$. The estimation result shows the variance parameters as follows in Table 3.

Table 3: Variance parameterization

$\sigma u=$	0.588	$\sigma 2u=$	0.3457
$\sigma v=$	0.005	$\sigma 2v=$	0.000025
$\lambda 2= \sigma u/ \sigma v$	117.6	$\gamma= \sigma 2u/(\sigma 2u + \sigma 2v) =$	0.9999
Decision			

Source: Own Computation, 2021

Aigner, Lovell, & Schmidt (1977) suggest that if $\lambda 2 \geq 0$, then there is technical inefficiency. Here $\lambda 2$= 117.6, which is far more than 1. And if gamma, γ=

$\sigma 2u/ \sigma 2$is closer to 1 or far more than 0, there exists inefficiency(Battese & Corra, 1977). Based on these literatures, the result in this study shows that the gamma (γ) value as indicated in table is 0.9999, which is almost equal to 1, showing that about 99.99% of the total variation is due to technical inefficiency and random error component accounts for 0.01% of the total variance. Therefore, in both the cases, there is technical inefficiency (see Table 3).

Hypothesis test: Cobb Douglas vs. Translog Model

Another test can be performed to check the specification of the models. The test is done through imposing restrictions on the model by using likelihood ratio statistic to decide whether the restriction is significant. Put differently, this hypothesis test is done to determine whether Cobb Douglas production function or Translog function more appropriate model. Thus the null hypothesis claims that Cobb Douglas production function is appropriate. As suggested by Kumbhakar, Wang, & Horncastle (2015), generalized likelihood ratio(LR test) statistic is provided as $\lambda = -2[\ln\{L(H0)\}-\ln\{L(H1)]$

Whereln{L(Ho)} is the value of log-likelihood obtained from Cobb Douglas model(H0), and ln{L(H1)} is the values of the log-likelihood computed from translog frontier model being alternative hypothesis (H1).

Table 4: Log-likelihood ratio

ln{L(H0)}	-24.6351
ln{L(H1)}	-280.466
$\lambda = -2[\ln\{L(H0)\}-\ln\{L(H1)]$	-511.662

Source: Own Computation, 2021

$\lambda = -2[\ln\{L(H0)\}-\ln\{L(H1)] = -511.662$ is negative, which is far less than the specified critical value and thus, the null hypothesis is accepted implying that Cobb Douglas is more appropriate as suggested by Kodde & Palm(1986).

Hypothesis testing: Truncated normal Vs. Half normal

In order to select the unbiased distributional assumption between truncated normal and half normal, the likelihood ratio test has been conducted. The null hypothesis is that half normal is appropriate distributional assumption.

Table 5: Log-likelihood ratio

ln{L(H0)}	-24.6351
ln{L(H1)}	-95.4051
λ= -2[ln{L(H0)}-ln{L(H1)]	-141.54

Source: Own computation, 2021

Accordingly, by plugging the log likelihood ratios under the two assumption which is ln{L(H0)}= -24.6351 and ln{L(H1)}= -95.4051 into this equation λ= -2[ln{L(H0)}-ln{L(H1)] provides us with λ= -141.54. The critical value for one restriction(df=1)at alpha 5% as suggested by Kodde & Palm(1986)is 2.71. Thus, the null hypothesis is not rejected implying that half normal is appropriate model.

Table 6: Likelihood ratio test: half normal vs. truncated normal (investment as output variable)

Likelihood-ratio test	LR chi2(1) = -141.54
(Assumption: Half Normal nested in truncated Normal)	Prob > chi2 = 1.0000

Source: Author's computation using STATA software packages

Here again, since the p-value of LR test is greater than the 5% alpha value, then null hypothesis is retained implying that half normal is appropriate distribution. Therefore, half normal assumption has been used in order to estimate technical efficiency taking investment as output variable.

4.3. Technical Efficiency Estimation-TFE Model and Half Normal Distribution

It is obvious that there are different assumptions and models underlying Stochastic Frontier Analysis. The author has come up with the output of the technical efficiency estimation after performing the pertinent tests. Based on the preceding discussions of the model specifications and distributional assumptions, the truncated normal half normal and exponential distributions are alternative distributional assumptions. The total equity to total asset ratio and total assets were selected as exogenous variables as these variables are believed to affect the distribution of inefficiency. The output oriented technical efficiency has also been used to show to what extent a firm can increase its output level to the maximum possible level without affecting the current input level. Year was taken as trend variable to see the progress in technology over time in the technical efficiency analysis.

After conducting the likelihood ratio test, particularly half normal distributional assumption is found to be appropriate one. Thus, the estimation and inferential analysis is made based on half normal distributional assumption. However, in order to show whether there is consistency in the estimation results, the output of alternative models and distributional assumptions are provided in a table. In table 6 true fixed effect model has been used as suggested by Greene (2005).

Table 7: Estimation result of efficiency under TFE model and Half Normal Distribution

sfpanel Invt dp lab cap Year, model(tfe)dist(hn)ort(o)

True fixed-effects model (half-normal)				Number of obs		126
Group variable: id				Number of groups		7
Time variable: Year				Obs per group: min=		18
				Avg=		18
				Max=		18
				Prob > chi2	=	0.000
Log likelihood = -24.6351				Wald chi2(4)	=	8.83E+03

Invt	**Coef.**	**Std. Err.**	**z**	**P>z**	**[95% Conf. Interval]**	
Frontier						
dp	0.616	0.000	8337.44	0.000	0.616	0.616
lab	-0.215	0.000	-3115.61	0.000	-0.215	-0.214
cap	0.018	0.000	5695.37	0.000	0.018	0.018
Year	0.174	0.000	91000.00	0.000	0.174	0.174
Usigma						
_cons	-1.061	0.126	-8.42	0.000	-1.307	-0.814
Vsigma						
_cons	-38.217	379.159	-0.10	0.920	-781.4	704.920
sigma_u	0.588	0.037	15.87	0.000	0.520	0.666
sigma_v	0.005	0.000	0.01	0.996	0.000	12000.0
lambda	116.987	0.037	3155.97	0.000	11000.0	11700.0

Source: Own computation, 2021

To begin with, coefficients and the corresponding p-values under frontier section show that deposit as input variable has positive coefficient and is significant at alpha value of 1% (β= 0.616 and p=0.000). This implies that keeping all other factors constant, an increase in deposits by one unit increasesinvestment by 0.616 unit and vice versa. This indicates that as deposits have positively influenced technical efficiency of commercial banks in Ethiopia, it could be inferred that deposit is an important input in increasing technical efficiency of banks, particularly if investment is taken into account. This result is consistent with the result of previous studies by Hasan, Kamil, Mustafa, & Baten(2012), who found out that deposit positively affects technical efficiency of Malaysian banks.

Labor input has negative and significant effect on investment as output variable (β= -0.215 and p=0.000) implying that commercial bank in Ethiopia experience technical inefficiency owing to labor inefficiency. For instance, a 1unit increase in expenditure on employees results in a 0.215 unit increase in technical inefficiency, provided that investment is taken as output variable and this effect is statistically significant at α=1%. This study result is consistent with the result of study conducted on Japanese banks by Barros, Managi, & Matousek(2012) who claim that labor as input contributed to technical inefficiency of Japanese banks. This shows that more and more technical efficiency is possible if banks can increase labor efficiency.

On the other hand, keeping all other factors constant, capital has positive and significant effect on investment (β= 0.18 and p=0.000). This implies that a 1% increase in fixed assets results in an increase in investment by 0.18% and this effect is statistically significant at 1% alpha value. Finally, year as a trend variable has positive and significant effect (β= 0.017 and p=0.000), on the output variable. This shows that due to technological progress, the efficiency of banks increase significantly overtime.

Hypotheses Testing

Based on the analysis result of Table 8, the following sub hypotheses were tested. Accordingly, all of the hypotheses were rejected based on the p-value corresponding to each sub hypothesis. Both deposit and capital as input factor positively affect the output factor of technical efficiency. This means that a bank can increase the level of its technical efficiency by increasing the level of deposit and capital. But the more the firm invests in labor cost the less will be the output factor.

Table 8: Hypothesis Testing

Classification of Hypotheses	Hypothesis Testing	Coefficient	P>z (P-vale)	Decision
Main Hypothesis	H03: There is no significant effect of each input factor on outputs factor of technical efficiency of banks in Ethiopia			
Sub-hypothesis1	H031: Total deposit as input has no significant effect on investment as the output factor of technical efficiency in Ethiopian banking industry	0.616	0.000	Reject
Sub-hypothesis1	H031: Labor input has no significant effect on investment as the output factor of technical efficiency in Ethiopian banking industry	-0.215	0.000	Reject
Sub-hypothesis1	H031: Capital input has no significant effect on investment as the output factor of technical efficiency in Ethiopian banking industry	0.018	0.000	Reject

Sources: Own computation, 20021

4.4. Comparison of different distributional assumptions under TFE Model

To show the extent of consistency among different distributional assumptions under the selected true fixed effect model, Table 9 shows the estimation results under truncated normal half normal and exponential distributions. The results under half normal and exponential distributional assumptions are more or less similar in terms the magnitude and sign of the coefficients and the statistical significances. However, the result under truncated normal largely varies particularly in relation to the coefficients of input variables. Under the three distributional assumptions, deposit and capital as input variables have consistently positive and statistically significant effect at $\alpha=0.01$ on the outcome variable. This confirms that they have significant and positive effect on the conduct of investment indicating that banks that are good at attracting more and more deposit have better capability to carry out more and more investment. In similar way, as banks have more and more fixed facilities, the more they perform in investing and the higher will be their investment. When we take the sign of the coefficient of the labor as input variable, it is negative in all the distributional assumptions, implying that labor has negative effect on the investment. However, this effect is significant (p=0.000) under both half normal and exponential distributional assumptions only. Year as a trend variable has an important bearing on the technical efficiency of firms. Accordingly, under both half normal and exponential distributional assumptions, it has positive and statistically significant effect on the outcome variable showing that there is positive technological progress that increases the efficiency of banks overtime.

Table 9: Comparison of distributional assumptions under true fixed effect model

Variable	Truncated normal			Half normal distribution			Exponential distribution		
Invt	**Coef.**	**Std. Err.**	**P>z**	**Coef.**	**Std. Err.**	**P>z**	**Coef.**	**Std. Err.**	**P>z**
dp	3.377	1.218	0.006	0.616	0.000	0.000	0.63842	7.72E-05	0.000
lab	-0.448	0.248	0.071	-0.22	0.000	0.000	-0.2107	0.000127	0.000
cap	0.264	0.090	0.003	0.018	0.000	0.000	0.0137	0.000131	0.000
Year	-0.022	0.001	0.000	0.174	0.000	0.000	0.16305	2.22E-07	0.000
MU - TETA	0.043	0.294	0.885						
-TA	1.917	1.185	0.106						
sigma_u	0.515	0.145	0.000	0.588	0.037	0.000	0.45493	0.04052	0.000
sigma_v	0.033	1.991	0.987	0.005	0.000	0.996	5E-07	2.93E-05	0.987
Lambda(λ)	15.782	2.118	0.000	117.0	0.037	0.000	977446	0.04052	0.000

Source: Own computation, 2021

4.5. Technical efficiency of each banks taking investment as output variable

As shown in Table 10, government owned commercial bank attained the highest mean score of technical efficiency during the study under consideration followed by Dashen bank, United Bank and Awash Banks. This implies, that taking investment as output variable, following half normal distributional assumption for the inefficiency and true fixed effect model, government owned commercial bank is the top performer in technical efficiency.

Table 10: Technical efficiency of banks using investment as output variable: Half Normal Distribution

	CBE	DB	UB	AIB	WB	BOA	NIB	Yearly Average
2000	0.646	0.819	0.421	1.000	1.000	0.595	1.000	0.783
2001	1.000	0.739	0.365	0.628	0.513	0.632	0.581	0.637
2002	1.000	0.949	0.648	0.635	0.357	0.451	0.670	0.673
2003	0.968	0.789	0.467	0.952	0.552	0.570	0.587	0.698
2004	0.957	0.741	0.842	0.765	0.563	0.926	0.571	0.767
2005	0.550	0.511	0.839	0.648	0.758	0.449	0.470	0.604
2006	0.743	0.473	0.351	0.549	0.405	0.396	0.397	0.474
2007	0.735	0.413	0.785	0.325	0.794	0.679	0.369	0.586
2008	0.572	0.409	0.468	0.387	0.589	0.329	0.202	0.422
2009	0.542	0.250	0.517	0.379	0.316	0.324	0.185	0.359
2010	0.565	1.000	0.416	0.694	0.804	0.444	0.769	0.670
2011	0.609	0.843	0.772	0.755	0.824	0.761	0.846	0.773
2012	0.593	0.876	0.929	0.867	1.000	1.000	1.000	0.895
2013	0.632	0.893	1.000	0.716	0.944	1.000	0.831	0.859
2014	0.658	0.742	0.969	0.797	0.176	0.942	0.710	0.713
2015	0.633	0.735	0.931	0.676	0.851	0.845	0.821	0.785
2016	0.620	0.654	0.854	0.574	0.753	0.731	0.799	0.712
2017	0.908	0.656	0.730	0.570	0.645	0.707	0.687	0.700
Mean	0.718	0.694	0.684	0.662	0.658	0.654	0.639	
Rankings	1st	2nd	3rd	4th	5th	6th	7th	

Source: Own computation, 2021

Summary of technical efficiency shows that on average a typical bank has technical efficiency of about 67%. The minimum efficiency is about 18% and the maximum efficiency level during the study period is 100%.

Table 11: Summary of technical efficiency, investment as output variables

Variable	Obs	Mean	Std. Dev.	Min	Max
TE	126	0.672703	0.211709	0.176	1.000

Source: Own computation, 2021

5. Conclusions and Recommendations

It could be concluded that the technical inefficiency level of banks in Ethiopia is about a third. This means that on average a typical commercial bank in Ethiopia can increase its technical efficiency level bay about 33% without increasing the input level or decease consumption of the input by 33% by maintaining its output level currently.

An increase in technical efficiency is attributed to an increase in deposit, capital and trend variable (technological progress). On the other hand, commercial banks in Ethiopia experience technical inefficiency owing to labor inefficiency.

It could be suggested that commercial banks in Ethiopia have to cut unnecessary labor costs, enhance optimum utilization of existing labor. In addition, they may enhance investment in earnings assets so as to increase the technical efficiency.

References

Aiello, F., & Bonanno, G. (2016). Efficiency in banking: A meta-regression analysis. International Review of Applied Economics, 30(1), 112–149. https://doi.org/10.1080/02692171.2015.1070131

Aigner, D., Lovell, C. K., & Schmidt, P. (1977a). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6(1), 21–37.

Aigner, D., Lovell, C. K., & Schmidt, P. (1977b). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6(1), 21–37.

Barros, C. P., Managi, S., & Matousek, R. (2012). The technical efficiency of the Japanese banks: Non-radial directional performance measurement with undesirable output. Omega, 40(1), 1–8. https://doi.org/10.1016/j.omega.2011.02.005

Battese, G. E., & Corra, G. S. (1977). Estimation of a production frontier model: With application to the pastoral zone of Eastern Australia. *Australian Journal of Agricultural Economics*, 21(3), 169–179.

Beccalli, E., Casu, B., & Girardone, C. (2006). Efficiency and Stock Performance in European Banking. *Journal of Business Finance & Accounting*, 33(1–2), 245–262. https://doi.org/10.1111/j.1468-5957.2006.01362.x

Berger, A. N. (2007). International Comparisons of Banking Efficiency. Financial Markets, Institutions & Instruments, 16(3), 119–144. https://doi.org/10.1111/j.1468-0416.2007.00121.x

Berger, A. N., Hancock, D., & Humphrey, D. B. (1993). Bank efficiency derived from the profit function. *Journal of Banking & Finance*, 17(2–3), 317–347. https://doi.org/10.1016/0378-4266(93)90035-C

Bumann, S., Hermes, N., & Lensink, R. (2013). Financial liberalization and economic growth: A meta-analysis. *Journal of International Money and Finance*, 33, 255–281. https://doi.org/10.1016/j.jimonfin.2012.11.013

Casu, B., & Molyneux, P. (2003). A comparative study of efficiency in European banking. *Applied Economics*, 35(17), 1865–1876. https://doi.org/10.1080/0003684032000158109

Coelli, T., & Perelman, S. (1999). A comparison of parametric and non-parametric distance functions: With application to European railways. *European Journal of Operational Research*, 117(2), 326–339. https://doi.org/10.1016/S0377-2217(98)00271-9

Fethi, M. D., & Pasiouras, F. (2010). Assessing bank efficiency and performance with operational research and artificial intelligence techniques: A survey. *European Journal of Operational Research*, 204(2), 189–198.

Gebremichael, B. Z., and Rani, D. L. (2012). Total Factor Productivity Change of Ethiopian Microfinance Institutions (Mfis): A Malmquist Productivity Index Approach (mpi). *European Journal of Business and Management*, 4(3), 105-114.

Goddard, J., Molyneux, P., & Williams, J. (2014). Dealing with cross-firm heterogeneity in bank efficiency estimates: Some evidence from Latin America. *Journal of Banking & Finance*, 40, 130–142. https://doi.org/10.1016/j.jbankfin.2013.11.025

Hasan, Md. Z., Kamil, A. A., Mustafa, A., & Baten, Md. A. (2012). A Cobb Douglas Stochastic Frontier Model on Measuring Domestic Bank Efficiency in Malaysia. PLoS ONE, 7(8). https://doi.org/10.1371/journal.pone.0042215

Huang, T.-H., & Wang, M. H. (2002). Comparison of Economic Efficiency Estimation Methods: Parametric and Non–parametric Techniques. The Manchester School, 70(5), 682–709. https://doi.org/10.1111/1467-9957.00320

Kodde, D. A., & Palm, F. C. (1986). Wald Criteria for Jointly Testing Equality and Inequality Restrictions. Econometrica, 54(5), 1243. https://doi.org/10.2307/1912331

Kumar, M., & Arora, P. (2010). Bank efficiency measurement using alternative techniques of frontier analysis: Evidence from India. Afro-Asian *Journal of Finance and Accounting*, 2(1), 40–69. https://doi.org/10.1504/AAJFA.2010.035194

Kumar, S., & Gulati, R. (2008). An Examination of Technical, Pure Technical, and Scale Efficiencies in Indian Public Sector Banks using Data Envelopment Analysis. 37.

Kumbhakar, S. C., Wang, H. J., & Horncastle, A. P. (2015). *A Practitioner's Guide to Stochastic Frontier Analysis Using Stata*. Cambridge University Press.

Mastromarco, C. (2008). Stochastic frontier models. Department of Economics and Mathematics-Statistics, University of Salento.

Meeusen, W., & van Den Broeck, J. (1977). Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error. International Economic Review, 18(2), 435–444. https://doi.org/10.2307/2525757

Mobarek, A., & Kalonov, A. (2014). Comparative performance analysis between conventional and Islamic banks: Empirical evidence from OIC countries. Applied Economics, 46(3), 253–270. https://doi.org/10.1080/00036846.2013.839863

Pagano, M. (1993). Financial markets and growth: An overview. European Economic Review, 37(2–3), 613–622.

Parmeter, C. F., & Kumbhakar, S. C. (2014a). Efficiency analysis: A primer on recent advances. Foundations and Trends® in Econometrics, 7(3–4), 191–385.

Parmeter, C. F., & Kumbhakar, S. C. (2014b). Efficiency analysis: A primer on recent advances. Foundations and Trends® in Econometrics, 7(3–4), 191–385.

Raphael, G. (2013). Efficiency of Commercial Banks in East Africa: A Non Parametric Approach. *International Journal of Business and Management*, 8(4), p50.

Sangeetha R., Jain Mathew. (2013). A study on technical efficiency of public sector banks in India. *International Journal of Business and Economics Research*, 2(2), 15-21

Semih Yildirim, H., & Philippatos, G. C. (2007). Efficiency of banks: Recent evidence from the transition economies of Europe, 1993–2000. *European Journal of Finance,* 13(2), 123–143.

Tesfay, H., & Tesfay, A. (2013). Relative efficiency of rural saving and credit cooperatives: An application of data envelopment analysis. *International Journal of Cooperative Studies*, 2(1), 16-25.

Does the Financial Industry Sustain Ethiopia's Economic Growth? Does Financial Liberalization Really Matter?

Tesfaye Etensa[1]

Abstract

Considering the importance of financial sector development in recent literature, their links are limited in both developed and developing countries, and whether strong economic performance is finance-led or growth-driven remains debatable. As well, the role of financial liberalization as a growth strategy in developing countries is currently questionable. Therefore, this study examined the dynamic nexus relationship between financial industry development, financial liberalization, and economic growth in Ethiopia based on Johansen's co-integration using annual time series data from 1974/75–2017/18. The Johanson cointegration test shows the existence of a long-run relationship. The study found that financial industry development, labor, capital, and exports have a positive effect on economic growth, while effective exchange rates and financial liberalization have a negative effect on economic growth in the long run. The causality test shows there is a unidirectional causality running from economic growth to the financial industry in the long run. Furthermore, in the short run, contrary to the long run, there is no causality from either economic growth to the financial industry or the financial industry to economic growth in Ethiopia. Finally, the study recommends that the government strengthen the financial sector by establishing a strong regulatory framework and the regulator needs to make a significant policy adjustment. Full financial liberalization of Ethiopia's capital market is not prioritized because it may result in a debt market and an unreversible crisis; thus, the government should not allow it until our home assignment is completed. Last, currency devaluation is not viable for primary product exporting until the country starts to export semi-manufactured and manufactured products, increasing its share of the world market. Hence, the exchange rate needs to be fixed at the current rate for some period of time, with a different exchange rate for remittances.

Keywords: Economic Growth, Johanson-Cointegration, Granger-Causality, financial industry, Ethiopia

---

[1] Addis Ababa University, Economics department; tesfayeetensa@gmail.com

1. Introduction

The financial industry is considered one of the key ingredients for economic growth and development. The financial industry determines the local saving level that contributes to productive investments in a local business. In emerging economies like Ethiopia, the national savings are very few and insufficient to finance the development needs necessitating a financial industry and the attraction of foreign direct investment (Dejene, 2016). The neoclassical growth theory postulated that every economy with the same savings and population growth rates per capita should converge. The incompatibility of the convergence hypothesis with the actual result led to the development of endogenous growth models that did not support the same implication. This inconsistency opened the way for other determinants of sustaining economic growth, such as fiscal policy and the financial industry (Noureen, 2008).

Schumpeter (1911) argued that the financial sector is essential for economic growth. Government involvement in the financial sector, such as setting interest rates and directing credit programs, discourages both the financial industry and economic growth. High interest rates encourage savings, which commercial banks can provide to the private sector for investment. The modern literature on economic growth started in the mid-1950s, when Robert Solow presented his growth model. Economists like Goldsmith (1969), McKinnon (1973), and Levine (1993) emphasized that the financial industry can be a crucial factor for economic growth. Financial development contributes to economic growth by stimulating investment in the country through level and efficiency effects (Meron, 2016). The efficiency effect argues that reforms and regulations in the financial sector ensure transparency and proper reporting systems, attracting both domestic and foreign investors. It also argues that the financial sector allocates financial resources to the most profitable projects.

Recently, the role of the financial industry has received much attention. An efficient and developed financial system facilitates those countries' economic development by providing information before funding, monitoring and evaluating after funding, easing the management of risks, encouraging saving, and facilitating trade. It offers improved financial decisions, supports the better distribution of resources, and thereby accelerates economic growth. A strong financial sector needs deep-rooted domestic and international banking systems and liquid stock markets (Sime, 2016).

The financial industry's role in sustaining economic growth has been one of the most debated issues in recent history, yet there has been little consensus. The key point of debate is whether strong economic performance is finance-led, growth-driven, or not related. This issue has important implications for policymakers decisions about strategic growth and the adoption of appropriate development strategies. Looking at Ethiopia, the national savings are very few and insufficient to finance the economic activities (18.95% of GDP in 2021). Ethiopia's financial sectors are, to put it mildly, in deplorable condition. Few banks are advancing in assisting the Ethiopian economy by providing finance for numerous activities, despite the nation's tiny and insufficient level of deposits (18.95% of GDP in 2021). From 18 to 30, there are now more than 30 banks, with 8,944 branches as of June 30, 2022, up from 5,564 four years earlier. There is currently one bank branch for every 11,516 people in the population (1:11,516) as a result of the expansion of bank branches. In terms of financial deepening, Ethiopia (35%), Asia (89%), and Kenya (45%). In Ethiopia, private sector loans account for 18% of GDP, while domestic credit to the private sector accounts for 17%. There is no investment banks, no mortgage banks, no venture capital. Islamic banks started; the treasure market started; and capital market ideas are starting. There is no clear road map for the financial sector. The issue of modernization of financial sector strategies is neglected, and there are no financial sector strategies as if they have not been important in our country for a long time (NBE, 2021/22). Therefore, examining the financial industry's role is vital.

Furthermore, seeing the issue of causality from a theoretical point of view, there are four schools of thought. Gold Smith-McKinnon-Shaw School of thought, and structuralist and neo-structuralist schools of thought. The first school of thought believes that the financial industry leads economic growth in a given country; this perspective is called the supply-leading hypothesis. The hypothesis is supported by Ugbaje & Edez, 2014; Mlachila et al., 2013; Pagano, 1993; Majid and Mahrizal, 2007; Odhiambo, 2007; Gries, 2009, 2011; Ang, 2009. The second schools are the structuralist and neo-structuralist schools of thought, which prove that economic growth is an input for financial development. This principle is called the demand-following 'hypothesis," that is, the unidirectional causation running from economic growth to financial development. It has been supported by many researchers, like Athenia and Alfred (2014), Ndlovu (2013), Majid and Mahrizal (2007), Odhiambo (2007), 2009, 2010, and Gries (2011).

The third perspective is called the feedback hypothesis. Patrick introduced this in 1966, which suggests that financial development and economic growth are supplementary to each other. Other studies have recognized this relationship, such as Greenwood and Smith, 1997; Gries, 2009; Wolde-Rufael, 2009; Jenkins and Katircioglu, 2010; and Gries, 2011. In contrast to the above, others, such as Ram

(1999), De Gregorio and Guidotti (1995), Change (2002), and Majid and Mahrizal (2007), argue that there is no causality between financial development and growth.

Many studies have addressed this issue through cross-country or time series analysis, and these studies usually have important policy implications, especially for developing countries that are understudied. Although many studies on the finance-growth nexus have been done in both developing and advanced countries, remarkably, Ethiopia has not featured in the cross-country studies that have included some of the sub-Saharan African countries. Single country studies have also been carried out in other sub-Saharan African countries like Zambia, South Africa, Nigeria, Ghana, Zimbabwe, and Namibia; similar studies in Ethiopia are very few.

Looking at Ethiopia, there is little consensus about the causality relationship between financial development and economic growth, despite the fact that there has only been a small amount of research on the topic.

As we have seen from the above empirical literature, it is very difficult to generalize the causality between financial sector development and economic growth for all countries in general and Ethiopia in particular. Meron (2016) and Roman (2012) support the demand side, whereas Dejene (2016) and Sime (2015) support the supply hypothesis; Abriham (2016) and Sime (2015) support bidirectional causality between variables. Moreover, as we can observe from the empirical literature, much of this research was conducted in other foreign countries. Furthermore, there are very few studies conducted in this area in Ethiopia. Thus, this research aimed to fill the gaps by investigating the financial industry's role in sustaining Ethiopia's economic growth and its causality.

In the 1980s and 1990s, the majority of African countries started adopting economic reform programs, including banking sector reform. In almost all of the SSA countries, the financial markets have been liberalized, market-based interest and exchange rates have been put in place, and local stock markets have been expanded. Significant changes in the rules governing the financial markets, such as rising interest rates and the opening up of exchange rates, have lately taken place in SSA. These measures worsened financial instability while encouraging investment and capital flows. In the majority of SSA countries, financial liberalization policies have tragically resulted in banking crises, unstable currency rates, a widening gap between lending and deposit rates, and a decline or stagnation in domestic credit to financial depth. These issues are attributable to the advent of financial liberalization legislation. These issues are attributable to the advent of financial liberalization regulations. Many studies (Daumont et al., 2004; Fowowe, 2013; Ikhide, 2015; Misati & Nyamongo, 2012) demonstrate that systemic banking crises took place in many SSA countries (for instance, Cameroon (1988-1991), Nigeria (1991-1995), Ghana (1982-1989), and Kenya (1993-1995)) right after they put financial liberalization policies into place. According to Misati and Nyamongo (2012), financial liberalization policies are still among the most contentious because of the harm they bring to the relationship between financial development and economic growth.

The empirical literature on financial liberalization and economic growth reveals a two-sided coin: one side looks at their beneficial link (Chang & Mendy, 2012; Ndikumana, 2000; Odhiambo, 2011; Oshikoya, 1994; Özdemir, 2014; Seck & El Nil, 1993); others (Ahmed, 2013; Daumont et al., 2004; Honohan & Klingebiel, 2000; Philip, 2007) while investigating whether financial liberalization is actually to blame for the financial instability and banking crises that afflict the majority of SSA nations. In conclusion, financial liberalization can have many different consequences, but considerable empirical research and cross-country analyses show that it is associated with higher volatility and procyclical capital flows. Alawode & Ikhide (1997) and Philip (2007) both make the case that financial liberalization policies expose countries to the ups and downs caused by changes in the global economy. This argument suggests that these policies might be harmful for the global economy.

It is crucial for policymakers to comprehend if financial liberalization genuinely aids economic development progress and to provide insight on how to manage the accompanying hurdles as Ethiopia's banking system finally experiences long-awaited complete financial sector reform.

Considering the above and other reviewed literature, this study is different and is expected to contribute to the existing literature in the following ways:
First, looking at Ethiopia, studies on the relationship between financial development and economic growth in Ethiopia are few. Demand-side arguments are supported by Meron (2016) and Roman (2012); the supply hypothesis is supported by Dejene (2016) and Sime (2015); and the bidirectional causality argument is supported by Abriham (2016) and Sime (2015). In light of the countries' long-awaited financial sector liberalization, this study aids in providing policy implications.

Second, according to the empirical literature, the majority of this study was conducted abroad, and there have been relatively few studies of developing countries in general and Ethiopia in particular. Ethiopia is now reconsidering its role and liberalizing its currency, which has an influence on how prepared it is for these changes and related issues. Therefore, this study adds to the understanding of these two characteristics among policymakers.

Third, to the best of the researcher's knowledge, there is no research that looks at the role of financial liberalization as one of the key policy variables in Ethiopia. In the literature, there is ongoing discussion over the long- and short-term relationships between financial freedom and economic progress, particularly in emerging nations. By using Ethiopia as a case study, this study adds to the dearth of literature. The author is not aware of any previous studies in Ethiopia in this area; hence, this is also the first study conducted there.

Fourth, the theoretical effect of financial development and financial liberation on the framework for economic growth is being introduced for the first time in this study, to the best of the researchers' knowledge. A built-in theoretical model supports our grasp of the effects and gives a strong framework for empirical study.

Given these significant gaps in the literature, the study's aim is to look at how Ethiopia's financial sector development, financial liberalization, and economic growth are linked in a dynamic way. The research specifically addressed the following questions: Does financial industry development affect economic growth in Ethiopia in both the short and long run? If yes, by what amount? What is the direction of causality between financial industry development and economic growth? Does financial liberalization really matter for Ethiopia's economic growth? If so, is it significant?

2. Litreature Review

The empirical investigation on financial development, financial liberalization, and economic growth in both developed and developing countries is summarized here.

Akinsola and Odhiambo (2017) examined the impact of financial liberalization on economic development, a linear generalized approach of moments was used using a sample of 30 SSA nations from 1980 to 2015. The finding indicates that the financial liberalization variable has a positive and significant correlation for SSA. The financial liberalization dummy sign went negative for low-income countries even though it was statistically insignificant. Njikam (2017) analyzed the effect of financial liberalization on the economic growth from 1970 to 2010 with regard to the complementarities of reform. A non-linear growth regression specification that interacts a proxy for financial liberalization with proxies for reform complementarities is estimated using a panel of 45 SSA states. Although the research does not show an obvious link between financial liberalization and growth, it is more likely to have a positive and significant impact on growth in the SSA area.

Using time series data, Abriham (2016) investigated the link between Ethiopia's financial sector development and economic growth and found that there is a significant long-term correlation between the two. The Ganger-causality test's findings also demonstrated a two-way causal link between financial developments and economic growth.

Dejene (2016) used the VAR approach and Johnson-Cointegration to examine if the expansion of the financial sector development in Ethiopia's post-communist economy fosters economic progress. The findings indicated that long-term importance is low for financial development indicators, which have a negative coefficient. Government spending and openness are what drive Ethiopia's economic expansion, but the financial sector did not develop to the extent necessary to support long-term economic growth. Murcy et al. (2015) supported the supply-side theory. Urgaia (2015) Panel data analysis was used to examine the role of the financial sector in the growth of east African economies. It was found that both the ratio of domestic credit to GDP and the annual growth rate of broad money have positive and significant effects on real GDP or long-term economic growth. The large yearly growth rate to GDP ratio, however, has a major negative impact on the local economy.

Sime (2015) discovered that private credit provided by deposit money banks and other financial institutions has a long-term bidirectional causal relationship with the GDP ratio and the real GDP growth rate, whereas deposit money bank assets have a long-term unidirectional causal relationship with the GDP ratio and the real GDP growth rate, which runs from finance to economic growth. Meron (2016) and Roman (2012) found a unidirectional relationship between Ethiopia's economic growth and the growth of its banking sector, and Dimpho et al. (2014) found the same result for Botswana's. Rachdi and Mbarek (2011) the study discovered that the causal relationship between economic growth and financial development is bidirectional in OECD nations but unidirectional in MENA countries. Atif et al. (2010) Analyze the impact of financial development and trade openness on GDP growth in Pakistan using annual data spanning the years 1980–2009. The ARDL bound test was used in the inquiry. Long-term relationships between the variables' economic growth, trade openness, and financial development were discovered.

Guglielmo et al. (2009) used panel data to evaluate the relationship between economic growth and the rise of the financial sector in eleven of the newest EU members. They found that while the banking sector has improved in efficiency, the stock and credit markets are still developing and contribute relatively little to economic expansion. Economic expansion and financial development are causally associated, but not in the other way, according to the Granger causality test. Odhiambo (2008) used time series data from 1968 to 2002 to examine the connection between financial development and economic growth in Kenya. The results showed that the proxy used to gauge financial development is a factor in determining how well the economy is doing, and that the causation in the balance flows from financial development to economic growth. This study mostly agrees with demand-following theory. Chistopoulos and Tsionas (2004) found a long-term, unidirectional causal relationship between financial development and economic growth, but did not identify a direction of causality between short-term economic growth and financial development.

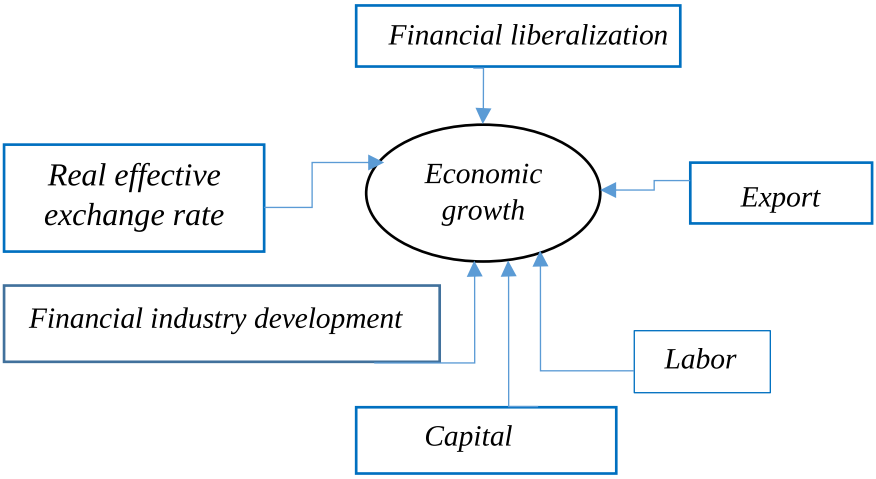
Carlin and Mayer (2003) Using data from OECD countries between 1970 and 1995, the authors examined the relationship between a country's financial system structure and industrial growth. They discovered a significant link between the structure of the financial system and the growth of industries dependent on outside capital and skilled labor. King and Levine (1993a) An empirical investigation was conducted between 1960 and 1989 using data from 80 countries to assess financial progress. Results showed a correlation between higher levels of financial development and faster economic growth, physical capital accumulation, and economic efficiency.

Fritz (1984) and Gupta (1984) both found that financial development was a direct cause of economic growth in 14 emerging nations. They also found evidence of causation from real to financial factors, suggesting that economic expansion was the cause of financial development. Joseph Schumpeter (1934) and Hicks (1969) both argued that financial intermediaries' services contribute to economic growth by directing resources towards creative business people. Schumpeter argued that financial development was a key factor in igniting industrialization in England.

In sum, the majority of research has found a long-term relationship between financial development and economic growth, with stock markets being less clear than banks. Different schools of economics measure financial development differently, and the direction of causality between growth and financial development is mixed. Studies have been conducted in foreign countries, but few have been conducted in developing countries in general and Ethiopia in particular.

Conceptual Framework

Figure 1: Own constructed conceptual frame work (2023)



3. Research Methodology

3.1 Sources and types of data

The time series data for the study ranged from 1974/75 to 2017/18. The data for all variables were extracted from the Economic Cooperation Ministry of Finance and Cooperation (MoFEC) and the National Bank of Ethiopia (NBE). Economic growth was the dependent variable, and the RGDP per capita served as a proxy for it. Financial industry development and financial liberalization are the main policy variables, while the control variables are the exchange rate, labor, capital, and export. The measurements and expected sign of each variable are shown in the table below.

Table 1: Definitions of the variables and their expected signs

Variables	Unit of measurement	Sign	Source
Economic growth	Real GDP at constant 2015 national prices (in mil. 2015 US$)	NA	NBE
Labor	The labor force comprises people ages 15 and older who supply labor for the production of goods and services during a specified period.	+	NBE
Capital	In line with many researchers, in the absence of capital stock, gross capital formation has been used as proxy for the stock of physical capital. The capital stock series is constructed from real gross capital formation using the perpetual inventory assumption with a depreciation rate of 5 percent. As a result, in this study, gross Investment in millioons of birr was used as a proxy of physical capital accumulation and expected a positive impact on economic growth.	+	NBE
Financial Liberalization	It is the elimination of directed credits and high reserve requirements, letting interest rates be determined by market forces rather than by regulation. It is a dummy variable, and it takes a value of 0 before 1994 (cases were fully repressed until 1994), whereas it takes 1 if the year is after 1994.	+	NBE
Devaluation	Effective exchange rate: Increases in real effective exchange rate indicates the devaluation of domestic currency as defined as domestic currency per foreign currency.	+	NBE
Financial sector development	Ratio of broad money supply to RGDP: The ratio of broad money base (M2) less currency in circulation to nominal GDP is used as an indicator of financial sector development, or banking sector. This measure of financial depth and the size of financial intermediation shows the expansion of payment and savings activities offered by the financial sector.	+	NBE
Export	Total exports of goods and services (constant 2015 in thousands of birr)	+	MOFEC

Model specification

This study utilizes the Neo-Classical Growth Model, which was developed by Solow (1956) and Swan (1956). According to Aghion and Howitt (n.d), the building block of this model is an aggregate production function exhibiting constant returns in labor and reproducible capital, which is given by:

$$Y_t = f(L_t, K_t) \quad \textbf{(1)}$$

Where Y is real output, L is total labour force and K is gross capital formation. In equation (1), since fixed capital formation is not available for developing countries like Ethiopia thus, Investment was used as a proxy for K. The Neo-Classical growth model which states that St equal to It, is modified when we come to the case of Ethiopia.

According to the definition given by the World Bank (2020), the extended New Endogenous Growth Model given in the Cobb-Douglas function may be enhanced to account for economic growth. This augmented Cobb-Douglas function was employed in this study and is given as follows:

$$Y = AK^{\emptyset}L^{\vartheta}\mathrm{F}^{\pi}J^{\tau} \quad \textbf{(2)}$$

$$Y = f(K^{\theta}, L^{\vartheta}, \mathrm{F}^{\pi}, J^{\tau}) \quad \textbf{(3)}$$

where Y indicates economic growth; F shows key policy variables and J stands for any control variables and $\emptyset, \tau, \vartheta$, π are denotes the elasticities.
Other influential variables also include under model specification. Thus, we can specify the econometric model as:

$$RGDP_t = F(TLF_t, GCF_t, EXP_t, FIIND_t, FILDUM, REER_t) \quad \textbf{(4)}$$

Except for FIIND and FILDUM, all variables are transformed into their natural logarithms so that their first differences approximate their growth rates. On the other hand, to eliminate the impact of heteroscedasticity for economic variable time series data, all variables are in natural logarithms. The empirical model was designed to model the three variables after logarithmic transformation for the linear model, which is easy to verify, so the transformed model:

$$LNRGDP_t = \beta_0 + \beta_1 LNTLF_t + \beta_2 LNGCF_t + \beta_3 LNEXP_t + \beta_4 FIIND_t + \beta_5 FILDUM + \beta_6 LNREER_t + \varepsilon_t \quad \textbf{(5)}$$

Overview of the Ethiopian economy and financial development sector

Ethiopian economic growth has shown different changes in various political regimes. These changes in government structure created a problem of inconsistency in implementing the policies of previous regimes, including external and internal wars as well as natural disasters like famine and drought, which had a depressing effect on the history of economic growth in the country. In modern Ethiopian political and economic history, the country has experienced three policy transitions: the imperial era (prior to 1973/74), the socialist (Derge) regime (1974/75–1990/91), and the EPRDF regime (1991/92–present), each with unique economic policies with different impacts on the economic performance of the country. Thus, the performance of the country's economy is highly correlated with its changing political economy.

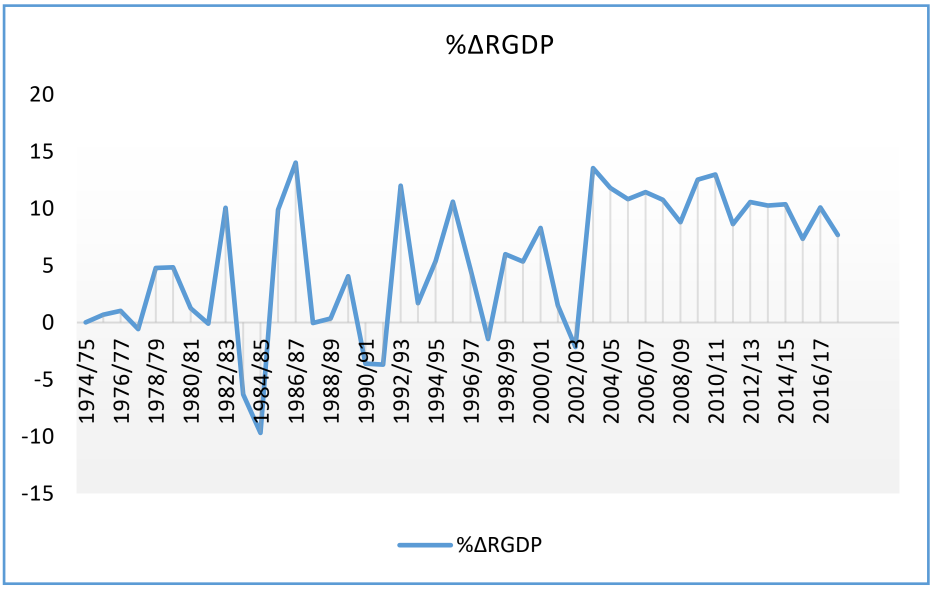
During the Imperial period (pre-1974), economic policy was mainly known to be market-oriented, and the political process was unpredictable and violent, which exerted a detrimental impact on economic performance. As a result, economic performance did not improve. During the Derge regime (1974/75–1990/1991), the government exercised centralized and command economic systems. Because of the intervention of the government in all types of economic activities and the nationalization of all types of property, the economy went to its worst. After the downfall of the Derge regime in 1991/92, the new government (EPRDF) liberalized the economic system, and relatively good economic performance was recorded, though it experienced fluctuations.

As shown in Figure 1, the GDP growth rate shows tremendous fluctuation. During the Derg regime, Ethiopia recorded the lowest economic growth rate, almost -10%. In addition to this, the average growth rate in real GDP was only 1.58% for the seventeenth year. Due to drought, growth was decelerated by 6.29% and 9.63% during 1983/84 and 1984/85, respectively. However, the growth rate displayed an amazing recovery from the previous years and reached 9.9% and 14.04% in 1985/86 and 1986/87 respectively, as a result of the economic reforms that have been taken, thus creating a relatively conducive environment for domestic and foreign private investors. The Ethiopian economy has grown rapidly as the transition from a command-based to a market-based economy takes place. However, the performance of the GDP growth rate at the beginning of the current EPRDF regime (1991–1992) was discouraging (-3.69%) due to the unfavorable economic basis and violence inherited from the Derge regime. Furthermore, the GDP growth rate was also very low in 1997/98 (-1.44%) because of Eritrea's unexpected aggression. Ethiopia registered the highest GDP growth (double-digit growth rate) in the current EPRDF government for the period 2003/04-2014/16, except in 2008/2009 and 2010/11 due to financial crises and inflation.

The Ethiopian economy, which had exhibited 10.04 percent average annual growth during 2010/11–2015/16, registered 7.33 percent growth in 2015/16 despite challenging macroeconomic and weather conditions. The Ethiopian average growth rate in 2016–17 and 2017–18 was 10.09694 and 7.698078, respectively. The 8 percent real GDP growth was 3.77 percentage points lower than the base case scenario GTPII target set for the fiscal year, although it was significantly higher than the 1.6 percent average growth estimated for sub-Saharan Africa (World Economic Outlook, 2016). The Ethiopian economy is targeted to grow 11.1 percent in 2016–17, in contrast to the 3.8 and 5.1 percent growth forecasts of the IMF for the world and Sub-Saharan Africa (SSA), respectively (WEO, 2016).

The growth rate trends of real GDP from 1974/5-2017/8 can be summarized as follows.

Figure 2: Trends of growth rate of real GDP from the year 1974/5-2017/18



Source: Own drawing (2022)

Developments in financial sector

Ethiopia's financial sectors are, to put it mildly, in deplorable condition. Few banks are advancing in assisting the Ethiopian economy by providing finance for numerous activities, despite the nation's tiny and insufficient level of deposits (18.95% of GDP in 2021). From 18 to 30, there are now more than 30 banks, with 8,944 branches as of June 30, 2022, up from 5,564 four years earlier. There is currently one bank branch for every 11,516 people in the population (1:11,516) as a result of the expansion of bank branches. The NBE asserts that banks have continued to function in a secure and sound way, notwithstanding the need to enhance efforts to open the banking industry for foreign investment. Ineffectiveness, a lack of fostering human capital, and unethical behavior in the banking sector. Currently, there are forty microfinance institutions, six capital goods finance and leasing businesses, eighteen insurance firms, one development bank, and a single insurance company (NBE, 2021/22).

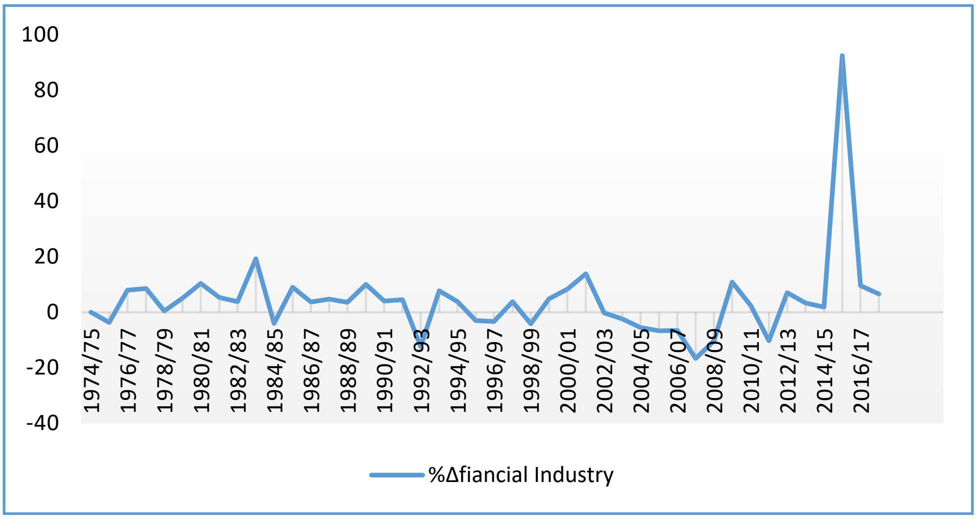
In Ethiopia, domestic credit to the private sector accounts for 17% and private sector loans for 18% of the GDP (NBE, 2021/22). There are now Islamic banks, and the stock market is beginning; nonetheless, there are no investment banks, mortgage banks, or venture capital firms operating in the nation. The financial industry lacks a precise road map. There are no financial sector risk management plans, as though they had long since lost significance in our nation, and modernization of financial sector strategies is not a priority.

Ethiopia is the lowest in terms of financial deepening, accounting for 35% compared to other African countries. The gender gap has increased from 8.9 to 15.2 percentage points, despite female account ownership increasing from 17.5 percent in 2015/16 to 22.7 percent in 2018/19. There are now 83.3 billion birr in deposit accounts, and the total deposits have increased from 899 billion in 2019 to 1.7 trillion in 2022. The net income of banks has climbed by 122% from 22.4 billion birr in 2019 to 49.9 billion birr in 2022. The issue is whether this advancement is necessary for growth in the economy.

Total resources mobilized by the banking system (deposit, loan collection, and borrowing) rose by 8.0 percent and reached Birr 149.6 billion by the end of 2015/16. Ethiopia's commercial banks' deposit liabilities increased to Birr 438.1 billion, showing a 19.3 percent annual growth. Savings deposits accounted for 49.5 percent of the total deposits, followed by demand deposits (39.0 percent) and time deposits (13.7 percent). The share of private banks in deposit mobilization increased to 33.6 percent from 32.2 percent last year due to the opening of 363 new branches.

The average growth rate of the financial industry during the Derge regime (1974/75-1990/91) was 4.388, which is extremely low. The average annual growth rate of the financial industry was 3.71 percent for the EPRDF period (1991/92-2017/18). Specifically, its average annual growth rate is 0.93 percent for the GTP I period (2010/11–2014/15), which is the lowest average growth rate.

Figure 3: The Trends in financial industry development



Source: Own drawing (2022)

The above figure shows that the trend of the financial industry from 1974 to 2014 shows a slight difference. Unlike other periods, the average growth of the financial industry was the highest in 2015/16, at 92.5. This is due to the low interest rate during this period, which is 7%, and low deposits in financial institutions.

4. Results and Discussion

4.1. Unit Root Test

It is necessary to test the nature of the stationarity of the variables before running regression analysis. This helps us avoid a spurious regression, which makes the result unreliable and inconsistent. This test can be done using the Augmented Dickey-Fuller (ADF) unit root tests. Table 2 shows the unit root results of the series at level and first differences. The absolute values of the calculated test statistics for all variables are less than their critical value at the 5% significance level. The result indicates that all variables are non-stationary at this level. Thus, the ADF test cannot reject the null hypothesis that each variable has a unit root at a given level. However, all the variables were found to be stationary at their first differences, and thus we reject the null hypothesis, and the model can be accepted since the coefficients of variables in all cases are negative and statistically significant.

Table 2: Results of Augmented Dickey Fuller Test

Variables	**ADF t-statistic at level, I(0)**		**ADF t-statistic at first difference, I(1)**		**Decision (Order of integration)**
	Intercept only	**Intercept and trend**	**Intercept only**	**Intercept & trend**	**Decision**
LNRGDP	3.8026[2] (NS)	0.0179 (NS)	-2.1382 (NS)	-6.6861*** (S)	Stationary (I(1))
FIIND	0.0638 (NS)	-0.8890 (NS)	-5.1940 (S)	-5.2370*** (S)	Stationary (I(1))
LNEXP	0.6572 (NS)	-1.8745 (NS)	-5.9494 (S)	-6.4807*** (S)	Stationary (I(1))
LNGCF	1.1716 (NS)	-1.4560 (NS)	-7.5728 (S)	-8.1615*** (S)	Stationary (I(1))
LNTLF	2.2720 (NS)	-0.7355 (NS)	-6.4965 (S)	-7.3168*** (S)	Stationary (I(1))
LNREER	-1.5284 (NS)	-1.5029 (NS)	-5.2090 (S)	-5.1685*** (S)	Stationary (I(1))
FILDUM	-1.0743 (NS)	-1.8891 (NS)	-6.4807 (S)	-6.4054*** (S)	Stationary (I(1))

MacKinnon (1996) with constant, no trend			with constant and trend		
	1% level	-3.621		1% level	-4.227
Test critical values:	5% level	-2.943	Test critical values:	5% level	-3.537
	10% level	-2.610		10% level	-3.200

Source: Own computation (2022)

Where NS & S indicates non stationary and stationary respectively.

The results imply that all the variables included in the models are integrated in order one, I (1). Thus, with the establishment of the order of integration, the study tested for long-run relationships by employing the Johansen approach. However, before applying this test, we need to first determine the appropriate lag length and check the stability of the VAR since Johansen's co-integration test and thus the VER are very sensitive to lag length determination.

[2] Although its tau statistics is greater than critical values it does not satisfies the other two assumptions: significant and negative.

Optimum lag length

The optimal lag order is determined with sequential modified likelihood ratio test statistics (LR), the final prediction error (FPE), the Akaiki information criterion (AIC), the Schwarz information criterion (SC), and the Hannan-Quinn information criterion (HQ). Lag that provides the minimum value is chosen as the optimal lag length, which means that among the ICs that provide the majority of lag, this has been chosen as the optimal lag length. While checking up to four lags to include the 5% significance level, it is suggested that lag 1 is the optimum lag length, which is confirmed by FPE, SC, and HQ. The smaller the value of the information criteria, the better the model is. Accordingly, this study employs the optimal lag length of one for estimation techniques (Table 3). The next step is to estimate the Johansen test of co-integration, the VECM, and the Granger causality test.

Table 3: VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
1	509.0082	NA	2.19e-18*	-23.6504	-22.1304*	-23.1008*
2	546.1907	52.0555*	2.28e-18	-23.7095	-20.6695	-22.6104
3	586.0452	43.8399	2.54e-18	-23.9023	-19.3423	-22.2535
4	623.4409	29.9166	4.78e-18	-23.9721*	-17.8921	-21.7737

* indicates lag order selected by the criterion

Johansen co-integration test for long run relationship

The existence of the same order of integration allows us to test for co-integration among the variables. To determine the number of co-integrating vectors, two test statistics called the maximum Eigen value (λmax) and trace statistics (λtrace) are computed. The trace test tests the null hypothesis of r co integrating vector r against the alternative hypothesis of k co-integrating vectors for r =0,1,2…,k-1. The null hypothesis of no co-integration is rejected by both the maximum Eigen value (λmax) and trace statistics (λtrace) tests. This means that the null hypothesis against the alternative hypothesis that there are r+1 or more than r in the system is rejected. It is concluded that among the variables, there is one long run relationship. The result of testing the number of co-integrating vectors is shown in Table 4. The maximum eigenvalue and trace statistic confirm that the variable is cointegrated by at most one. Table 4 reports that the null of no co-integration vector is rejected by trace statistics and the maximum eigenvalue at the 1% significance level.

Table 4: Johansen co-integration

Trace statistics test			
Hypothesized No. of CE (s)	**Eigenvalue**	**Trace statistics**	**Critical value**
None *	0.7787	156.7543	125.6154
At most 1	0.6130	93.4015	95.7537
At most 2	0.3927	53.5330	69.8189
At most 3	0.2800	32.5864	47.8561
At most 4	0.2636	18.7908	29.7971
At most 5	0.1317	5.9422	15.4947
At most 6	0.0003	0.0135	3.8415

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)			
Hypothesized No. of CE (s)	Eigenvalue	Max-Eigen statistics	Critical value
None *	0.7787	63.3528	46.2314
At most 1	0.6130	39.8685	40.0776
At most 2	0.3927	20.9467	33.8769
At most 3	0.2700	13.7956	27.5843
At most 4	0.2636	12.8486	21.1316
At most 5	0.1317	5.92866	14.2646
At most 6	0.0003	0.0135	3.8415

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Own computation (2022)

On the other hand, one co-integration vector is not rejected by tests, and thus we can conclude that there exists only one co-integration vector; there exists a meaningful long-run relationship between economic growth and financial industry, gross capital formation, labor force, export, real effective exchange rate, and financial liberalization.

Long-run and short-run model estimation results

Table 5: Long run estimation result

Variables	Coefficients	Standard error	t-statistics
Financial industry	0.0259	0.0096***	2.69022
Financial liberalization	-0.0330	0.0030***	-10.9497
Labor	0.1144	0.0097***	11.7790
Capital	0.0255	0.02920	0.8736
Export	0.5195	0.0511***	10.1734
Effective Exchange rate	-0.0517	0.0127***	-4.0665

Short run Estimation Result

Variables	Coefficients	Standard error	t-statistics	p-value
Financial industry	0.0008	0.0118	0.0712	0.9437
Financial liberalization	0.0044	0.0032	1.3910	0.1735
Economic growth (-1)	0.4429	0.2140**	2.0691	0.0464
Labor	-0.1830	0.1498	-1.2218	0.2304
Capital	-0.0023	0.0325	-0.0721	0.9430
Export	-0.0220	0.0756	-0.2913	0.7726
Effective Exchange rate	0.0425	0.0198**	2.1478	0.0392
Conistnat	0.0036	0.0017**	2.0609	0.0473
CointEq(-1)**	-0.2709	0.1346**	-2.0131	0.0423

R-squared: 0.5164

Over all test: F-statistics: 3.3484 (0.0000)

Diagnostics and Stability tests (the value in parenthesis is p-value)

Normality test: Jarque-Bera: 1.4196; p-value: 0.4917

Serial correlation test: Obs*R-squared: 0.0331; p-value: 0.8557

Durbin-Watson stat: 1.9536

Heteroskedasticity test: Obs*R-squared: 9.3598; p-value: 0.8073

CUSUM= stable ; CUSUM Square: stable

Note: The superscripts *, ** and *** denote significance at the 10%, 5% and 1% levels.

Source: Own computation (2022)

Table 5 shows that financial industry development, labor, and exports have a positive and statistically significant relationship with economic growth in the long run. However, capital has a positive and statistically insignificant relationship with economic growth in the long run. This is due to the fact that, in Ethiopia, there has been low capital formation over time. Financial liberalization and the effective exchange rate have a significant negative effect on economic growth. The key policy variables are discussed as follows:

Financial industy development. It has a significant positive effect on economic growth in Ethiopia. A one percent increase in financial industry development results in a 2.6% increase in economic growth; this is due to the fact that it contributes to economic growth by financing different public and nonpublic projects. However, it is not statistically significant in the short run due to the fact that the time lag of the role of the private sector in economic growth shows the underdevelopment of the financial industry in the short run. This indicates that technology development and growth in the economy need the use of financial intermediaries, such as savings mobilization, project evaluation, and risk management. Financial growth promotes effective capital allocation and improves awareness of potentially profitable projects. By producing structural change via innovation and welfare advantages for the whole economy, expanding financial access also promotes dynamic efficiency. The banking industry determines the level of local saving that enables successful investments in small businesses, especially when national savings in emerging countries are inadequate and insufficient to satisfy development requirements. This finding is in line with the theories of Schumpeter (1911), Goldsmith (1969), McKinnon (1973), and Levine (1993), Roman (2012), Dimpho et al. (2014), Murcy et al. (2015), Abriham (2016), and Meron (2016).

Financial liberalization. Semi-liberalizing the financial sector in Ethiopia has a negative effect on economic growth, decreasing it by 3.3% on average in the long run while having no significant effect in the short run. This is due to the lack of modernization, a clear road map, weak capacity, incompetent management, weak risk management, and a lack of foreign exchange fund management. This has been the result of financial repression policies. The benefits of financial liberalization have not been proven, primarily because countries have lagged behind in terms of complementarities between reforms (Williamson, 1993; Rodrik and Subramanian, 2009). Financial liberalization is also associated with increased domestic competition and technology transfers, which have a potential positive influence on economic growth. According to Rodrik (1999) and Edison et al. (2002), the growth effect of financial liberalization might be disappointing if it is implemented in a setting with inadequate human capital, which is unable to accept foreign capital inflows and the related technologies. The fundamental reason for this sluggish development appears to be the adoption of poor policies, such as financial repression (Fowowe, 2013; Abbas, 2014). Financial openness was chosen as the best development approach for SSA nations in order to attain better rates of economic growth. Collier and Gunning (1999), Reinhart and Tokatlidis (2000), and Njikam (2017) all provide support for the study.

Real effective exchange rate. This result is against the theory in the long run. In Ethiopia's case, devaluation deteriorates trade balances and decreases economic growth by 5.17% on average in the long run. This is due to the fact that our export volume is very small and our imports are still increasing, especially for basic goods, and the uncertainty within global commodity markets. Despite export-led sectors, the trade deficit in Ethiopia is widening, as imports have been increasing at a faster pace than exports. For instance, Ethiopia exported $1.16 billion worth of coffee in 2021; however, despite coffee having the largest export market share (4.3%), assuming that Ethiopia is influencing the global market is absurd. Ethiopia's imports also reached a record high in 2021, rising from $14.2 billion in 2020–2021 to $18.1 billion in 2021–2022. As a result, the country's trade imbalance, which was already $14 billion higher than it was the previous year when it sold $4.1 billion worth of goods, has grown. Ethiopia's trade imbalance is growing despite investments in industries that are export-driven since imports have been rising faster than exports (Job Creation Commission Ethiopia, 2020; Ministry of Trade and Regional Integration, 2022).

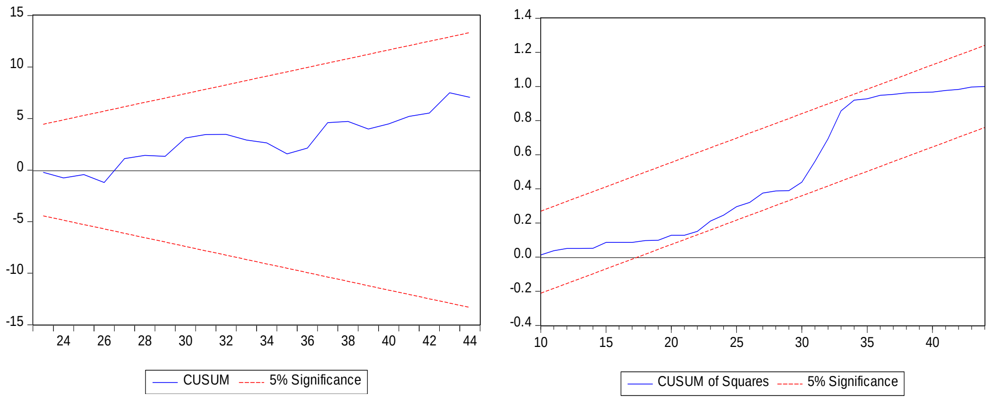
Export: It has a positive contribution to economic growth in the long run, indicating that a one percent increase in exports increases economic growth by 0.5195% on average. Unlike in the long run, total exports of goods and services are not significant in the short run, and the sign of the coefficient is also incorrect. This insignificant result might be related to primary agricultural products; more than 68 percent of the export level in the country comes from agricultural primary products, which suffered from an international price shock. Furthermore, the insignificant result might be due to the huge gap in resource balance (17.8% as a ratio to real GDP), which indicates that exports of goods and services have an insignificant impact on Ethiopian economic growth. This result was also confirmed by MoFEC, particularly during 2011–12 and 2012–13, despite the fact that it was expected to play an important role in accelerating economic growth during the GTP period. Furthermore, this finding is consistent with the study conducted in Ethiopia by Gezehegn (2012), who found that total exports of goods and services were insignificant on Ethiopian economic growth even though there was a positive impact in the long run, while there was an inverse relationship between economic growth and export volatility (Tesfaye, 2017).

Capital. The capital is insignificant in both the short and long run. This may be due to the fact that benefits from capital accumulations (both private and public) are not ensured in a short period of time and may have a crowding out effect on growth, and it may also be due to the small capital accumulation in the country. The additional justification may be due to macro-economic instability like inflation, and thus no one is willing to invest and thus accumulate capital; the result is supported by Tesfaye (2017).

The impact on economic growth can be explained on average in the short run as follows: A 1% growth in the economic growth of the lagged one year increases the current economic growth by 0.4429%, on average, while a 1% growth in the effective exchange rate increases the current economic growth by 0.0425% in the short run, on average. This may be due to the inflow of capital from the rest of the world. The rest of the variables have either a positive or negative sign with an insignificant level of significance.

The short-run speed of adjustment 27.09% of the disturbance in the short run is corrected each year, or it adjusts any disequilibrium towards the long-run equilibrium state path. According to Bannerjee et al. (2003), as cited in Kidanemarim (2014), the highly significant error correction term further confirms the existence of a stable long-run relationship. Since the Durbin-Watson statistic is greater than R-squared, we accept the model. R2 is 51.64%, which indicates that the fitted value explains the model well. Moreover, the overall significance of the F-test established that all variables are jointly significant. Also, to strengthen our analysis, the stability of the estimated parameters in the model is examined using the stability test of recursive residuals. The stability of the model is checked using the CUMSUM and CUMSUMSQURE methods, and the graphs that show the results are presented as follows: The following figure affirms that the model's coefficients are stable over a sample interval.

Figure 4: Parameter stability test VECM: Recursive Estimates (OLS only)



Source: Own drawing (2022)

Figure 4 shows the parameter stability test of the VEC model by using CUSUM and CUSUM squares. Therefore, according to the above figure, the CUSUM squares plot bounds within the plus and minus 2 standard errors, and the CUSUM plot bounds within the plus and minus 5 standard errors. Thus, the two tests show that the parameters are stable over the period under investigation. The diagnostic test of residuals shows that the model has desirable properties of OLS. A residual test of normality, a serial correlation LM test, and a heteroskedasticity test were conducted, and all tests were satisfied (Table 5).

Furthermore, this study applied Wald tests to the various null hypotheses involving sets of regression coefficients. The results are shown in Table 6. The P-value indicates that we reject the null hypothesis that the regression coefficients of all the variables in the economic growth equation are equal to zero. The null hypothesis that the regression coefficients in each equation are equal to zero is also rejected, as shown by the p-values. Thus, it indicates that all variables jointly affect economic growth.

Table 6: Wald Coefficient Test

Test Statistic	Value	Df	Probability
F-statistic	8.390054	(8, 33)	0.0000
Chi-square	67.12043	8	0.0000

Source: Own computation (2022)

Long run-granger causality test

The simplest method for examining the cause-and-effect relationship between variables in a bivariate system is the dynamic relationship. However, Granger (1969) used Granger causality tests to effectively assess the underlying dynamic causation, which is not captured by the conventional linear regression model. The purpose of this test is to see whether changes in one variable have an impact on the other. The Granger causality test analysis must make sense in order to identify the direction of causation between two variables. The Granger causality test for Ethiopia's banking sector and economic growth is displayed in the table below.

Table 7: Pairwise Granger Causality Tests

Null Hypothesis	Obs.	F-statistics	Prob.
Financial industry development does not granger cause economic growth	43	0.0114	0.9156
Economic growth does not granger cause Financial industry development		4.1799	0.0475

Source: Own computation (2022)

As can be seen from the table above, we reject the null hypothesis that economic growth does not cause financial industry development, but we fail to reject the null hypothesis that the financial industry does not cause economic growth. Therefore, it is shown that Granger causality runs one way from economic growth to the financial industry and not vice versa. That is, this study supports the demand-following hypothesis by supporting the unidirectional causality from economic growth to the financial industry, which suggests that policy on the financial industry has no effect on economic growth. Thus, in the long run, the Granger causality is unidirectional from economic growth to the financial industry, which implies that it is not viable to depend on financial development alone to promote economic growth and that the government should invest in the financial industry so as to develop a well-established financial industry without compromising economic growth in the long run.

This is due to the fact that the financial industry development has low development, and there is no well-developed financial industry in Ethiopia. One way the financial industry contributes to economic growth is by providing loans for private investors. However, such a grant does not exist in Ethiopia due to high collators requested by the financial industry, presence of technically weak, conservative, and uninformed, which is one of the most significant hurdles to digitization and financial innovation. The scenario may be different for a developed economy; the more developed the country, the better the financial industry, which is essential to fast economic growth. In this case, financial industry growth would cause economic growth. The finding is supported by Levine, 2008; Ang, 2008; Odhiambo, 2009; Odhiambo, 2010; Roman, 2012; and Meron, 2016.

Short run granger causality wald test

As long as the error correction term has a negative sign and statistical significance, we can test the short-run causality between the financial industry and economic growth. To examine short-run causality, we use the technique of Wald coefficient restriction. Table 8 shows the results of the tests.

Table 8: VEC Granger causality wald test result

Test Statistic	Value	Df	Probability
t-statistic	-1.716743	30	0.0963
F-statistic	2.947207	(1, 30)	0.0963
Chi-square	2.947207	1	0.0860

Source: Own computation (2019)

There is no short-run causality running from the financial industry to economic growth because the probability of Chi-Square is greater than 5% level of significance, thus, we accept the null hypothesis that says there is no short-run causality running from the financial industry to economic growth. In able 10, where economic growth is the dependent variable, the null hypothesis is that the financial industry does not cause economic growth, and the alternative hypothesis is that the financial industry does cause economic growth. The table shows that the P value is 0.9137, which is higher than 5%, and based on the "P-value," we tend to accept H0. That is, the financial industry does not granger cause economic growth in the short run, and the same is true when the industry is dependent.

Table 10: Vector error Correction model Granger Causality Test

VEC Granger Causality/Block Exogeneity Wald Tests			
Dependent variable: Economic growth			
Excluded	**Chi-sq**	**Df**	**Prob.**
Financial industry	0.011758	1	0.9137
Dependent variable: Financial industry			
Excluded	**Chi-sq**	**Df**	**Prob.**
Economic growth	0.018378	1	0.8922

Source: Own computation (2022)

The finding of this study is due to the fact that there is a weak financial industry in Ethiopia; the financial reform of Ethiopia has a lag effect in affecting economic growth; the existence of financial constraints, especially foreign reserves; the existence of imperfect financial markets; due to a lack of training or corruption, this may lead to the dependence of the financial system on the real side of the economy, making the contribution of the financial sector to economic growth less (Hurrlin and Venet, 2008); and there is high collateral, which hides private investors.

5. Conclusion and Policy Implications

The study scrutinized the dynamic nexus relationship between financial industry development, financial liberalization, and economic growth in Ethiopia both in the short and long run based on a Johanson cointegration and VEC model using annual time series data from 1974/75–2018/19 while controlling for capital stock, labor force, real effective exchange rate, and exports.

The Johanson cointegration test shows the existence of a long-run relationship among the variables.The model estimation shows the financial industry, exports, and labor force have positive and statistically significant relationships with real GDP in the long run. Effective exchange rates and financial liberalization have a negative and statistically significant relationship with real GDP. Furthermore, in the long run, the Granger causality test reveals unidirectionality from economic growth to the financial industry, which supports the demand hypothesis. ' In the short run, the empirical evidence reveals that only the one-year lagged value of real GDP and real effective exchange rate is significant in affecting current growth. In the short run, the estimated short-run Wald test for causal relationships reveals no short-run causality running from the financial industry to economic growth or vis-à-vis Ethiopia for the period under investigation. The short-run speed of adjustment coefficient of -0.2709 indicates that 27.09% of the short-run adjustment is made within a year.

Based on the empirical result, we can infer the following recommendations: According to the study, Ethiopia's financial industry has a long-term impact on economic growth. As a result, with the banking system dominating the financial industry, the financial sector should strengthen the banking sector through a strong regulatory structure.

The study results show a unidirectional causal flow from economic growth to the financial industry's development in the long run. Thus, policymakers should consider the financial industry's development to support its quest for rapid economic growth and to eliminate poverty. The government should strengthen this sector by creating robust financial sector strategies (capacity building on technological, managerial, risk management, foreign exchange fund management, and financial inclusion).

The NBE should allow banks to create and deploy new financial products. Strengthen the currently established "liability and asset company..." The loan should be given for "productive investments." The government should establish investment and mortgage banks; Islamic banks should be encouraged; and "deposit insurance schemes."

The existence of a central bank that is technically weak, conservative, and uninformed is one of the most significant hurdles to digitization and financial innovation in the financial sector. Due to these characteristics, the NBE does not allow banks to create and deploy new financial products. It also ignores the bank's requests. The lack of a national ID, which should have been implemented at the national level, aggravates the digitalization problem. Fearing retaliation from the NBE for their defensive position, which is not unusual, and deterred by the bureaucratic hurdle for approval of new digital products, banks are being pushed to stick to already recognized and approved financial products rather than working on a new and better one. The regulator needs to make a significant policy adjustment.

The relationship between financial liberalization and economic growth in Ethiopia shows a significant negative effect on economic growth. This shows that currency or financial liberalization at this moment is destructive to economic growth via different channels. Thus, the study strongly recommends that fully liberalizing it brings an unreversible crisis to our country; we have to take a lesson from Sudan, which completely liberalized the exchange rate of the Sudanese Pound (SDG) without the intervention of the Central Bank of Sudan (CBoS) determining foreign exchange rates and establishing the foreign exchange market, and then, within 6 years, their exchange rate exhibited an unthinkable increase from 5.96 to 436.28. On May 30, 2015, 31 January 2016, 31 January 2017, 30 January 2018, 31 December 2019, 31 December 2020, and 31 December 2021, the United States dollar/Sudanese pound exchange rate was 5.96, 6.11, 6.44, 11.64, 45.55, and 436.28, respectively. Hence, the government should be intervening in the development of the financial industry and should not be allowed full financial liberation, which would result in economic collapse in our country until we finalize our home assignments, and it should be supported by strong risk management.

The effective exchange rate has a negative and statistically significant relationship with economic growth. Therefore, currency devaluation as a growth strategy is not viable for our country with primary product exporting, and thus the country starts to export semi-manufactured and manufactured products, aggressively increasing the export volume, so that it increases its share of the world market. We need to have a different exchange rate for remittances between the legal and parallel market rates. The exchange rate needs to be fixed at the current rate for the rest of economic activity for some period of time.

The study recommends that capital markets not be prioritized for Ethiopia. Due to the fact that it is difficult to obtain a listed company except for banks, since a listed company needs a serious accounting evaluation system, it is hard to get companies that would fulfill the accounting system evaluation. Second, if there are no potential buyers for these stocks, it becomes a debt market, which gives loans to the government alone, considering free risk, and the private loans will decline; this results in macroeconomic instability. Therefore, it may be the debt market in terms of the capital market. Third, it should not be a priority to apply it in our country but rather to increase agricultural productivity, balance the money supply with economic growth, minimize inflation, reduce unemployment, and stabilize foreign exchange rates.

Last, as a future investigation, in this study, the importance of the stock market is "Tekonnena." Last, as a future investigation, in this study, the importance of the stock market is discussed. Thus, further study will be needed on the fate that our country may face if a stock market is established, and further study is required to address this related issue. Second, financial industry development affects economic growth through productivity, and thus further study can extend this study by including this variable. Finally, although financial industry development is general, different measurements should also be considered in its measurement.

References

Abbas, Q., Hunjra, A. I., Azam, R. I., Ijaz, M. S., & Zahid, M. (2014). Financial performance of banks in Pakistan after Merger and Acquisition. *Journal of Global Entrepreneurship Research*, 4, 1-15.

Ahmed, A. D. (2013). Effects of financial liberalization on financial market development and economic performance of the SSA region: An empirical assessment. Economic Modelling, 30, 261–273. https://doi.org/10.1016/j.econmod.2012.09.019.

Akinsola, F. A., & Odhiambo, N. M. (2017). The impact of financial liberalization on economic growth in sub-Saharan Africa. Cogent Economics & Finance, 5(1), 1338851.

Alawode, A. A., & Ikhide, S. I. (1997). Why should financial liberalization induce financial crisis? Savings and Development: Quarterly Review, 21, 261–274.

Ang, J .B. (2008).Survey of recent developments in the literature of finance and growth. *Journal of Economic Surveys* 22, 536–576.

Ang, J. B. (2009). Financial development and the FDI-growth nexus: the Malaysian experience. *Applied Economics* 41(13), 1595-1601.

Athena, B. S. and, Alfred, B. (2014). Banking sector development and economic growth Evidence from Zimbabwe. Banks and Bank Systems, 9(2), 51-58.

Atif, R. M., Jadoon, A., Zaman, K., Ismail, A., & Seemab, R. (2010). Trade liberalization, financial development and economic growth: Evidence from Pakistan (1980–2009). *Journal of International Academic Research*, 10(2), 30-37.

Banerjee, S. B., Iyer, E. S., & Kashyap, R. K. (2003). Corporate environmentalism: Antecedents and influence of industry type. *Journal of marketing*, 67(2), 106-122.

Chang, C. C., & Mendy, M. (2012). Economic growth and openness in Africa: What is the empirical relationship? *Applied Economics Letters*, 19(18), 1903-1907.

Change, T., (2002). Financial development and economic growth in Mainland China: a note on testing demand-following or supply-leading hypothesis. Applied Economics Letters 9(13), 869873.

Christopoulos, D. K., & Tsionas, E. G. (2004). Financial development and economic growth: evidence from panel unit root and cointegration tests. *Journal of development Economics*, 73(1), 55-74.

Collier, P., & Gunning, J. W. (1999). Why has Africa grown slowly? *Journal of economic perspectives*, 13(3), 3-22.

De Gregorio, J., Guidotti, P., (1995). Financial development and economic growth. World Development 23, 433–448.

Daumont, R., Le Gall, F., & Leroux, F. (2004). Banking in Sub-Saharan Africa: what went wrong?

Dimpho Sebina, M. K. Sukumaran Nair and M. Rathedi. (2014). The Causal Relationship between Financial Development and Economic Growth: Does Inflation matter? Empirical Evidence from Botswana.

Dejene. (2016). Does Financial Sector Development Drive Economic Growth in a Post-Communist Economy? Evidence from Ethiopia, *Journal of Economic Insights – Trends and Challenges*.

Edison, H. J., Levine, R., Ricci, L., & Sløk, T. (2002). International financial integration and economic growth. *Journal of international money and finance*, 21(6), 749-776.

Fowowe, B. (2013). Financial liberalization in sub-Saharan Africa: What do we know? *Journal of Economic Surveys*, 27(1), 1-37.

Fritz, R. G. (1984). Time series evidence of the causal relationship between financial deepening and economic development. *Journal of Economic Development* 9,1 (July): 91–112.

Goldsmith, R. W. (1969). *Financial Structure and Development*. New Haven: Yale University Press.

Granger, C. W. (1969). Investigating causal relations by econometric models and cross-spectral methods. Econometrica: *Journal of the Econometric Society*, 424-438.

Greenwood, Jeremy and Smith, Bruce. (1997). Financial Markets in Development, and the Development of Financial Markets, J. Econ. Dynamics and Control, Jan. 1997, 21(1), pp.145–81.

Gries, T., Kraft, M., Meierrieks, D. (2009). Linkages between financial deepening, trade openness, and economic development: Causality evidence from Sub-saharan Africa. World Development 37(12), 1849-1860.

Gries, T., Kraft, M., Meierrieks, D. (2011). Financial deepening, trade openness and economic growth in Latin America and the Caribbean. *Applied Economics* 43, 4729-4739.

Gupta, K.L. (1984). Financial liberalization and economic growth: Some simulation results. *Journal of Economic Development*, 9,2 (December):25–44.

Gurley, J., Shaw, E. (1967). Financial structure and economic development. Economic Development and Cultural Change 34, 333-46.

Hicks, J. (1969). *A Theory of Economic Growth*. Oxford: Clarendon Press.

Honohan, P., & Klingebiel, D. (2000). Controlling the fiscal costs of banking crises (Vol. 2441). Washington, DC: World Bank Publications. https://doi.org/10.1596/prwp.

Ikhide, S. (2015). The finance and growth debate in Africa: What role for financial inclusion. University of Stellenbosch Business School.

Jenkıns, H. P., & Katırcıoglu, S. T. (2010). The bounds test approach for cointegration and causality between financial development, international trade and economic growth: the case of Cyprus. *Applied Economics*, 42(13), 1699-1707.

King, R. G., and R. Levine (1993). Capital Fundamentalism, Economic Development, and Economic Growth. Carnegie-Rochester Conference Series on Public Policy 40 (June): 259-92.

Levine, R., Loayza, N., & Beck, T. (2000). Financial Intermediation and Growth: Causality and Causes. *Journal of Monetary Economics,* 46, 31-77.

Levine, R. (1997). Financial Development and Economic Growth: Views and Agenda. *Journal of Economic Literature*, 35: 688-726.

Levine, R. and S. Zervos (1999). Stock Markets, Banks, and Economic Growth. American Economic Review, 88: 537-558.

Majid, M. S. A., Mahrizal., (2007). Does financial development cause economic growth in the ASEAN-4 countries? Savings and Development 31(4), 369-398.

Meron (2016). The Nexus between Financial Development and Economic Growth in Ethiopia; Addis Ababa University MSc. Thesis

Mckinnon, R. I. (1973). Money and Capital in Economic Development. Washington DC: Brookings Institution.

Misati, R. N., & Nyamongo, E. M. (2012). Financial liberalization, financial fragility and economic growth in Sub-Saharan Africa. *Journal of Financial Stability*, 8(3), 150-160.

Mlachila, M., Dykes, D., Zajc, S., Aithnard, P. H., Beck, T., Ncube, M., & Nelvin, O. (2013). Banking in sub-Saharan Africa: Challenges and opportunities.

Murcy, K.J., Kalio, A., and Kibet, L. (2015). Effect of Financial Development on Economic Growth in Kenya: Evidence from Time Series Analysis. European Journal of Business and Social Sciences, 3(11), pp. 62-78.

NBE. (2021/22). National Bank of Ethiopia, Annual Report.

Ndlovu, G. (2013). Financial sector development and economic growth: Evidence from Zimbabwe. *International Journal of Economics and Financial Issues*, 3(2), 435-446.

Ndikumana, L. (2000). Financial determinants of domestic investment in Sub-Saharan Africa: Evidence from panel data. World development, 28(2), 381-400.

Njikam, O. (2017). Financial liberalization and growth in African economies: The role of policy complementarities. Review of development finance, 7(1), 73-83.

Noureen A. (2008). The role of the financial sector in economic growth, Lecturer Comsats institute of Information Technology, Islamabad, Pakistan.

Odhiambo, N. M. (2007). Supply-leading versus demand-following hypothesis: Empirical evidence from three SSA countries. African Development Review 19(2), 257-280.

________. (2008). Financial depth, savings and economic growth in Kenya: A dynamic causality linkage. Economic Modelling 25, 704-713.

________. (2009). Finance-growth-poverty nexus in South Africa: A dynamic causality linkage. *The Journal of Socio-Economics* 38, 320-325.

________. (2010). Finance-investment-growth nexus in South Africa: an ARDL-bounds testing procedure. Economic Change and Reconstruction 43, 205-219.

Oshikoya, T. W. (1994). Macroeconomic determinants of domestic private investment in Africa: An empirical analysis. Economic development and cultural change, 42(3), 573-596.

Özdemir, D. (2014). Economic growth and financial liberalization in the EU accession countries. Applied Economics Letters, 21, 1036–1044.https://doi.org/10.1080/13504851.2014.907470.

Patrick, H.T. (1966). Financial development and economic growth in underdeveloped countries economic development and cultural change. *Chicago Journal*, 14 (2) 174-189.

Pagano, M. (1993). Financial markets and growth: An overview. European economic review, 37(2-3), 613-622.

Philip, A. (2007). Financial liberalization and the relationship between finance and growth. In A. Philip & M. Sawyer (Eds.), A handbook of alternative monetary economics (pp. 346–364). Cheltenham: Edward Elgar.

Rachdi, H., & Mbarek, H. B. (2011). The causality between financial development and economic growth: Panel data cointegration and GMM system approaches. *International Journal of Economics and Finance*, 3(1), 143-151.

Ram, R. (1999). Financial Development and Economic Growth. Additional Evidence . *The Joirnal of Development Studies*, 35 (4), 164-174.

Reinhart, C. M., & Tokatlidis, I. (2000). Financial Liberalization: The African Experience. *Journal of Africa Econmies* vol 12 (AERC supplement).

Rodrik, D., & Rodrik, D. (1999). The new global economy and developing countries: making openness work (Vol. 24). Washington, DC: Overseas Development Council.

Rodrik, D., & Subramanian, A. (2009). Why did financial globalization disappoint? IMF staff papers, 56(1), 112-138.

Roman. (2015). The link between financial development and economic growth in Ethiopia; Addis Ababa University; MSc thesis.

Schumpeter, J. (1911). *The Theory of Economic Development*. Cambridge: Harvard University.

________. (1934). The fundamental phenomenon of economic development. Schumpeter, *The Theory of Economic Development*, 57-94.

Seck, D., & El Nil, Y. H. (1993). Financial liberalization in Africa. World Development, 21, 1867–1881.

Shaw, E. S. (1973). *Financial Deepening in Economic Development*. New York, Oxford University Press.

Sime (2016). Causality between Financial Development and Economic Growth: Empirical Evidence from Ethiopia; *Research Journal of Finance and Accounting*.

Solow, R. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 70, 65-94.Yale University Press.

Tesfaye E. (2017). Energy and economic growth in Ethiopia, presented on the 16th EEA annual conference on the Ethiopian Economy

Ugbaje, D. O., & Edez, U. H. (2014). Empirical study of financial sector development on economic growth in Nigeria (1990-2010). *International Journal of Public Administration and Management Research*, 2(3), 122-137.

Urgaia, R. (2015). The contribution of financial sector development to the east African economy. Unpublished manuscript. Economics Department, Addis Ababa University.

Williamson, O. E. (1993). Calculativeness, trust, and economic organization. The journal of law and economics, 36(1, Part 2), 453-486.

Wolde-Rufael, Y. (2009). Re-examining the financial development and economic growth nexus in Kenya. Economic Modelling 26, 1140-1146. Xu, Z. (2000). Financial Development, Investment, and Economic Growth. Economic Enquiry, 38 (2), 331-344.

World Bank. (2020). Global economic prospects, June 2020. The World Bank.