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Ethiopian Economics Association (EEA)
Yeka Sub-city, Woreda 11
CMC area adjacent to St. Michael Church
Telephone: +251-(0)11-645 3200, 3329, 3041
Fax: +251-(0)11-645 30 20
P.O.Box 34282, Addis Ababa, Ethiopia
Email: eje@eea-et.org
Website: www.eea-et.org
P.O.Box 34282, Addis Ababa, Ethiopia

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Liberalizing Financial Sector in Ethiopia: Constraints, Consequences and Policy Issues[1]

Fetene Bogale[2], Birku Reta[1], Shibiru Ayalew[3], and Abule Mehare[4]

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Abstract

This paper was instigated to examine the constraints, consequences, and policy issues of the intended financial sector liberalization process in Ethiopia. Primary data from financial sector operators and secondary data *from National Bank of Ethiopia, IMF and the WB were employed to achieve the objectives of the study. Descriptive and econometric approaches were used to analyse the data and the results revealed that Ethiopian financial sector performance is not satisfactory. The liberalization process can be effective if implemented sequentially within a stable macroeconomy; in both the long run and the short run. The policy will also improve economic growth directly and indirectly by improving efficiency. However, it may reduce economic growth indirectly by increasing bank fragility. In nut shell, the intended financial sector's liberalization is expected to bring both benefits and costs to individual firms and the country as a whole. The benefits may include speeding up foreign direct investment, reducing the population to financial sector ratio; lowering lending interest rates; economies of scale; improving consumer and mortgage credit; and ensuring a more stable source of credit. While the negative consequences of liberalization may include a loss of macroeconomic stability and biased credit provision, causing small businesses to face credit shortages, less mobilizing of domestic capital, capital flow volatility. Therefore, the government should design strong prudential regulations, and strengthen institutional capacity to implement sequential financial sector reform.*

Keywords: Finance Sector, Liberalization, Policy and Ethiopia
JEL Classification: F36

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[1] We are grateful to the European Union (EU) for funding this research.
[2] PhD, Adama Science and Technology University (ASTU), Adama, Ethiopia
[3] PhD Candidate, Adama Science and Technology University (ASTU), Adama, Ethiopia
[4] PhD, Senior Researcher, Ethiopian Economics Association

1. Introduction

It is widely believed that financial liberalization is an essential part of the financial sector's development process, particularly in developing countries. The argument supporting financial liberalization goes back to McKinnon's (1973) and Shaw's (1973) paradigms. They argue that government intervention in the financial sector distorts the financial market, depresses savings, and leads to inefficient investment. The World Bank and IMF have endorsed this paradigm and prescribed for most developing countries as part of structural adjustment programs. Since the 1980s, many developing countries have begun to implement financial liberalization schemes.

Even though Ethiopia also adopted the structural adjustment program (SAPS) and achieved rapid financial sector growth, the sector is still underdeveloped and characterized by low competition, high concentration, and low inclusion (WB, 2019). The performance of Ethiopia's financial sector on many financial metrics, including the number of banking branches, percent of adults who have an account with formal financial institutions, ATMs per 100,000 adults, depositors and creditors for 1,000 adults and mobile banking, is substantially behind the average Sub-Saharan African countries and neighbouring countries. In 2014, only 34.8% percent of adults had an account with formal financial institutions, less than the SSA average of 42.6% (Global Findex, 2017). In the same year, 82% of adults have an account in Kenya, while account ownership stands at 50% in Rwanda. In 2016, mobile banking per 100,000 adults in SSA, Kenya and Rwanda was 24, 57, and 13 percent, respectively, compared to only 1 percent in Ethiopia (WB, 2017). The insurance and Microfinance penetration rate also remains low in Ethiopia, at around 0.4% and 4%, respectively (WB, 2017).

There is also a huge investment-saving gap. According to the National Bank of Ethiopia (2019/20) report, investment as a percentage of GDP was 30.4% during 2019/20, while the growth in the domestic saving rate was only 20.9%. Due to this huge investment saving gap, public investment has been financed by tapping external financing, keeping government consumption low, and deploying heterodox mechanisms such as controlled interest rates and financial repression (World Bank, 2019).

Even though a series of financial sector reforms have been introduced since 1994, Ethiopia's financial sectors remain closed to foreign ownership and have no capital market. Over the past decades, it has been operating under a financial repression framework used by the government to manage its monetary and foreign exchange policy and finance large infrastructure projects and state-owned enterprises. Although one can observe a strong growth and revival of the private sector since partial liberalization in 1994; yet, the state-owned banks seem to dominate the industry.

Currently, the Ethiopian government is considering liberalizing its financial sector as part of its financial development strategy. It is unquestionable that the move by the government of Ethiopia to liberalize its financial sector is a critical policy decision that needs to be supported by empirical pieces of evidence, but little has been known as to the possible impacts of opening up the financial sector. Therefore, this research aims at providing research evidence to policymakers and scholars by examining constraints, consequences, and policy issues associated with Ethiopia's financial sector liberalization.

2. Empirical Review

There are many empirical studies in support of this argument. For instance, Demirgüç-Kunt et al. (1998) and Akinsola and Odhiambo (2017) concluded that foreign bank entry accelerated the domestic banking sector's efficiency. Morgan and Yoshino (2017) indicate that opening the financial sector to foreign ownership leads to greater financial inclusion. Romānova et al.'s (2018) study also suggest that opening the financial sector promotes competitiveness, innovation, and new product development. Private ownership participation will increase operational efficiency (Dong et al., 2014).

Moreover, the presence of foreign banks improves domestic banks' risk management capabilities (Lensink & Hermes, 2004). Levine et al. (2000) revealed that greater financial intermediation development positively affected economic growth. Porta et al., 2002 investigated the ownership structure of banks in 92 countries and found that higher government ownership of banks resulted in lower per capita GDP growth. They also found that higher government ownership of banks was associated with slower subsequent financial sector development and lower productivity growth.

In contrast, researchers have found a negative correlation between foreign bank participation and banking sector outreach (Detragiache et al., 2008; Bech et al., 2007; Cull & Peria, 2010). Detragiache et al. (2008) found a negative correlation between foreign bank participation and banking sector outreach using cross-sectional data from 2003 to 2008 for 18 countries. They argue that a decline is observed in loans, deposits, and several branches due to the greater presence of foreign banks in a country. Studies by Bruno and Hauswald (2014) and Beck et al. (2018) found that foreign banks' credit is skewed to large firms so the entry will harm financial inclusion.

3. Data and Research Methodology

3.1. Population of the study

The entire financial institutions of Ethiopia, which were well established and started operations before 2018, are the population of this study. At the end of 2018/2020, there were 18 banks (16 private and 2 public), 18 insurance companies (one public and 17 private), and 41 microfinance institutions registered (only 30 are operational) at the National Bank of Ethiopia (with 11 public, 13 private, and 17 NGOs). Thus, out of 30, we have considered 19 MFIs (2 public, 1 NGO, and 16 private microfinance institutions) whose head offices are operating in Addis Ababa.

3.2. Data collection method

The primary data was collected from the head offices of financial institutions through a structured questionnaire .In addition, we used unstructured questionnaires to collect primary data from National Bank senior managers. Secondary data were also used to supplement the primary data. It covers from 1994 -2020 for the banking sector, 1996-2020 for the insurance sector, and 2010-2020 for the microfinance sector. The main sources of the data were the NBE, IMF and WB.

3.3. Methods of data analyses

Quantitative and qualitative data analysis methods were adopted to enable a more complete and comprehensive analysis. The qualitative analysis helps investigate operators' perception about the existing financial market performance and policy, expected competition, benefits and losses of opening the financial sector to foreign operators. Descriptive statistics (frequency, percentage and the mean) were used to explore the relative position of domestic financial institutions. Finally, econometric approach has been used to examine the expected effects of financial liberalization in Ethiopia. Total factor productivity can be examined with the following model[5]

$$Y_t = AK_t^{\alpha} \quad \textbf{(1)}$$

Where at time t, Y_t denotes the aggregate, K_t is the investment, while A denotes total factor productivity growth (TFP). Given that TFP is endogenously determined, the endogenous growth literature argues that financial development and bank competition affect growth through capital accumulation and the TFP channel. This channel suggests that an efficient financial system affects growth by facilitating the adoption of modern technology to boost the development of knowledge and technology intensive industries.

A=F (Gcf, HCI, FStab, Fc, FLI, Inf, Ef, FivMob) **(2)**

By substituting equation (2) in to equation (1), we obtain

$$Y_t = Gcf_t^{\alpha_1} HCI_t^{\alpha_2} FStab_t^{\alpha_3} FC_t^{\alpha_4} FLI_t^{\alpha_5} Inf_t^{\alpha_6} Ef_t^{\alpha_7} Fivmob_t^{\alpha_8} \quad \textbf{(3)}$$

By log transformation of equation (3), we obtain:

$$\begin{aligned} LnY_t = {} & \alpha_0 + \alpha_1 LnGcf_t + \alpha_2 LnHCI_t + \alpha_3 LnFStab_t + \alpha_4 LnFC_t + \\ & \alpha_5 LnFLI_t + \alpha_6 LnInf_t + \alpha_7 LnEf_t + \alpha_8 LnFivmob_t + F_{i,t} + T_{i,t} + \varepsilon_t \end{aligned} \quad \textbf{(4)}$$

The coefficientsα_1-α_8 are elasticities of their respective variables, $\alpha_0$is the constant component, t denotes time, ε is the error term and $T_{i,t}$ is a time-fixed effect. Where, Y, Gcf, HCI, FStab, FC, FLI, Inf, Ef, and Fivmob represent real gross domestic product per capita, a ratio of gross capital formation to GDP, human capital index, financial stability, financial competition, financial liberalization index (proxied by the deposit interest rate), inflation rate, financial efficiency index and financial innovations which mobile subscribers represent. Financial stability (Z score=k+μ/σ, where k is equity capital and reserve as a percent of total assets, μ is

[5] Based Bayraktar and Wang (2008) model specifications and including other more relevant variables for Ethiopia.

average net income as a percent of total assets, and σ is the standard deviation of return on assets as an indicator of return volatility) respectively.

4. Discussion and Analysis[6]

4.1. The relative position of Ethiopia's financial institution

This section assessed available financial development indicators in Ethiopia and two other countries from the three continents (Africa, Asia, and Latin America).We considered the economic diversity (low income and high income) and the financial sector's globalization. Indicators of financial sector development, such as access, depth, efficiency, profitability, competition, and stability were considered.

4.1.1. Access to financial institutions in Ethiopia

We used different indicators to investigate the relative position of Ethiopia's financial access to other countries such as ATMs per 100,000 adults, small firms with a bank loan, etc. Except for a few indicators, Ethiopia's access to financial products and services remains below the SSA average. For example, ATMs per 100,000 adults (0.17-Ethiopia, 10.69- SSA and 7.58-Kenya and electronic payments in percent (5.27-Ethiopia, 21.55-SSA and 71.32- Kenya).

Table 1 shows that bank globalized SSA have better banking service access than non-globalized SSA. For instance, on average (from 2005-to 2019), 21 percent of adults have access to bank accounts in countries that open their banking sectors to foreign investors. In contrast, only 12 percent of adults have access to bank accounts in SSA countries, which blocked foreign investors' entry into the banking sector. More people made digital payments in bank-globalized SSA countries (26.62%) than that did not open (14.47%).

Overall, Table 1 shows that allowing foreign banks entry into the domestic banking sector might improve the penetration of the banking industry in the country. This might be because foreign banks come with financial innovations especially for the unbanked society.

[6] A summary of data used for econometric analysis was attached in the appendix section.

Table 1: Financial access

Country	Bank branches per 100,000 adults	Firms with a bank loan or line of credit (%)	Small firms with a bank loan or line of credit (%)	Saved at a financial institution (% age 15+)	Received wages: into a financial institution account (% age 15+)	Credit card ownership (% age 15+)	Made digital payments in the past year (% age 15	Paid utility bills: using a mobile phone (% age 15+)	ATMs per 100,000 adults	Loans requiring collateral (%)
Ethiopia	**1.46**	**24.30**	**16.75**	**19.96**	**2.65**	**0.33**	**5.27**	**0.05**	**0.17**	**85.55**
Botswana	8.67	38.60	30.80	20.34	17.00	9.28	35.92	6.70	31.07	73.75
Kenya	4.58	31.63	25.10	26.75	14.97	5.46	71.32	27.83	7.58	80.50
Indonesia	12.65	22.80	20.90	21.13	7.73	1.51	21.58	1.83	32.35	82.00
South Korea	17.27	.	.	51.65	43.34	58.70	87.04	7.97	260.64	.
Argentina	13.26	43.70	32.00	5.02	16.58	24.16	31.58	1.59	31.62	57.80
Chile	16.18	74.35	68.55	16.18	30.37	26.93	51.72	5.18	54.59	49.00
SSA- G	6.65	22.26	16.76	12.62	8.54	4.03	26.62	5.10	14.03	83.23
SSA –NG	6.16	16.28	12.81	8.83	4.02	2.25	16.47	4.63	7.34	80.98
SSA	6.41	19.27	14.79	10.73	6.28	3.14	21.55	4.87	10.69	82.11
High Income	33.20	47.30	42.51	42.27	46.17	41.99	79.27	8.24	87.41	70.46
Middle income	14.85	34.68	28.58	13.38	14.63	8.28	28.02	3.05	29.80	78.24
Low Income	2.66	18.73	14.24	7.32	3.52	1.70	15.03	3.06	2.68	85.42

Source: Authors' calculations from World Bank global financial development database, 2022

***Note**: SSAG represents bank globalized Sub-Saharan African countries, and SSANG is: Non-bank globalized Sub-Saharan African country.*

4.1.2. Depth of financial institutions in Ethiopia

A common indicator of financial deepening is domestic credit to the private sector as a percentage of GDP. Other indicators used to measure the depth of the financial sector in the economy are listed in Table 2.

Table 2: Financial depth

Country	Deposit money banks' assets to GDP (%)	Nonbank financial institutions' assets to GDP (%)	Financial system deposits to GDP (%)	Life insurance premium volume to GDP (%)	Nonlife insurance premium volume to GDP (%)	Insurance company assets to GDP (%)	Domestic credit to private sector (% of GDP)	Stock market capitalization to GDP (%)
Ethiopia	**28.42**	**3.80**	**31.84**	**0.03**	**0.46**	**0.81**	**18.89**	**-**
Botswana	30.56	4.48	42.00	2.14	0.89	16.71	28.53	-
Kenya	42.65		36.25	0.90	1.20	6.63	30.55	33.31
Indonesia	35.80	4.83	34.68	1.04	0.42	3.74	34.97	41.98
South Korea	118.41	7.22	91.36	6.51	3.96	51.30	132.76	84.86
Argentina	22.38	0.45	19.69	0.45	1.78	3.47	13.53	13.11
Chile	77.06	36.65	49.30	2.46	1.28	19.23	102.23	103.04
SSAG	32.21	23.37	29.65	0.98	0.76	7.53	24.41	63.99
SSNG	44.20	1.35	34.33	0.32	0.54	2.81	14.90	-
SSA	38.205	12.36	31.99	0.65	0.65	5.17	19.655	63.99
High Income	33.20	47.30	42.51	42.27	46.17	41.99	79.27	8.24
Middle income	14.85	34.68	28.58	13.38	14.63	8.28	28.02	3.05
Low Income	2.66	18.73	14.24	7.32	3.52	1.70	15.03	3.06

Source: Authors' calculations from World Bank global financial development database, 2022

As Table 2 shows, the financial depth in Ethiopia from 2005-2020 was very poor. For instance, on average, from 2005-2020, domestic credit to the private sector (percentage of GDP) was about 18.89 percent, which is less than the SSA's average (21.17%) and high-income countries (79.27%). The descriptive evidence for SSA countries shows that countries that open their banking sector to foreign ownership have higher bank service depth (24.41 percent) than countries that block their banking sector to foreign ownership (14.90 percent).

4.1.3. Efficiency of a financial institution in Ethiopia

The financial efficiency ratio is a quick and easy measure of a bank's ability to turn resources into revenue. The lower (higher) the ratio, the better, and an increase in the efficiency (inefficiency) ratio indicates either increasing costs or decreasing revenues. Table 3 shows indicators of bank efficiency, such as bank net interest margin (%) and bank overhead costs to total assets (%). These indicators are lower in the Ethiopian banking sector than in SSA countries. The result shows operational efficiency remains relatively satisfactory compared to SSA's average.

Table 3: Efficiency

Country	Bank net interest margin (%)	Bank lending-deposit spread	Bank overhead costs to total assets (%)
Ethiopia	**5.08**	**3.42**	**3.53**
Botswana	5.22	6.29	3.53
Kenya	8.21	7.78	5.64
Indonesia	5.76	5.02	3.27
South Korea	2.07	1.68	1.68
Argentina	6.58	6.76	6.13
Chile	4.06	3.27	2.45
SSA-G	6.35	10.33	5.44
SSA-NG	7.20	11.16	5.75
SSA	6.78	10.75	5.60
High Income	2.43	4.39	1.92
Middle income	5.35	7.79	4.05
Low Income	6.95	14.22	5.83

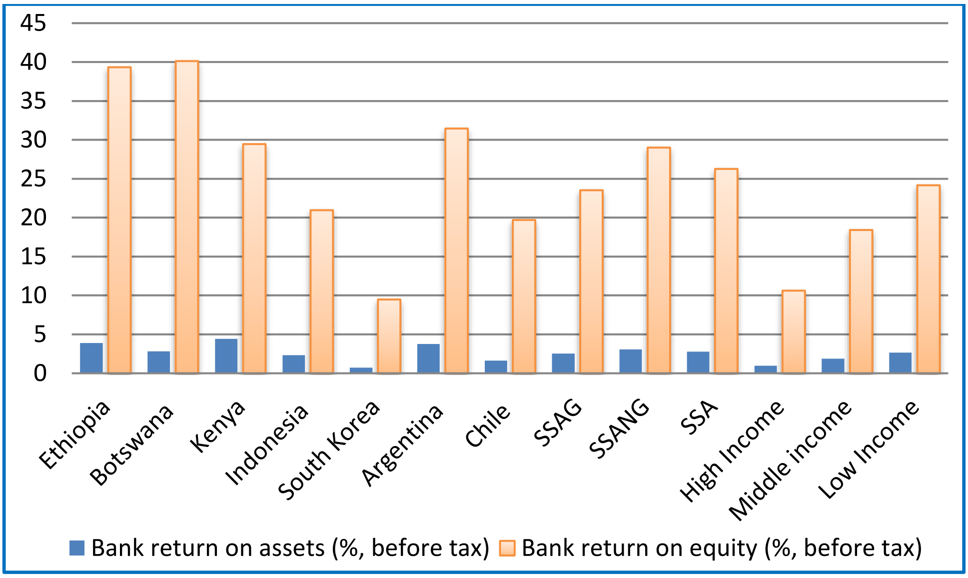
Source: Authors' calculations from World Bank global financial development database, 2022

Table 3 also shows that all indicators are higher in non-bank globalized SSA countries than in bank-globalized SSA from 2005-2020. The result is consistent with empirical evidences (Bayraktar and Wang, 2004 and Hunegnaw and Adem, 2021). However, Hermes and Nhung (2010) revealed that the gains from liberalization were highest for countries that liberalized their stock markets first and the weakest relationship between the performance indicators and the foreign bank is obtained for the countries which liberalized their capital account first.

4.1.4. Profitability of financial institutions

Bank profitability is proxied by return on assets (ROA) and return on equity (ROE). Figure 1 shows that the Ethiopian banking sector profitability is higher than the SSA average. This study also shows that non-bank globalized SSA countries' profitability is higher than bank-globalized SSA countries. Figure 1 also shows that Ethiopia's rate of return (ROA and ROE) is higher than higher-income countries' average, which has the potential to come and invest in Ethiopia if our banking system is liberalized. This shows that the opening up of the financial sector will attract many financial institutions to Ethiopia to come and enjoy this higher return.

Figure 1: Rate of return



Source: Authors' calculations from World Bank global financial development database, 2022

4.1.5. Stability of financial institutions in Ethiopia

The Z-score measures the probability of bank insolvency (bank stability). Table 4 indicates that Ethiopia has better financial soundness (bank Z-score) than the SSA average and the SSA countries that open their banking sector to foreign investors have better financial soundness than those that do not allow foreign ownership of their banking sector. However, this descriptive result is inconsistent with empirical evidences (Demirgüç-Kunt and Detragiache, 2000; De Haas and Van Lelyveld, 2014 and Dwumfour, 2017).

Table 4: Financial sector stability

	Bank Z-score	Bank nonperforming loans to gross loans (%)	Bank regulatory capital to risk-weighted assets	Liquid assets to deposits and short term funding (%)	Provisions to nonperforming loans (%)	Banking crisis dummy (1=banking crisis, 0=none)
Ethiopia	11.98	-		38.83	-	0.00
Botswana	6.73	4.23	19.56	26.13	57.60	0.00
Kenya	20.06	7.45	19.32	24.05	38.81	0.00
Indonesia	4.09	3.13	19.83	26.75	54.34	0.00
South Korea	11.26	0.58	13.95	13.58	70.59	0.00
Argentina	7.35	2.74	16.16	33.09	130.78	0.00
Chile	8.79	1.81	13.26	18.22	133.21	0.00
SSAG	14.39	8.43	18.34	34.64	58.14	0.01
SSNG	14.68	13.02	20.64	49.45	68.93	0.02
SSA	14.54	10.73	19.49	42.05	63.54	0.02
High Income	16.51	4.54	16.26	33.45	58.22	0.08
Middle income	16.97	6.84	17.77	34.78	78.57	0.01
Low Income	13.02	11.65	20.83	45.11	64.80	0.01

Source: Authors' calculations from World Bank global financial development database, 2022

4.1.6. Banking competition

Table 5 provides an overview of the competitiveness and in the banking industries in Ethiopia and shows that banking environment is more competitive than the SSA countries on average. However, Ethiopia's banking environment is less competitive than SSA countries that open banking sector to foreign investors. This might be due to its close-door policy to foreign investors.

Table 5: Bank competition

Country	3-Bank concentration (%)	5-bank assets concentration
Ethiopia	72.28	86.10
Botswana	79.65	96.09
Kenya	50.95	66.96
Indonesia	36.40	48.59
South Korea	67.67	81.99
Argentina	51.04	64.32
Chile	68.92	85.41
SSA	80.44	88.35
SSG	70.96	83.94
SSNG	86.93	92.33
High Income	75.30	84.78
Middle income	67.26	77.64
Low Income	78.05	88.28

Source: Authors' calculations from World Bank global financial development database, 2022

Table 5 shows that bank-globalized SSA countries (83.94%) have lower asset concentration among the top 5 banks than the non-globalized SSA countries (92.33%). From this result, we can conclude that foreign bank presence increases bank competition in the SSA countries' banking sector, but we need to take caution here. Perhaps, other regional differences (for example, general development and regulations) influence the effect of foreign presence and asset concentration on competitiveness and efficiency, as hinted by Claessens and Horen (2014).

Table 5 shows that the overall performance of Ethiopia's financial sector was not satisfactory during the 2005-2020 periods, at least compared to the African average. The result is worst compared to advanced markets. Moreover, bank-globalized SSA countries' overall financial performance was better than non-bank globalized ones.

Table 6: Overall financial sector development

Country	FD Index	FI Access	FI Depth	FI Efficiency	FI Index	FM Access	FM Depth	FM Efficiency	FM Index
Ethiopia	**0.11**	**0.02**	**0.05**	**0.73**	**0.21**	**0.00**	**0.02**		**0.01**
LIC	0.12	0.11	0.07	0.51	0.21	0.01	0.04	0.01	0.02
Adv. Markets	0.59	0.63	0.58	0.63	0.67	0.47	0.49	0.49	0.49
SSAG	0.17	0.12	0.14	0.56	0.26	0.15	0.09	0.14	0.07
SSNG	0.10	0.10	0.06	0.46	0.18	0.00	0.04		0.01

Source: Authors' calculations from World Bank global financial development database, 2022.

4.2. Consequences of financial sector liberalization in Ethiopia

Hence, Ethiopia does not open the financial sector to foreign operators; we can use proxies for liberalization such as interest rate liberalization, efficiency, stability, and competitiveness. We used interest liberalization as a direct proxy for liberalization and other variables, such as efficiency and stability, as an indirect proxy for financial liberation. To control for the macroeconomic variables, the GDP per capita, gross capital formation, human capital index, and inflation rate were used as control variables. The estimation was made for the short-run and long-run effects of financial liberalization. Before estimating the long-run effect, the long-run relationship among variables was checked using the ARDL bound procedure. Table 7 shows the computed F-statistics and critical values at 5 percent. If the statistic lies between the bounds, the test is inconclusive. The null hypothesis of no level effect is rejected if it is above the upper bound. If it is below the lower bound, the null hypothesis of no level effect cannot be rejected. In this estimation, F statistics fall above the upper bounds of critical values at the 5 percent significance level. This result indicates the existence of cointegration among variables.

i. Long-run effect

Table 7 shows that financial liberalization (deposit interest rate) positively affects gross domestic product per capita in the long run. A 1 percent increase in the financial liberation rate (deposit interest rate) increases GDP per capita growth by 0.048 percent but it is not statistically significant. Table 7 shows that the inefficiency variable (EFR) is negatively related to gross domestic product per capita (GDPPC), indicating that when the inefficiency of the banking sector increases by 1 percent, the gross domestic product reduces by 0.044 percent. Many empirical studies (Claessens et al., 2001; Bayraktar and Wang, 2005 and Hunegnaw and Adem, 2021) showed that an increase in foreign bank share reduces domestic banking inefficiency by reducing costs and net interest margins. This result shows that opening the banking sector to the global market may improve economic growth indirectly by reducing banking sector inefficiency.

Another variable of interest, the Z-score as a stability indicator, positively affects the GDP per capita growth. Table 7 shows that as banking stability (the Bank-Z score) increases by 1 percent, the gross domestic product increases by 0.117 percent in the long run, which is statistically significant. Many theoretical and empirical studies agree that when foreign banks' asset share increases in the banking sector, instability increases (Kasman and Kasman, 2015; Mulyaningsih et al., 2015; Demirgüç-Kunt and Detragiache, 2001; De Haas and Van Lelyveld (2014; 2017; and Dwumfour, 2017) .The result may imply that when the banking sector is opened to global operators, banking instability may increase, and gross domestic product per capita will be harmed. Thus, opening the banking sector to foreign owners will indirectly reduce stability and GDP growth through this channel.

Table 7: Estimated long run coefficients

ARDL(1,0,1,0,0,1,0,0,1) selected based on Schwarz Bayesian Criterion
Dependent variable is GDPPC
29 observations were used for estimation from 1991 to 2019

Regressors[7]	Coefficient	Standard Error	Prob
GCFGDP	.219	.057	.001
STAB	.117	.042	.013
HC	.507	.099	.000
FC	-.610	.098	.000
INF	-.037	.009	.001
FLI	.048	.039	.241
EFR	-.044	.012	.002
FIVMOB	.046	.011	.001
INPT	8.991	.568	.000

Testing for the existence of a level relationship among the variables in the ARDL model

F-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
5.9249	2.8474	4.4581	2.3323	3.7400

Source: Authors' calculation based on World Bank development indicators and financial development indicators and IMF Data, 2022

[7] Where GDDPC is gross domestic product per capita (constant 2015 US$); GCFGDP is the share of gross capital formation (% of GDP); STAB is the Bank Z-score proxy for bank stability, HC is the human capital index; Fc represents bank deposits to GDP ratio as a proxy to competition, INF represent inflation rate; FLI represents deposit interest rate; EFR represents efficiency ratio, FIVMOB represents Mobile subscriber per 100 adults.

In the long run, coefficients of control variables such as mobile bank subscription (FIVMOB), inflation rate (INF), human capital (HC), and gross capital formation to GDP ratio (GCFGDP) were found to be statistically significant. As expected, the gross capital formation to GDP ratio (GCFGDP) coefficient is positive and statistically significant and a 1-percentage point increase in gross capital formation ratio to GDP might increase GDP per capita by approximately 0.219 percent. Similarly, human capital index (HC) has an expected positive sign, indicating that a 1 percent increase in the human capital increases GDP per capita by 0.507 percent. The indicator of financial innovation (mobile phone subscribers) also has positive sign.

On the other hand, high inflation rates as signals of macroeconomic instability have an expected negative impact on Ethiopia's gross domestic product per capita (GDPPC). If inflation goes up by one percent, the GDPPC of Ethiopia falls by 0.037.

ii. Short-run effect

Table 8 shows the short-run coefficient and coefficient on ECT. Our error correction system is well-behaved and has a robust long-term relationship. The negative sign of the coefficient on ECT ensures that the series is non-explosive so that long-run equilibrium can be attained.

Table 8: Error correction representation

ARDL (1,0,1,0,0,1,0,0,1) selected based on Schwarz Bayesian Criterion
The dependent variable is Dgdppc
29 observations used for estimation from 1991 to 2019

Regressor	**Coefficient**	**Standard Error**	**Prob**
dGCFGDP	.114	.031	.001
dSTAB	.007	.016	.654
dHC	.264	.061	.000
dFC	-.317	.061	.000
dINF	-.010	.004	.010
dFLI	.025	.019	.206
dEFR	-.023	.008	.007
dFIVMOB	.014	.008	.081
ecm(-1)	-.520	.058	.000

Source: Authors' calculation based on World Bank development indicators and financial development indicators and IMF Data, 2022

The ECT coefficient is −0.520. The value shows a deviation of GDP per capita from long-run equilibrium because the shock from last year is corrected by approximately 52% in the current year. The finding indicates a relatively slow pace of adjustment or convergence to equilibrium.

The short-run elasticities of efficiency and the indirect proxies of financial liberalization to GDPPC, were statistically significant, but the direct proxy for financial liberalization (deposit interest) is not statistically significant. Thus, financial liberalization may improve GDPPC through increased efficiency in the short run. It may reduce GDPPC by reducing financial stability, such as banking fragility, but it is not statistically significant.

Generally, the empirical results in this research support that opening the financial sector to the global market may have both costs and benefits for the Ethiopian economy in both short run and long run. Foreign operators' entry into the financial sector may improve economic growth directly and indirectly by improving efficiency. However, the entry will reduce economic growth indirectly via increasing bank fragility.

Table 9 shows diagnostic test results. The *R2* and R2 are goodness of fit measures, which reasonably suggest a good fit and for heteroscedasticity test, Breusch-Pagan test was employed. The test result shows that we cannot reject the null hypothesis: "the nonexistence of heteroscedasticity. Finally, Breusch-Godfrey serial correlation LM(*X2H*) test results show the absence of serial correlation problem at a 5% significance level". The model also passed the normality Jarque Bera test at 5 percent significance.

Table 9: Diagnostic Tests

Test Statistics	LM Version	F Version
A: Serial Correlation	CHSQ(1)=5.8440[.016]	F(1,15)=3.7856[.071]
B: Functional Form	CHSQ(1)=1.0541[.305]	F(1,15)=.56577[.464]
C: Normality	CHSQ (2)=1.9086[.385]	Not applicable
D: Heteroscedasticity	CHSQ(1)=2.0296[.154]	F(1,27)=2.0318[.165]

A: Lagrange multiplier test of residual serial correlation

B: Ramsey's RESET test using the square of the fitted values

C: Based on a test of skewness and kurtosis of residuals

D: Based on the regression of squared residuals on squared fitted values

Source: Authors' calculation based on World Bank development indicators and financial development indicators and IMF Data, 2022

Figure 2: Model Stability Test

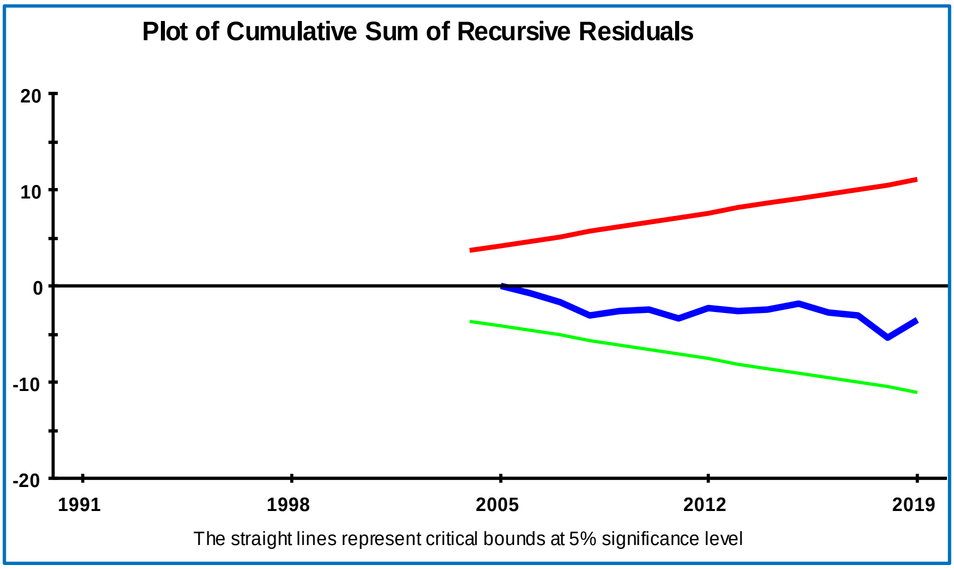


Figure 2 shows the straight lines representing critical bonds at a 5 percent significance level. The CUSUM plot does not cross the critical bounds, shows the model is stable.

4.3. Operators' perceptions on financial sector performance and policy

4.3.1. The Background of financial institutions

We surveyed 51 firms in the financial industry in Ethiopia, of which 16 were banks, 16 were insurance companies, and 19 were microfinance institutions. Forty five (90%) of these firms are privately owned, while the remaining belong to the public (6%), NGO (2%), and public-private partnership (2%) ownership. The average age of financial institutions is 20 years[8].

[8] With regard to individual respondents representing financial institutions, 98% of the individual respondents have attained minimum bachelor's degree. The average age of the individual respondents was 42 years. In addition, the individual respondents have been working in the financial industry for 14 years on average.

Table 10: Background of financial institutions

Backgrounds		N	%	
Type of Financial Sector	Bank	16	31.4	
	Insurance	16	31.4	
	Micro Finance	19	37.3	
	Total	51	100.0	
Ownership type	Public	3	6.0	
	Private	45	90.0	
	NGO	1	2.0	
	Public-Private Partnership	1	2.0	
	Total	50	100.0	
Average Year of Establishment		20		20

Source: Authors' calculation based on primary data survey, 2022

4.3.2. Financial operators' perceptions on performance

As can be seen in Table 11, financial operators generally perceive the current status of the Ethiopian financial sector as inefficient, less competitive, unstable, less innovative, undiversified, not inclusive, and poorly capable. Scholars believe if the financial sector performs poorly in above indicators, the cost of liberalization would be higher than its benefits for domestic firms. In other words, this result implies that the firms in the financial sector are not yet ready to welcome the liberalization policy.

Table 11: Operators' perceptions of Ethiopia's financial sector and policy

	Mean	St. Deviation	N	Max	Min
Efficiency	2.55	.76	51	4.75	1.00
Competition	2.65	.58	51	4.00	1.00
Stability	2.65	.77	51	5.00	1.50
Innovation and diversification	3.07	.73	51	4.50	1.00
Inclusiveness	2.36	1.06	51	5.00	1.00
Capability	2.79	.87	51	5.00	1.00

Source: Authors' calculation based on primary data survey, 2022.

4.3.3. Financial sector operators' perception on policy

As can be seen from Table 12, only 39 percent of respondents either strongly disagreed or disagreed that the National Bank of Ethiopia has the capability required to supervise the financial system, while about 24 percent of them were indifferent. This implies that many respondents perceive that NBE Ethiopia lacks the supervision capability that the financial system demands. Similarly, about 50 percent of the respondents perceived that NBE's operations are not free from political interventions, while only 20 percent perceived the opposite. It is believed that the autonomy of the regulatory body is vital for efficient and effective financial system management.

Table 12: Operators' perceptions on financial sector policy

No		Scale	N	Percent
1	Currently, National bank of Ethiopia has a required capability to supervise the Ethiopian Financial system	Strongly Disagree	5	9.8
		Disagree	15	29.4
		Neutral	12	23.5
		Agree	18	35.3
		Strongly Agree	1	2.0
		Total	51	100.0
2	Ethiopian Financial system regulation should be relaxed	Strongly Disagree	2	3.9
		Disagree	9	17.6
		Neutral	9	17.6
		Agree	23	45.1
		Strongly Agree	8	15.7
		Total	51	100.0
3	The national bank of Ethiopia operates free from political interventions	Strongly Disagree	8	16.0
		Disagree	17	34.0
		Neutral	13	26.0
		Agree	7	14.0
		Strongly Agree	5	10.0
		Total	50	100.0
4	Share of Private ownership should be increased in Ethiopia's financial sector	Strongly Disagree	0	0.0
		Disagree	2	3.9

		Neutral	10	19.6
		Agree	22	43.1
		Strongly Agree	17	33.3
		Total	51	100.0
5	It is better if foreign owners participate in the Ethiopian financial sector with limited share	Strongly Disagree	2	3.9
		Disagree	3	5.9
		Neutral	4	7.8
		Agree	29	56.9
		Strongly Agree	13	25.5
		Total	51	100.0
6	It is better if foreign owners participate in the Ethiopian financial sector without any limitation	Strongly Disagree	16	31.4
		Disagree	22	43.1
		Neutral	3	5.9
		Agree	6	11.8
		Strongly Agree	4	7.8
		Total	51	100.0

Source: Authors' calculation based on primary data survey, 2022

Furthermore, 76 percent of respondents believed that the share of private firms in Ethiopia's current financial sector should be increased. Similarly, about 82% perceived that the share of foreign banks in the current financial sector, if ever allowed, should be limited. Finally, about 75 percent of participants perceived that foreign participation in Ethiopia's financial sector should not be without restrictions. The findings suggest that the current policy guiding the financial sector needs to be revised; the National Bank of Ethiopia lacks political independence, the share of private ownership should be increased; the share of foreign ownership in the financial sector should be to a limited extent, and there should be some restrictions in allowing foreigners to operate in the country's financial systems.

Finally, we asked our respondents to rate their perception on the importance of strict supervision and regulation for the current financial system. About 74 percent of the respondents agreed that strict supervision and regulation are essential for the current financial system. The survey shows that banks and microfinance institutions prefer more strict supervision and regulation than the insurance sector.

Table 13: Regulation and supervision of the financial sector

			N	Percent
Sector	Bank	No	4	25.0
		Yes	12	75.0
	Insurance	No	8	50.0
		Yes	8	50.0
	Micro Finance	No	1	5.6
		Yes	17	94.4
	Total	No	13	26.0
		Yes	37	74.0

Source: Authors' calculation based on primary data survey, 2022

Respondents also identified the following major challenges in the process of regulation and supervision; regulatory body has limited capability to closely supervise and regulate financial system; government hampers fair competition; increasing incidence of corrupt and unethical behaviors in the financial sector; no or little participation of financial actors in process of designing policies, regulations, and directives that govern the financial sector; poor and inconsistent implementation of existing directives and regulations across board; seldom use of appropriate technology in the process of supervision and regulation; politically motivated and frequent changes in directives of the NBE, which make the regulatory environment unpredictable; directives, regulations and supervision are not up to the global standard; supervisory efforts focus on operational issues instead of focusing on strategic issues and many directives are more prohibitive than enabling business activities in the sector.

4.3.4. Inclusiveness, diversification and innovations of financial sector

We asked our respondents to rate the inclusiveness of Ethiopia's financial sector and 68 percent of the respondents rated the inclusiveness of Ethiopia's financial sector as low or very low. More specifically, of those who reported low or very low, about 21 percent were banks, about 21 percent were insurance companies, and 26 percent were from microfinance institutions.

Table 14: Inclusiveness of Ethiopian financial sector

	How do you rate the inclusiveness of Ethiopian Financial Sector?									
	Very-Low		Low		Medium		High		Very-High	
	N	Percent	N	Percent	N	Percent	N	Percent	N	Percent
Bank	3	6.4	7	14.9	5	10.6	1	2.1	0	0.0
Insurance	6	12.8	4	8.5	3	6.4	1	2.1	0	0.0
Micro Finance	5	10.6	7	14.9	5	10.6	0	0.0	0	0.0
Total	14	29.8	18	38.3	13	27.7	2	4.3	0	0.0

Source: Authors' calculation based on primary data survey, 2022

The provision of customer-based, diversified and innovative financial products is crucial to competing in the post-liberalization era, which is expected to be much more competitive. To this end, we asked banks, insurance companies, and microfinance institutions to list the financial products and innovations they currently provide to their respective customers. The result shows that Ethiopian financial institutions' products are currently limited to basic financial products and do not adopt innovations (e-commerce, e-marketing, biometric identifications and remote data processing)[9]. Finally, understanding the major challenges hindering the inclusiveness, innovations and diversification practices of financial institutions in Ethiopia has been identified by respondents, absence of competition, highly scattered rural population, poor infrastructures (internet, power, and roads), low income and

[9] See details in Annex 2-4

high level of inflation, insecurity in remote areas of the country, limited capacity of the financial institutions (technology and expertise), poor strategic leadership, low financial literacy and awareness, collateral-based credit provision, unattractive saving rate and unpredictable directives and restrictive regulations of the government (National Bank of Ethiopia).

4.3.5. Sequences of the liberalization process

To know in what order activities should be done to effectively liberalize the financial sector, we identified five major activities related to the liberalization process and asked our respondents to rank the order of these activities. Table 15 shows as opening up the secondary financial market was ranked first, followed by the liberalization of capital accounts. This finding is in line with the government's steps because the government plans to open the stock market before liberalizing the financial sector to foreign operators.

Table 15: Sequences of the liberalization process

No.	Activities	Mean	Rank
1	Opening of capital market	4.0	1st
2	Liberalization of capital account (offshore borrowing and multiple exchange rate market)	3.0	2nd
3	Liberalization of regulations on reserve ratio and interest rate	2.8	3rd
4	Liberalization of domestic financial sector to foreign investors	2.7	4th
5	Privatization of existing public financial institution	2.6	5th

Source: Authors' calculation based on primary data survey, 2022
Note: (weight: first=5; second=4; third =3; fourth=2; fifth=1)

Similarly, experience of successful economies (South Korea, Indonesia, Botswana and others) and failure economies (Argentina, Chile other South American Countries) in liberalization process tells us, maintaining macroeconomic stability, strengthening capability (NBE, financial institutions), strengthening supervision, and following an appropriate sequence of the financial sector as precondition for liberalization. Based on successful economies experiences, there is no uniformity sequence of liberalization across the board; rather, depending on the context. However, according to Patabendige & Senarath (2014) and Mohammed (2017), the optimal sequence of financial sector liberalization would follow the following order.

Table 16: Optimal sequence of liberalization

Sequence	**Sequence 01** ⇒	**Sequence 02** ⇒	**Sequence 03**
	Liberalizing of the real sector	Liberalization of the domestic financial sector	Liberalization of the external financial sector
Instruments	• Fiscal discipline (stability) • Elimination of implicit and explicit taxes and subsidy • Privatization	• Privatization of the domestic financial system • Creation/reactivation of the money market	• Liberalization of capital account • Creation of foreign currency exchange market and currency convertibility • elimination of control on capital movement

4.3.6. The consequence of financial sector liberalization

To identify the potential benefits and costs of the liberalization policy, we surveyed banks, insurance companies, and MFIs operating in Ethiopia. Accordingly, 98 percent of the respondents agreed that liberalization of the Ethiopian financial sector would benefit by bringing new skills, technology, innovations, and systems; 94 percent of the respondents agreed that financial liberalization improves the sector's service quality; 93 percent of the respondents agreed that financial liberalization may benefit from improving the financial system's infrastructure and 90 percent of the respondents agreed that liberalization makes the financial sector more competitive

Liberalization of the financial system also has costs. As can be seen from the Table 18, about 80 percent agreed that financial liberalization would lead to a fall in the market share of the domestic financial sector; 68 percent agreed that financial liberalization would weaken the local financial institutions; ; about 58 percent agreed that financial liberalization would cause sudden capital outflow; 57 percent agreed that biased credit provision to big firms, 42 percent agreed that financial sector liberalization would trigger supervisory difficulty and about 41 percent agreed that foreign financial firms would promote home country exports instead of domestic exports.

Table 17: Potential benefits of financial sector liberalization

	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
	N	Percent	N	Percent	N	Percent	N	Percent	N	Percent
Bring new skills, technology, innovations and system	0	0.0	0	0.0	1	2.0	17	34.0	32	64.0
Improve financial supervision and regulation	3	6.0	6	12.0	9	18.0	23	46.0	9	18.0
Development of financial markets	1	2.0	2	4.0	9	18.0	20	40.0	18	36.0
Improvement of the financial system's infrastructure	0	0.0	1	2.0	3	6.1	26	53.1	19	38.8
Enhance the overall stability	1	2.0	3	6.1	21	42.9	17	34.7	7	14.3
Competition will be enhanced	0	0.0	2	4.1	3	6.1	23	46.9	21	42.9
Improve quality service	0	0.0	0	0.0	3	6.0	23	46	24	48.0
More credit supply can be offere	0	0.0	3	6.1	11	22.4	20	40.8	15	30.6
Transfer of good institutions practice	0	0.0	1	2.0	12	24.0	24	48.0	13	26.0
Introduce new product and servic	0	0.0	1	2.0	5	10.0	21	42.0	23	46.0

Source: Authors calculation based on primary data survey, 2022

Table 18: Potential costs of financial liberalization

	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
	N	Percent	N	Percent	N	Percent	N	Percent	N	Percent
Weakening of domestic financial sector (infant industry argument)	1	2.0	5	10.0	11	22.0	22	44.0	11	22.0
Foreign financial firm entry may increase operating costs	4	8.0	8	16.0	15	30.0	18	36.0	5	10.0
Sudden capital outflow (foreign shortage)	1	2.1	6	12.5	13	27.1	21	43.8	7	14.6
Domestic misallocation of capital flows	1	2.1	4	8.5	19	40.4	19	40.4	4	8.5
Biased credit provision to big firms	3	6.1	8	16.3	10	20.4	22	44.9	6	12.2
Fall of market share of domestic financial sector	1	2.0	4	8.0	5	10.0	27	54.0	13	26.0
Foreign financial firm will promote home country export instead of domestic export	2	4.1	6	12.2	20	40.8	15	30.6	6	12.2
Financial sector liberalization trigger instability	3	6.0	10	20.0	22	44.0	12	24.0	3	6.0
Trigger supervisory difficulty	4	8.0	6	12.0	19	38.0	14	28.0	7	14.0

Source: Authors calculation based on primary data survey, 2022

4.3.7. Financial operators' and supervisory readiness

The level of readiness of the financial sector to compete with foreign financial operators is very essential to minimize post-liberalization costs. In order to overcome the stiff competition expected from foreign operators, local financial operators need to enhance their competitiveness levels ahead of time. To do so, our respondents suggest: allowing a stock market; digitalization of financial institutions; build up global capabilities in technologies, knowledge and skills; enhancing their efficiencies; hold adequate capital; increase their foreign currency access and reserve; increase research and development budget, focus on continuous improvement; offshore borrowing; being innovative and customer focused; adopt merger and acquisition strategies and enhancing their cyber security system.

Similarly, during interview with key informants (vice presidents of the NBE), they indicated that government is committed and taking the following steps to cop up potential costs of liberalization. These are raising of paid-up capital to 5 billion, allowing banks to borrow from foreign institutions, reducing of surrender requirement except for remittances and exports, set up institutions for training and consultancy, priority of foreign currency is given to import technology, introduction of Basel III, increasing in autonomy of NBE, opening up of interest rate and introducing know your customer system.

5. Conclusion and Policy Implications

5.1. Conclusion

We conducted an in-depth analysis of Ethiopia's financial sector in view of the government's plan to open up the domestic financial sector to foreign operators and the following conclusion are drawn from the findings.

- The current status of financial industry can be characterized as less competitive, less innovative, less diversified, non-inclusive, poorly capacitated and monopolistic competition in nature.
- In both long run and short run, liberalizing the financial sector may improve economic growth directly and indirectly by improving efficiency. However, it may reduce economic growth indirectly by increasing bank instability.
- The current policy framework guiding the financial system needs to be customized to meet the emerging needs of the financial sector in the country; and NBE shall reduce its political dependence.
- Ethiopia's financial sector is characterized by low diversification and innovative products, and no inclusiveness because of population settlement, infrastructure

(road, power, and internet), leadership, technology, financial literacy and awareness.

- Liberalization of the financial sector shall follow a gradual approach with a stable macro economy and strong financial sector as a pre-condition.

5.2. Policy implications

5.2.1. Regulatory and supervisory framework

Before opening up financial sectors to foreign operators, NBE shall articulate prudent but less bureaucratic policies and regulatory mechanisms to ensure the required supervision and leadership capacity to properly manage liberalization. Thus, NBE may revise its directives (foreign currency surrender, extent of share of foreign banks, capital flight, extent of reinvestment) and ensure the merit-based appointment of management. In the pre-liberalization stage, NBE shall also closely supervise and work in supporting domestic financial institutions to build up their management and organizational capabilities. Similarly, in post-liberalization, NBE shall strictly supervise and monitor to ensure the effective implementation of policies and directives in the right sequence and strict regulations on nonperforming loans, reserve ratio, interest rate spread, and capital adequacy.

5.2.2. Capacity building

Capacity development (staff, cyber security, technology and finance) should be a priority task for both the incumbent firms and the supervisory body to reap the benefits and minimize the costs associated with financial liberalization. Hence, the concerned bodies shall work to upgrade their human capital and boost their investment in research and development activities.

5.2.3. Sequence matters

As an African proverb goes on "*Only a fool can test the depth of the water with both feet*". The lessons from successful countries and opinions from local financial operators show that the liberalization of the financial sector shall follow a gradual approach (1st liberalizing of the real sector, 2^{ndly} liberalization of the domestic financial sector and 3rdly liberalization of the external financial sector). Moreover, a stable economy needs to be a pre-condition to open up the financial sector, and it should not be considered a solution to macroeconomic instability.

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Annexes

Annex 1: Summary of Macroeconomic variables related to cost benefit Model

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per capita (constant 2015 US$)	31	410.016	193.779	218.102	826.950
Share of Gross capital formation (% of GDP)	31	1.140	5.497	0.038	30.752
Bank Z-score(Stab)	23	10.941	2.427	6.206	14.465
Human capital index	30	1.241	0.109	1.074	1.455
Bank deposits to GDP FC	31	14.540	0.354	14.436	15.976
Inflation rate	31	0.104	0.093	-0.058	0.335
Deposit interest rate(FLI)	31	6.054	2.292	2.875	11.500
Efficiency Ratio	31	122.915	76.558	11.508	287.645
Mobile subscriber per 100)FIVMOB	22	17.579	19.773	0.010	49.442

Annex 2: Innovations adopted by banks in Ethiopia

		N	Percent
ATMS	No	0	0
	Yes	16	100
Mobile Banking	No	0	0
	Yes	16	100
Internet Banking	No	2	12.5
	Yes	14	87.5
Electronics payment	No	3	18.8
	Yes	13	81.3
Electronics Transfer	No	2	12.5
	Yes	14	87.5
Remittance technology	No	3	20.0
	Yes	12	80.0
Agency banking	No	5	33.3
	Yes	10	66.7
E-commerce	No	6	40.0
	Yes	9	60.0

Source: Authors calculation based on primary data survey, 2022

Annex 3: Innovations adopted by insurance companies

	No		Yes	
	N	**Percent**	**N**	**Percent**
Claim Automation	7	43.8	9	56.3
online insurance	13	81.3	3	18.8
mobile insurance application	11	68.8	5	31.3
E-marketing	14	87.5	2	12.5
Biometrics	13	81.3	3	18.8
ATMS	19	90.5	2	9.5
mobile banking	14	66.7	7	33.3
Network systems automation	9	42.9	12	57.1
remote data processing	14	66.7	7	33.3
Biometrics identification	**18**	**90.0**	**2**	**10.0**

Source: Authors calculation based on primary data survey, 2022

Annex 4: Innovations adopted by Micro finance institutions

	No		Yes	
	N	**Percent**	**N**	**Percent**
ATMS	19	100	0	0.00
mobile banking	14	73.68	5	26.32
Network systems automation	8	42.10	11	57.90
remote data processing	13	68.42	6	31.58
Biometrics identification	18	94.74	1	5.26%

Source: Authors calculation based on primary data survey, 2022

Household Saving Behavior in Rural Ethiopia: Challenges and Policy Options[1]

Hailu Elias[2], Mohammed Beshir[3], and Abule Mehare[4]

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Abstract

Despite remarkable progress in increasing domestic saving over the last two decades, it has been unable to keep pace with investment rates. Hence, it is crucial to identify and implement feasible policies to mobilize more domestic savings to reduce the financial gap. To this end, dependable empirical evidence is imperative. This study aims to identify the major drivers of saving in general, and in-cash and in-kind savings in particular among rural households. We rely on both primary (panel data sets, key informant interviews, and focus group discussions) and secondary (data collected from Micro Finance Institutions (MFIs) and the National Bank of Ethiopia) sources. Descriptive and econometric approaches were employed to analyze the data and answer the research questions posed. The results show that about 75% and 77% of surveyed households saved in formal or informal financial institutions in 2014 and 2022, respectively. Nominal savings per household have increased in the past decade, but most of the improvement has come from in-kind savings which are destined for informal mechanisms. As a result, the main source of finance for rural households, MFIs, faced difficulty meeting the loan demands with their own savings. The rise in inflation, especially in recent years, forced households to reduce cash savings and hold assets. Our econometric analysis shows that ensuring access to formal financial services, financial knowledge, and building trust in formal financial institutions (FFIs) and their services significantly increases cash saving. Therefore, improving access to FFIs and diversifying financial products will improve the rate of savings and therefore, the rate of investment in Ethiopia. The results also show that building trust in the services and products of formal financial institutions (FFIs) can help bring in-kind savings and informal cash savings to formal cash deposits in financial institutions.

Key words: Rural households, savings, Investment, financial institutions
JEL Classification: D14, D15, E21, C23

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[1] We are grateful to the European Union (EU) for funding this research.
[2] Assistant Professor of Economics, Department of Economics, Addis Ababa University, hailu.elias@aau.edu.et
[3] PhD Candidate, Department of Economics, Addis Ababa University, mohabeshir@gmail.com
[4] PhD in Economics and Senior Researcher at EEA

1. Introduction

Savings mobilization is critical for individual and societal welfare (Karlan et al., 2018). For individuals, some of the benefits embedded in savings include hedging against unforeseen circumstances (Chowa, 2006; Karlan et al., 2014; Lugilde, 2018; Demirguc-Kunt et al., 2018), building of assets, tapping investment opportunities (Tekie and Wolday, 2014; Demirguc-Kunt et al., 2018), provision for retirement (Demirguc-Kunt et al, 2018; Lugilde, 2018), purchasing or improving dwellings, to enjoy a sense of independence and the power to do things (Ashraf et al., 2010; Asare et al., 2018), and debt settlements (Rehman et al., 2011; Zwane et al., 2016).

At the macroeconomic level, saving rates strongly predict future economic growth (Karlan et al., 2018). Hence, to reap the aforementioned benefits of savings, there have been strong efforts in place by governments to encourage domestic saving mobilizations.

In Ethiopia, the savings rate was 14.1% in the year 2008/2009, and it has been increasing at an average rate of 7.2% per annum over the last 10 years to reach 24.3% in 2018/19 (NBE, 2020). The contribution of new saving products such as the GERD bond, house savings, and pension contribution was significant to realize the progress (MoFED, 2015; FDRE PSRC, 2018). However, there are still valid reasons to drive domestic resource mobilization beyond its past achievements. First, in recent years, there have been efforts by the government to increase the private sector's role in the national economy beyond its low contribution in the past. This requires mobilizing more private savings since public savings are often used for public investments (UNCTAD, 2007). Second, despite the past effort to improve agricultural output and productivity, the country still faces a large yield gap (Bachewe et al., 2019; Amare et al., 2019; Cepheus R and A, 2021). One of the major explanations for this gap is the low technological adoption rate and intensity of use among smallholder farmers due to financial constraints. For instance, only 30% to 40% of Ethiopian smallholders apply fertilizer, and the application rate is only 37 to 40 kg per hectare, which is far below the recommended rate (Amare et al., 2016).

Smallholder farmers who produce nearly 90% of the country's agricultural production are resource-poor, which limits their investment in productivity-enhancing inputs (Bachewe et al., 2019; Spielman et al., 2013; Belissa et al., 2019). The financial service provision to the agricultural sector is limited in terms of access, quantity, and quality of financial products (CIMMYT, 2015; Desalegn and Yemataw, 2017; National Bank of Ethiopia, 2019). Most financial institutions are concentrated in urban areas, and only a few serve nearly 80% of the country's rural population, which results in low financial inclusion. Demirguc-Kunt et al. (2018) found that only 35% of those aged 15 years and above have accounts in formal financial institutions (FFIs) in Ethiopia, and the majority of those who do not have accounts in FFIs mentioned that absence of these institutions in their vicinity as a major barrier. That is far less than in neighboring east African countries like Kenya, Uganda, and Tanzania, where 80% in Kenya and nearly 50% in Uganda and Tanzania have accounts in FFIs.

In terms of product quality, gaps exist for all major product categories, including credit, savings, insurance, and payments for all major actors in the agricultural sector, including farmers, traders, and manufacturers. In terms of product quantity, the supply of rural finance is far short of the demand, which is partly driven by rural households' poor saving culture in formal financial institutions (Mirach and Hailu, 2014; FDRE PSI, 2018; Demirguc-Kunt et al., 2018; Negeri, 2018; Addis et al., 2019), since they opt to save in kind or cash under the mattress and informal institutions such as 'Iqqub' (Demirguc-Kunt et al., 2018). Saving in kind and cash saved in informal in institutions may not be channeled to entrepreneurs (deficit units in the financial system with feasible business or project ideas), and as a result, such types of savings are mostly less efficient compared to saving in cash and in formal financial institutions (UNCTAD, 2007). To this end, this study was initiated to answer two specific research questions, namely: (i) Why is saving culture low among rural households in Ethiopia? And (ii) what can be done to help farm households save more in cash and in formal financial institutions than they do in kind and through informal methods?

2. Literature Review

2.1. Definition and Institutions of Saving

Household saving is the action of putting aside part of one's current income in order to consume or invest it later on (Gardiol, 2004). This saving can be practiced in kind, such as cattle, grain, jewelry, and so forth, or cash (money). The money saved can be kept as savings deposit in the formal sector (banks, insurance companies, and so forth.), semiformal sector (microfinance institutions, saving and credit co-operatives, and so forth.), and informal sectors such as "Iqqub"[5], "Iddir"[6] or save at home (Fenta et al., 2017).

2.2. Theories of Saving

The amount of savings is calculated as a residual between disposable income and total current consumption. Hence, saving theory is basically consumption theory, and the determinants of saving should be the same as those of consumption (Lugilde, 2018). Accordingly, we have discussed below the standard consumption theories as theories of saving.

A. Life cycle hypothesis (LCH)

This hypothesis states that individuals choose to maximize utility derived from life time resources by allocating them optimally between current and future consumption (Modigliani, 1986). According to this hypothesis, saving is future consumption, and positive saving is motivated by the smoothening of consumption across time as households rationally expect a decline in their income patterns. To this end, individuals borrow in their early ages to acquire education, skills, etc.; save in their middle (working ages) to use it in their old ages (Modglani, 1986). The conclusion is that in addition to household income, the age of the individual also determines saving behavior. Furthermore, it implies that households with a high dependency ratio will have less probability or amount to save as the income will be used either to educate the dependents (in their early years) or for consumption (in their later years).

B. Permanent income hypothesis (PIH)

The PIH enables us to differentiate the components of permanent and transitory income, which in turn helps identify determinants of household saving. *Permanent income* is defined in terms of the long-term income expectations over a planned period and with a constant rate of consumption maintained over the lifetime given the present level of wealth. On the other hand, *transitory income* is the

[5] According to Aredo (1993) Iqqub is a savings association where each member agrees to pay periodically a small sum
into a common pool so that each, in rotation, can receive one large sum and
[6] Iddir is a sort of insurance programme run by a community or a group to meet emergency situations.

difference between actual or current income and permanent income. According to PIH, permanent income determines consumption, and households practice of saving if current income is above permanent income. In this hypothesis, individuals are assumed to not consume from transitory income, so the marginal propensity to save from this income is nearly one (Modglani, 1986).

Generally, the traditional theoretical models discussed above assume that saving behavior by individuals is mainly driven by the desire to balance current versus anticipated consumption (Steinert et al., 2018; Lugilde, 2018) and they are supported by many empirical analyses in rich countries and are robust to varying assumptions (Karlan and Morduch, 2010). However, many empirical works showed that these models are less applicable to Africa and to more collectivist societies (Aron, 2007; Karlan and Morduch, 2010; Steinert et al., 2018). In case of extended families, there is an obligation to care the elderly inter-generationally rather than by the individual which weakens the relationship between age and savings. Morduch and Armendariz (2005) further discussed that the models are designed to describe the behavior of nuclear families. As a result, they poorly predict savings in complex and multigenerational households. In support to this, Demirguc-Kunt et al. (2018) used global FINDEX data base and found that nearly half of adults in high-income economies to have saved for old age, whereas in developing economies, only 16 percent did it for old ages. Furthermore, the above models assume the supply side factors (that is, access/service of financial institutions, and so forth) as given in less developing countries (for example, no constraint in credit access, and so forth) and this poorly captures the reality on the ground because a large proportion of the population especially in rural Africa are out of the outreach of FFIs and their services (UNCTAD, 2020). Therefore, it is vivid from these discussions that a comprehensive analysis of saving and its determinants at micro level has to address a range of factors such as institutional characteristics, difference in cultures, societal factors, and risk behavior.

C. Empirical literature review

Few researches are conducted in Africa, even though the merits of domestic savings deserve more attention and should have been one of the dominant focuses of researchers.

A study on saving behavior among households of teachers, entrepreneurs, and small holder farmers in rural parts of Nakuru, Kenya showed that household saving is significantly determined by income of the household (positively), type of occupation (businessmen save more than teachers and farmers), credit access (negatively), and age of the household (negatively) (Kibet et al., 2009).

Household saving behavior in Ghana was studied by Anang et al. (2009) using a probit model, and they found that demographic variables such as age, sex, and marital status were significant determinants. Contrary to most other findings, household income and education status of respondents weren’t significant determinants of saving among Ghanaian households.

Touhami *et al.* (2009) employed microeconometrics to investigate the determinants of households’ saving in Morocco, and they found that income and saving had strong and positive relationship. Moreover, family size is a significant determinant of household savings only in urban areas, and it is negatively related to saving. Moreover, they found that there is a lack of access to formal financial institutions in rural areas.

Zwane et al. (2016) employed panel data estimation models to identify the determinants of household saving in South Africa. The result of their study revealed that household saving in South Africa is strongly driven by income, age structure, educational achievement, and employment status. Their result about the impact of age on saving is positive, and they noted that their finding validates the life cycle hypothesis. As far as educational achievement is concerned, educated households have higher savings than illiterate ones. Moreover, family size significantly and negatively affects household savings in South Africa. Interestingly, as mentioned above, this paper used panel data, which allows accounting for unobserved differences across households, and the 2SLS estimation technique to overcome the endogenity problem that arises due to simultaneity between income and saving. More specifically, although a rise in an individual’s income might increase savings, higher savings may also result in increased income growth. Estimating such causality would result in a potential endogenity bias, leaving the estimates of both the fixed effect and the random effect biased and inconsistent. They used the lagged value of income as IV while estimating 2SLS. However, variables of the model in this study are more about household attributes and achievements such as income, education, age, and location of the household, and no attempt is made by the researchers to analyze the potential impacts of access, trust, and so forth of financial institutions on household savings in their case study.

A number of research works have been conducted with the objective of identifying the determinants of household saving in Ethiopia. The following table summarizes empirical works carried out on determinants of household saving in Ethiopia. The table presents the case studies, type of data used, methods employed, and major findings. This helps to compare and contrast past efforts easily and also to draw major line of findings.

Table 1: Summary of empirical research works on determinants of household saving in Ethiopia

Author/s & year of publication	Area/case study	Data Type	Method Used	Main Findings (significant variables with the associated impact on saving)			
				Economic Variables/ wealth indicators	Social variables	Financial Institutions	Risk
Addis et al (2019)	South West Amhara	cross section	Ordered probit	Land size (+), Expected income (+), Remittance (-), aid (-), festive expenditure(-)	Education level (+), membership of community based health insurance (+)	Access to FIs (+), Credit access (-)	
Teman & Feleke (2018)	Wolaita and Dawuro Zone, SNNPR (rural HHs)	cross section	Tobit Model	HH income (+), Amount of land holdings (+), Unemployed family member (-)	Age(-)	Distance to FIs(-)	
Teshome et al (2013)	East Hararghe zone-Rural HHs	cross section	Tobit model	Livestock holding in Tlu (+ve), Income(+)	sex (+ve for female), education level (+), contact to extension workers (+)	Access to credit service (+)	
Fenta et al (2017)	Zonal cities of Amhara regional state	Cross section	Logistic Regression	Employment Status (+), Asset from parents(+) & House ownership (+) for owners and renters compared to those who live in Kebele Houses)	Education level (+)		

Mirach & Hailu (2014)	North Gonder Zone-both rural and urban HHs	cross section	Tobit model	Income (+)	age(+), Sex of the head (Higher saving for male headed HHs), Marital status (-ve for those married HHs)	Type of financial institutions used (more saving for those who use formal financial institutions)
Negeri (2018)	Sinana Woreda, Oromia Region	cross section	Probit Regression	Income (+), expenditure (+),	Education status (+), access to extension service (+)	Distance to Fis (-)
Ayenew (2014)	Arba Minch Town	cross section	logistic Regression	HH income (+), ownership of urban agriculture (+)	Family size (-)	Credit access (-)
Yonas & Gebrekirstos (2016)	Dire Dawa City	Cross section	Probit	HH income(+)	Marriage (+), Age (+)	- -
FDRE PSRC (2018)	Urban & rural	Panel	Probit	HH income (+), Productivity level of woredas (+)	Age(-), Family size (+), Education level (+)	Access to MFI in km (+)
Asare et al (2018)	Rural	Cross sectional	Two part model-probit for participation	Land size(+) Bad production season at t-1 (-)	Access to extension(+)	

			and OLS for intensity/amount equation		Market information(+)	
Zeleke & Endris, 2019	Urban & Rural	Cross sectional	Logistic regression	Income(+) Main occupation-not being a farmer(+)	Age of HH head(+) Family size (+) Education (+)	Knowledge of interest rate (+)
Saliya, A. Y. (2018)	Urban (Mekelle City)	Cross sectional	Logistic regression	Income(+) Additional earner in a HH(-)	Female headed HHs(+) Age of HH head(-) Dependency ratio(-)	Prior saving experience(+)
Gonosa et al (2020)	Rural (North Bench district)	Cross sectional	Logistic regression	Number of livestock (+)	Age of HH head(-) Extension service(+) Education level(+)	Access to credit (+) Transaction cost of saving in FFIs (+)
Amha & Tekie (2014)	Rural & Urban	Cross sectional	Heckman selection model	Income(+)	Number of dependents within HH(-) Number of members currently in school (+) Mean age of members of the HH(+) Male headed HHs(+)	

As noted from the above review of empirical works abounding in Ethiopia, saving increases with increases in most wealth indicators (that is, income, land, and livestock ownerships), education level, and access to extension services. However, the impacts of access to FFIs and their services on gender, marital status, and the age of the household head are not conclusive. In our study, we tried to get more evidence on the determinants of savings in Ethiopia by bringing additional variables into the analysis, such as knowledge and trust in financial institutions and their services.

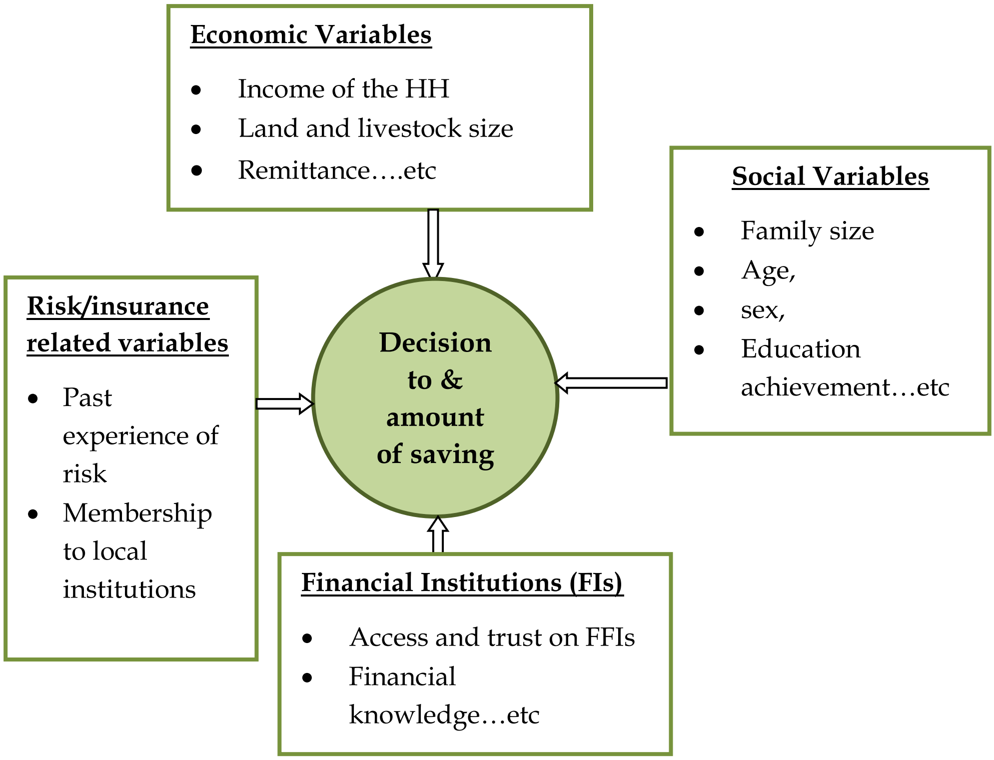
Moreover, almost all micro-level studies in Ethiopia rely on cross-sectional data, but our research work used three rounds of panel data. The use of panel data helps in getting more realistic and robust estimations since it accounts for some of the problems of cross-sectional data such as endogeniety bias and unobserved heterogeneity in a cross-sectional unit (Wooldridge, 2010).

In sum, it is our belief that this study contributes to the existing literature on household saving in Ethiopia in the following ways: ***first,*** in contrast to abundant works in Ethiopia that used cross-sectional data, this study uses a panel data set, which, as mentioned above, gives more robust and accurate coefficient estimates by controlling household heterogeneity in cross-sectional data. ***Second***, in addition to the panel household data, we have conducted FGDs, KIIs, and gathered and analyzed secondary data related to the topic, which provides an in-depth analysis of our research problems in contrast to previous papers that mainly rely on either of the data sources. ***Third***, we attempted to address the determinants of cash and in-kind savings separately since prior efforts, especially factors that affect the latter, are almost nonexistent in Ethiopia. Doing so helps to identify and target those factors that could potentially decrease in-kind savings and boost cash savings in FFIs.

3. Conceptual Framework

On the basis of the theoretical and empirical literature reviewed above, we have developed the following diagrammatic illustration that guides our analysis of the determinants of saving behavior and the amount of savings by rural households in Ethiopia.

Figure 1: Conceptual framework of determinants of rural household savings



Source: Own sketch based on theoretical and empirical reviews on household savings

4. Methodology

4.1. Data types, sources, and sampling method

We mainly rely on three waves of households' panel data to get information regarding the demand and supply side determinants of saving at the household level. The first round survey was conducted in 2014 by the Association of Ethiopian Micro Finance Intuitions (AEMFI). In the second round, the same households were contacted in 2018 by the then-FDRE Policy Studies and Research Center (PSRC) in collaboration with AAU's Department of Economics. The third round was collected by the EEA in 2022, and in each round, 302[16] rural households (that is, a total of 906) are taken. Data was collected from four regions (Amhara, Oromia, SNNPR, and

[16] Actually, the surveys in 2014 and 2018 have covered 1500 & 3005 rural households respectively including those contacted in 2022 by our recent survey.

Afar), and we tried to include households from different agro-ecologies and main livelihoods such as crop and livestock sub-sectors.

Table 2: Sample weights

Region	Percentage	Sample size
Oromia	28.67	87
Amhara	28.67	87
SNNPR	28.33	85
Afar	14.33	43
Total	**100**	**302**

Moreover, we have conducted 8 focus group discussions (2 FGDS in each region) and KIIs with selected community leaders, rural money lenders, and other relevant stakeholders to identify the institutional constraints that hamper savings mobilizations from rural households. Furthermore, we collected secondary data from the National Bank of Ethiopia and the Association of Ethiopian Microfinance Institutions (AEMFI) about the saving trends of commercial banks and microfinance institutions, respectively.

4.2. Methods: Empirics and model specification

According to the random utility model, farmers as rational agents decide to save only if their utilities increase compared to the decision not to save (Cameron and Trividi, 2005). Let $Y_1 \& Y_0$ be utilities expected by farmers from decision to save and not to save, respectively. If $Y_1 > Y_0$, households decide to save, and they don't save when $Y_1 \leq Y_0$.

However, we can't directly observe the utilities, only their decisions, which take a binary value (that is, 1 if the farmer saves and 0 otherwise).

$ss = 1\ if Y_1 > Y_0,$ in terms of probabilities this can be further written as

$P(ss = 1/X) = P(Y_1 > Y_0)$

Hence, our dependent variable is a binary outcome that takes a value of 1 if the household decides to save, in cash or kind and 0 otherwise. The potential models for consideration are the pool of non-linear panel data models (that is, random/fixed effect probit and logit models). Wooldridge (2010) claimed that the popular model for binary outcomes with panel data is the unobserved effects probit model.

Following Wooldridge (2010) and Cameron and Trivedi (2009), let us start from the latent variable model, which is specified as follows:

$$y_{it}^* = x_{it}\beta + \gamma + \overline{x_i}\delta + c_i + e_{it}$$
$$y_{it} = 1\ if\ y_{it}^* > 0$$
$$y_{it} = 0\ if\ y_{it}^* \leq 0$$
$$e_{it} \,\middle|\, x_{it},\ c_i \sim Normal(0, \delta_c^2) \qquad \textbf{(2)}$$

Where

$\boldsymbol{x_{it}}$ contains both time variant and invariant explanatory variables including time dummy, $\boldsymbol{c_i}$ is unobserved random variable and $\boldsymbol{e_{it}}$ is error term. δ_c^2 is the conditional variance of c_i in the first equation and it is assumed that it doesn't depend on x_i.

On the other hand, the amount of saving ($E[y_{it}]$) can be expressed as follows:

$E\ [y_{it}|\ y_i \text{ if observable}] = E\ [y_{it}|\ z^*_i>0]$

$= E\ [X_{it}\beta + \varepsilon_{it}\ |\ z^*_i>0]$

$= E\ [X_{it}\beta + \varepsilon_{it}\ |\ w_i\gamma + u_i>0]$

$= E\ [X_{it}\beta + \varepsilon_{it}\ |u_i>-w_i\gamma]$

$= X_{it}\beta + E\ [\varepsilon_{it}\ |u_i>-w_i\gamma]$

However, $E\ [\varepsilon_{it}\ |u_i>-w_i\gamma] = \rho\sigma_e^2\lambda_i(\alpha_u)$

Thus, $E\ [y_{it}|\ y_i \text{ if observable}] = X_{it}\beta + \rho\sigma_e^2\lambda_i(\alpha_u)$ where $\lambda_i(\alpha_u) = \varphi\ (w_i\gamma/\ \sigma_u)/\Phi\ (w_i\gamma/\ \sigma_u)$

Hence, $E\ [y_{it}|\ y_i \text{ if observable}] = X_{it}\beta + \rho\sigma_e^2\ \ \varphi\ (w_i\gamma/\ \sigma_u)/\Phi\ (w_i\gamma/\ \sigma_u)$.

In this model: φ is the normal density function and Φ is the normal distribution function.

On the other hand, $\lambda_i(\alpha_u)$ is the Inverse Mills Ratio which is estimated in the first stage regression and inserted in the second stage tobit model as an explanatory variable.

4.3. Variables of the model and expected signs

Based on the theoretical and empirical literature reviewed in the previous sections, here below we have presented the variables included in our model with their description, measurement, and expected signs.

Table 3: Variables of the model and expected signs

Variables	Description and Measurement	Expected sign	
		Probability of saving	Amount of saving
Log of household income	Continuous variable and it is the log of total income of the HH for the last 1 year measured in *ETB*	+	+
Family size	Continuous variable and it counts all the members of a HH that permanently lives in the house	+/-	+/-
Distance to the nearest formal financial institution	It is continuous variable and measures in KM the distance between residence of a HH and the nearest financial institution (it is a measure of access to FIs)	-	-
trust on FFIs	It is qualitative measurement (no trust, low, medium and high trust)- we have assigned 0 for those who responded no/low trust and 1 for those who replied medium and high trust on FFIs	+	+
Sex of the HH head	It is dummy variable and has values for Male headed HH = 1 & Female headed HH=0	+/-	+/-
Age of the HH head	It is a continuous variable and it measures age of HH head in years	-	-
Participation in off-farm activities	It is dummy variable and has values equal to 1 if the household Participated in income generating off-farm activities, and 0 otherwise	+	+

Variables	Description and Measurement	Expected sign	
		Probability of saving	Amount of saving
Receipt of remittance by the HHs	It is dummy variable and has values for HHs who received remittance in the last 12 months = 1, if not= 0	-/+	-/+
Financial knowledge of the HHs	It is dummy variable and has values for HHs who have basic financial knowledge about saving products = 1, if not =0	+	+
Land size	It is continuous variable and measures land in ha	+	+
Number of livestock	It is continuous variable and counts the number of livestock a HH owns	+	+
Membership to local institutions	It is dummy variable and has values equal to 1 for those HHs who are members of local saving institutions, and 0 otherwise.	-	-
Agro-ecology	Dega, Woyna Dega, Kola & Desert	+/-	+/-

5. Results and Discussions

5.1. Descriptive analysis

I. Rural saving practice: the bigger picture

As depicted in Table 4 below, MFI's savings has grown on average by 32.53% per annum for a decade. More importantly, the share of voluntary saving has continuously increased to reach 84.71% in 2019. The growth in total savings was higher than the growth in the number of active borrowers, which improved savings per borrower significantly. However, this remarkable growth in saving per borrower was far below the growth of loans per borrower. As a result, the capacity of MFIs to meet loan demand from savings has decreased over time especially in recent years. The growth of the overall financial gap of MFIs is also evident in the last decade, as the difference between total loans and total savings has been growing continuously except in 2014.

Table 4: Ethiopian MFIs Saving Trend, Saving & loan per Borrower (in Million birr)

Year	Compulsory Saving-in million ETB (A)	Voluntary Saving-million ETB(B)	Total Saving-million ETB –C	No of Active Borrowers (D)	Voluntary / Total Saving (%)	Growth of T. Saving (%)	Saving per Borrowers (ETB)-E=C/D	Loan per Borrowers (ETB)-F	Gap per borrower=F-E	growth of gap per client
2010	817.13	1,738.60	2,555.73	2.33	68.03	-	*1,098.81*	2,453.39	1,354.58	-
2011	931.25	2,764.77	3,696.02	2.48	74.80	44.62	*1,489.84*	2,882.96	1,393.11	2.84
2012	1,407.29	4,067.06	5,474.35	2.64	74.29	48.11	*2,075.48*	3,635.71	1,560.22	12.00
2013	2,164.47	5,853.83	8,018.31	3.15	73.01	46.47	*2,545.70*	4,117.37	1,571.67	0.73
2014	2,934.57	8,584.04	11,518.61	3.37	74.52	43.65	*3,422.10*	4,672.81	1,250.71	(20.42)
2015	3,165.79	11,699.09	14,864.88	3.81	78.70	29.05	*3,904.45*	5,374.17	1,469.71	17.51
2016	3,384.16	13,600.69	16,984.85	3.86	80.08	14.26	*4,397.34*	5,867.59	1,470.25	0.04
2017	4,622.97	20,563.27	25,186.25	4.82	81.64	48.29	*5,226.97*	7,166.67	1,939.70	31.93
1018	5,234.12	23,730.05	28,964.16	5.11	81.93	15.00	*5,672.91*	8,491.62	2,818.71	45.32
2019	6,014.12	33,330.10	39,344.22	5.00	84.71	35.84	*7,869.74*	11,001.80	3,132.06	11.12
Average	**3,067.59**	**12,593.15**	**15,660.74**	**3.66**	**77.17**	**32.53**	***3,770.33***	**5,566.41**	**1,796.07**	**10.11**

Source: Association of Ethiopian Microfinance institutions (AEMFIs) & own computation.

II. Rural savings in the study area

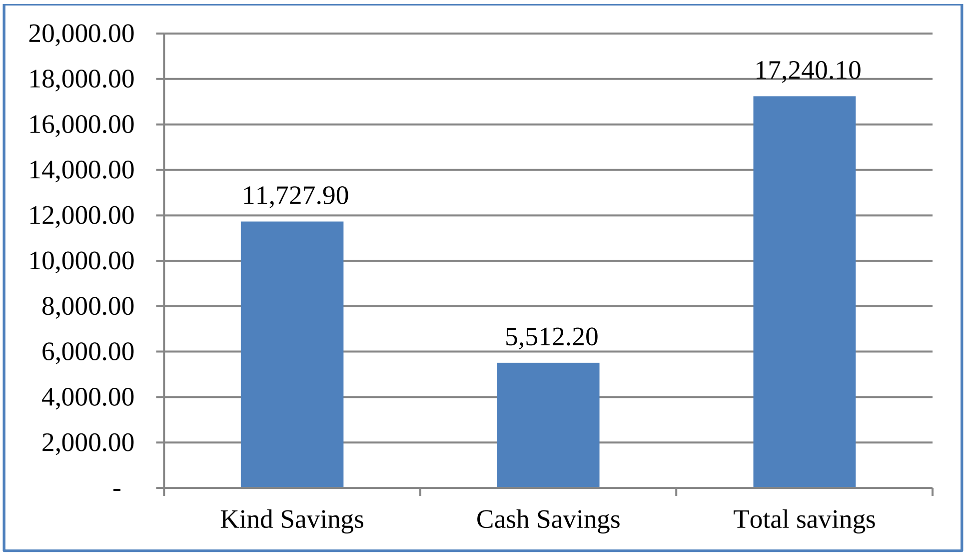
The majority of the households in the study area (72.6%) save their resources either in kind or in cash. For those who saved, the average value of in-kind saving amounted to Birr 11,728 while the cash saving was almost half of that amount (ETB 5,512). The total average savings was, therefore, Birr 17,240 (Figure 2).

Table 5: Saving status/practice

Saving Status	Freq.	Percent
Practice saving	658	72.63
Don't practice saving	248	27.37
Total	906	100

Source: own computation based on panel data

Figure 2: Average saving per HH



Source: Own computation based on panel data

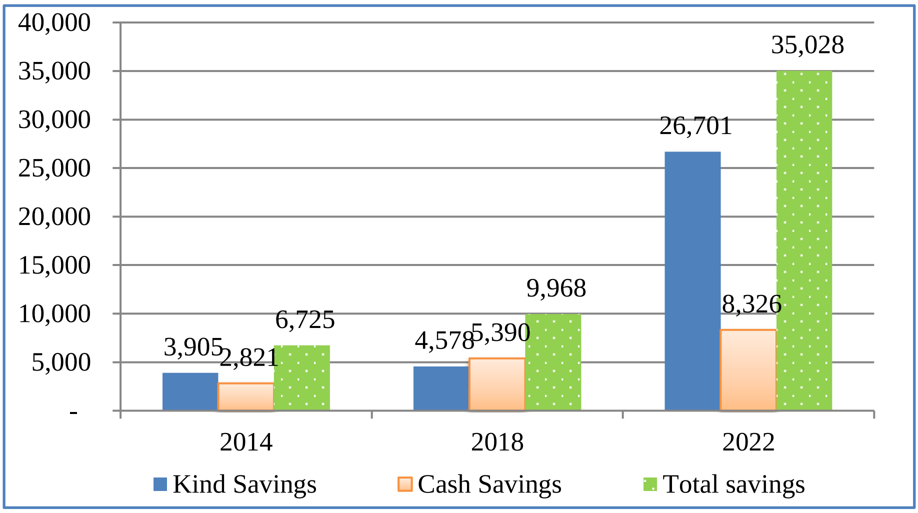
The nominal value of saving of the sampled households has been increasing over the years. The average savings amounted to be Birr 6,725 in 2014, grew to 9,968 in 2018, and reached Birr 35,027.5 in 2022, where the average growth rate was about 20.6%. In real terms, assuming a 25% annual inflation rate, the growth of savings was about 11.9%, which was nearly half of the growth in nominal saving. On the other hand, saving in kind was growing faster than saving in cash, reflecting households' response to the country's growing inflation rate over the years. As a complement to this, in 2022, 35% of those who practice saving said that the previous years' inflation forced them to reduce their savings in cash and resort to in-kind saving, where these figures were 21.6% and 16% in 2018 and 2014, respectively.

Table 6: Nominal vs. real saving over the years

Year	Nominal saving value	Nominal saving value (ln)	Real saving value	real saving value (ln)
2014	6,725	8.814	6,725	8.814
2018	9,967.7	9.207	6,645.133	8.802
2022	35,027.5	10.464	17,513.75	9.771
Growth rate		**20.63%**		**11.96%**

Source: Own computation based on panel data

Figure 3: Cash and in-kind savings over time (mean values)

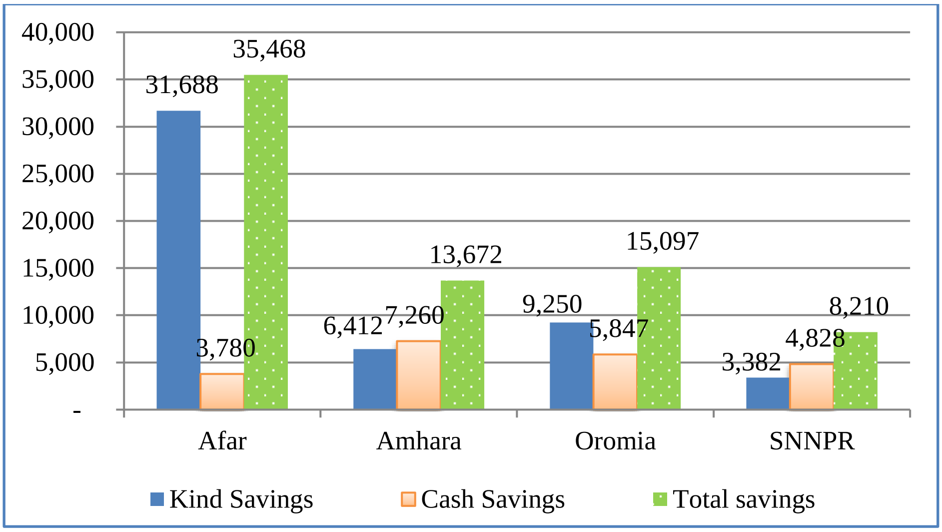


Source: Own computation based on panel data

Those households who saved in kind mentioned that their main motives to save in this form are the expectation of higher returns (62.5%) and protecting their wealth from inflation (15%), whereas cash saving decisions by rural households are mainly driven by safety issues (49.5%) and a high demand for liquidity (47.3%).

Regional savings (that is, both cash and kind savings) seem alike across regions (Fig. 4) with the exception of Afar, where there is a substantially huge amount of kind savings. This may be due to low access to formal financial institutions in the region, which forces households to save more in-kind, and an appreciation of prices for values stored in-kind following a wave of inflation in the country.

Figure 4: Cash and in-kind savings across sample regions

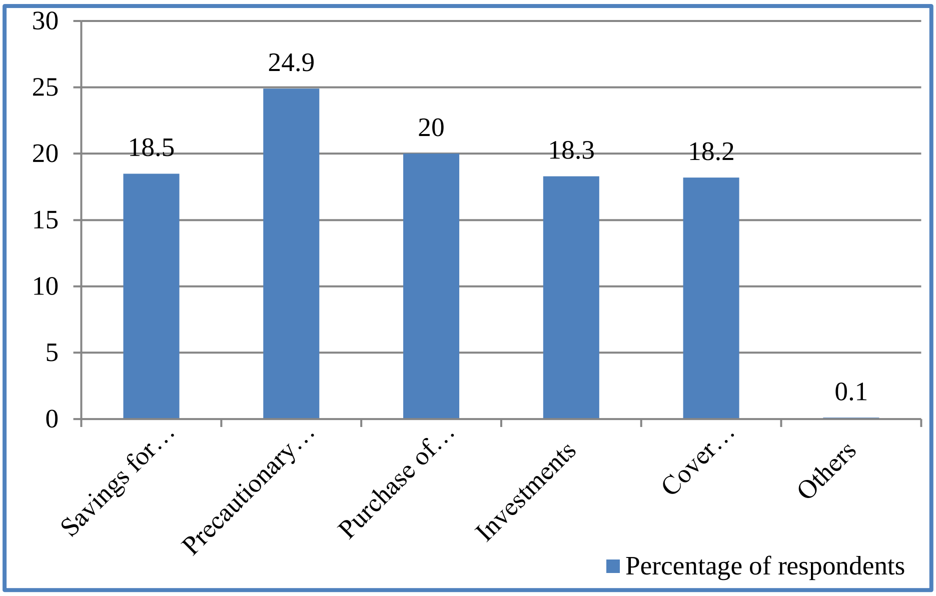


Source: Own computation based on panel data

III. Motives for savings (aggregate-both in kind and cash)

Respondents were asked about what is the most motivating factor for practicing savings in cash and/or kind. Nearly 25% of the respondents replied that the precautionary motive is the main driving force for savings. More specifically, rural households mainly practice saving so that it can be used for mitigating any shocks, if encountered. This is in line with the findings of Saliya (2018) and Gonosa et al. (2020), who noticed that saving is mainly driven by households' desire to overcome unexpected shocks in the cases of Mekelle city (Tigray) and Bench Majji zone (SNNPR), respectively.

Figure 5: Motives for saving (aggregate)



Source: Own computation based on panel data

Furthermore, as shown in the above graph, quite a significant portion of households practice saving to purchase household durables and assets (20%), to smoothen consumption in older ages (18.5%), to invest in profitable businesses (18.3%), and to cover education expenditures (18.2%).

These results have important implications on the role of efficient insurance schemes such as modern health, crop, livestock, and so forth, because a fair uptake of these kinds of products helps to cope with shocks at reduced cost and, in turn, boost, a capital available for investment.

IV. Institutions of rural savings

As far as the institutions for rural saving are concerned, in 2022, 22.6% of savers were using only formal financial institutions, 27.8%, were using informal institutions, and the remaining 49.6% were using both formal and informal financial institutions. Accordingly, we observed that rural households diversify their savings institutions more in recent periods, since only 21.66% of the savers practiced saving in both institutions in 2014 (Table 7).

Table 7: Institutions for rural saving

Institutions for saving	Percentage of savers-2014	Percentage of savers-2022
Formal	39.69%	22.6
Informal	38.65%	27.8
Both	21.66%	49.6

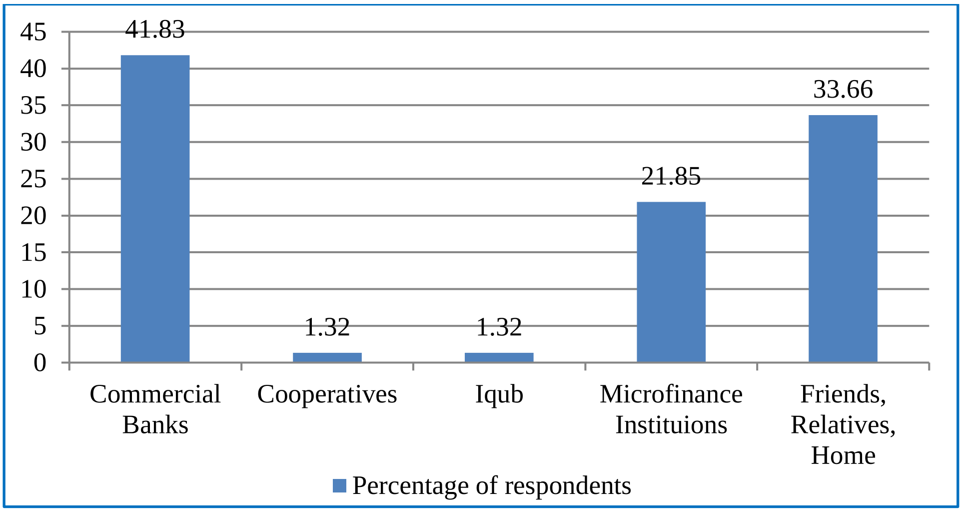
Source: Own computation

In 2022, among those respondents who used to save in informal institutions, 65% and 33.1% of them replied that proximity and ease of access are, respectively, the main drivers for saving in informal institutions. Safety (78%), ease of access (13.9%), and the motive to get other services such as loans (4.3%) are the other factors behind visiting FFIs for deposits.

V. *Trust on various saving institutions*

The level of trust a household has placed in various saving institutions is expected to determine where wealth is stored. We empirically assess the types of saving institutions in which rural households put their maximum trust to keep their savings.

Figure 6: Trust on various saving institutions



If rural households have the resources to save, 41.8% of them opt to deposit money in commercial banks. However, still large percentages of rural households, 33.7%, have the maximum faith in their home, friends, and/or relatives to keep their wealth. The microfinance institutions, which are more committed to providing formal financial services for rural households, stood third with 21.9% of respondents as their first choice.

Moreover, we tried to observe the dynamism, if any, in terms of shifts in trust in depository institutions across time among rural households. Accordingly, as shown in the following table, banks, friends, relatives, and deposits under the mattress have gained more trust in recent periods by rural households, and all these shifts happen at the expense of loss of trust in microfinance institutions[17].

Table 8: Trust on various saving institutions across time

Institutions	2012		2022	
	Number of respondents	percentage	Number of respondents	percentage
Commercial Banks	97	32.1	159	52.6
Cooperatives	4	1.3	3	1.0
Iqqub	3	1.0	6	2.0
Microfinance Institutions	133	44.0	23	7.6
Friends, Relatives, Home	65	21.5	111	36.8
Total	**302**	**100**	**302**	**100**

Source: Own computation based on panel data sets in 2012 & 2022

It requires further assessment why there is deteriorating trust in MFIs, though these institutions are still believed by governments, especially in low income countries where they are highly crucial to efficiently delivering formal financial services to rural households.

VI. Knowledge about saving products of FFIs

The financial knowledge of respondents about saving products was assessed along with the main sources of information for their knowledge. The products were a

[17] It should be noted that the current institutions households deposited their wealth may not be a direct replica of trust on saving institutions because what trusted most may not be accessible to rural households.

savings account, compulsory and voluntary saving, children's savings account, and interest on own savings. Among all products, awareness about saving accounts is the best (56.6%), followed by interest from saving (38.7%). The main sources of information are friends, relatives, neighbors, CBs, and MFIs (Table 9).

Table 9: Sources of financial knowledge

Types of Financial Products	Financial knowledge			Main source of information
	I knew it before (%)	I heard about it (%)	I don't know about it (%)	
Saving account	56.6	25.8	17.5	Friends, relatives, neighbors & CBs, MFIs
Compulsory & voluntary saving	29.5	20.9	49.7	Friends, relatives, neighbors & MFIs
Children saving account	25.5	20.2	54.3	Friends, relatives, neighbors & Radio
Interest from saving	38.7	21.5	39.7	Friends, relatives, neighbors & CBs, MFIs

Source: Own computation based on panel data sets

Furthermore, we observed that in 2012, approximately 52% of respondents had basic knowledge about the meaning, types, and benefits of saving accounts in formal financial institutions. This figure has steadily risen for 10 years to reach 61.6% in 2022.

Table 10: Knowledge of Saving Accounts across time

Description	2012		2022	
	Number of respondents	Percentage	Number of respondents	Percentage
I knew it before	157	52.0	186	61.6
I heard about it	77	25.5	78	25.8
I don't know about it	68	22.5	38	12.6
Total	**302**	**100**	**302**	**100**

Source: Own computation based on panel data sets in 2012 & 2022

We further noticed that there is no significant difference in the source of information across the two aforementioned periods.

5.3. Econometrics results and discussion

a. Determinants of household saving

To understand the determinants of saving behavior of farm households in the study area, initially we run a correlated random effects Probit model using surveys from 2014, 2018 and 2022. However, we found that the coefficients of the average values of the continuous variables, which are added to the model to control for unobserved heterogeneity, are not jointly different from zero. As a result, we estimated random effects probit after excluding these variables. Moreover, we run random effects tobit regression to identify the major determinants of the amount of savings by rural households.

The inverse mills ratio, which is obtained from the participation equation and regressed with other variables in the intensity equation, is statistically insignificant (see Appendix B for details), and hence we run our tobit model excluding the inverse mills ratio. The result is presented in Table 11 below.

Table 11: Econometric estimation of determinants of probability and amount of saving by rural households - (APE)

Explanatory variables	Probability of saving-Random effects regression (probit)		Amount of saving(ln)-Random effects Tobit regression	
	Coefficient	*Delta-method Std. Err.*	*Coefficient*	*Delta-method std. Err*
Family size within a HH	0.01*	0.006	0.117	0.073
Sex of the HH head	0.003	0.041	0.394	0.550
Age of the HH head	0	0.006	0.068	0.083
Square of age of HH head	0	0	-0.001	0.001
Participation in off-farm activity	0.019	0.038	-0.247	0.473
Receipt of remittance	-0.127***	0.045	-2.095***	0.612
Household income(ln)	0.024***	0.005	0.429***	0.067
Basic financial knowledge of HH head	0.13***	0.032	1.804***	0.421
Trust on formal financial institutions (FFIs)	0.015	0.031	-0.212	0.406
Distance measured in KM from FFIs	-0.006**	0.002	-0.073**	0.033
Number of livestock	0.001	0.001	0.022**	0.010
Amount of land size measured in Ha.	0.025	0.016	0.404**	0.188
Membership to local saving institutions	0.003	0.041	0.580	0.489
Ecology_n				
Desert	-0.162***	0.059	-2.063***	0.756
Kola	-0.021	0.052	-0.742	0.692
Woyina dega	-0.009	0.048	-0.730	0.631
Number of obs.		906		906
Uncensored		-		658
Left censored		-		248
Right censored		-		0
LR/Wald chi2(16)		96.7		119.01
Prob> chi2		0		0

****, ** & * shows statistical significance at 1%, 5% & 10% respectively*

A key factor that is found to have a significant effect on households' decisions to save is ***household income.*** A one percent increase in a household's income increases the probability of saving by 2.4%. The result is in line with the findings of Teshome et al. (2013), Mirach and Hailu (2014), Fenta et al. (2017), and Temam and Feleke (2018). Furthermore, for those households that decide to save, a 1% increase in rural income is associated with a 0.43% increase in savings, other things being equal.

Households' ***awareness of formal financial services, especially savings products increased with*** the recent boom in the number of branches of financial institutions across regions in recent years, which increased access to financial services and played a huge role in increasing household awareness. Our regression results also show that, compared to those households who do not have knowledge about financial services, the probability of saving increases by about 13 percent for those who have better knowledge about financial services, and positive impacts are observed on the amount of savings. However, we found that about 50 percent of the households in our study area still have no idea about compulsory and voluntary saving products, indicating the need to work more on raising awareness about different saving products.

From the results, the reader can also note that ***distance*** matters. As households go farther and farther away from formal financial institutions, the transaction cost to save also increases, which is more likely to reduce the probability of saving. Moreover, those households whose residence is far away from such institutions are less aware of the services of formal financial institutions (FFIs), and as a result, they have a relatively lower commitment to save. The regression result also shows that the probability of saving declines by 0.6 percent as distance from formal financial institutions increases by one more kilometer, and this result is significant at 5%. This result is consistent with previous findings by Negeri (2018) and Addis et al. (2019). In relation to distance to FFIs and amount of savings concerned, depending on households' decisions to save, the amount of savings by rural households reduces by 1.8% for each additional kilometer from the nearest FFIs.

Based on the nature, frequency, and behavior of the households', ***receipt of remittance*** affects the probability of saving either positively or negatively. In our case, a receiver of remittance is estimated to reduce the probability of saving by 12.7% compared to those who didn't receive it, and this result is statistically significant at 1%. This may be due to two reasons. First, the remittances are sent occasionally, mostly for emergency purposes, to be spent right away and may not be saved. Second, even though it was sent on a constant basis, households may develop dependency, which reduces the probability and their amount of saving because the receiver usually becomes more or less certain about the next remittance cycle to smooth out their consumption or cope with emergencies. This result is consistent with the findings of Addis et al. (2019).

In addition to the aforementioned variables, the amount of savings by rural households is positively and significantly affected by land size and the number of livestock. More specifically, each additional acre of land and pound of livestock increases the probability of saving by 2.5% and 0.1%, respectively. Moreover, for those rural households that decide to save, the amount of saving increases by 40.4% and 2.2% in response in a one unit increase in land size and livestock. These positive outcomes are a priori expected because both land and livestock holdings are measures of wealth among rural households, and many empirical evidences support the notion that saving rises with wealth. Studies by Asare et al. (2018), Temam and Feleke (2018), and Addis et al. (2019) found that in the country, a larger land area is correlated with more savings. In other studies, Teshome et al. (2013) and Gonosa et al. (2020) showed that savings are higher for households that own more livestock.

b. Determinants of saving in cash and in-kind

Below, we have presented discussions on the results of regression on the determinants of cash (mostly in the formal financial institutions) and savings in kind. As illustrated in the above table, household income, participation in off-farm activities, trust in formal financial institutions, and agro-ecology (that is, desert) affect both cash and in-kind savings significantly. In addition to these variables, saving in kind is significantly affected by family size, knowledge about financial services, distance from formal financial institutions, and the number of livestock and land holdings. The following discussion is based on these findings.

An increase in household income tends to increase the probability and amount of cash and in-kind savings, with a more pronounced impact on the latter. More specifically, a 1% rise in household income results in an increase in the probability of cash and in-kind savings of 1.2% and 3.4%, respectively. This difference in magnitude can be explained by the vivid shift from cash to in-kind savings following the rising inflation of recent periods. As evidence to this, we asked the respondents a hypothetical question about the use of additional income if their current income doubled, and 57.4% of the respondents replied that they would keep it in the form of in-kind savings, whereas 24.18% preferred to deposit the additional income in MFIs, with the remaining eye on boosting their current consumption level.

Table 12: Average marginal effect of cash and kind savings after probit regression

	Probability of saving in cash		Probability of saving in kind	
	Coefficients	**Delta-method Std. Err.**	**Coefficients**	**Delta-method Std. Err.**
Family size within a HH	0.007	0.006	0.012*	0.006
Sex of the HH head	0.046	0.046	0.031	0.047
Age of the HH head	0.003	0.007	0	0.007
Square of age of HH head	0	0	0	0
Participation in off-farm activity	0.077*	0.041	-0.084**	0.04
Receipt of remittance	-0.072	0.051	-0.082	0.051
Household income(ln)	0.012**	0.005	0.034***	0.006
Basic financial knowledge of HH head	0.056	0.036	0.212***	0.034
Trust on formal financial institutions (FFIs)	0.072**	0.034	-0.059*	0.035
Distance measured in KM from FFIs	-0.004	0.003	-0.007***	0.003
Number of livestock	0	0.001	0.002**	0.001
Amount of land size measured in Ha.	0.004	0.016	0.038**	0.016
Membership to local saving institutions	0.011	0.043	0.012	0.041
Ecology_n				
Desert	-0.28**	0.065	-0.21***	0.063
Kola	-0.013	0.059	-0.102*	0.059
Woyina dega	-0.024	0.054	-0.194***	0.054
Number of obs	906		906	
LR chi2(16)	100.48		137.68	
Prob> chi2	0		0	

****, ** & * shows statistical significance at 1%, 5% & 10% respectively*

Participation in off-farm activities increases the probability of saving cash by 7.7%, whereas the impact of the same on the probability of saving in-kind is negative (that is, participation in off-farm activities reduces the probability of in-kind saving by 8.7%). A possible reason for this may be that petty trade is the main form of rural households' off-farm participation, which forces traders to deposit their income mainly in cash to replenish their stock of goods or services quite often.

We expect a higher tendency to save in cash or mainly in formal financial institutions by those households that trust the services of FFIs. On the contrary, low trust or an absence of trust will force households to make in-kind savings. Consistent with this, we found that rural households with medium and high in trust have FFIs have 7.2% higher probability of saving cash compared to those households with low and no trust. Furthermore, better trust in FFIs results in a reduction of in-kind savings by 5.6%. This result signals that increasing outreach and financial awareness alone will not result in the intended change in households' decisions to save. But more work is required in building trust between smallholder farmers and the service providers.

In addition to the above socio-economic factors, in-kind saving is also affected by financial knowledge, distance to FFIs, and the number of livestock and land holdings.

Many households in rural areas are engaged in animal husbandry and farming. The household's income from such activities is determined by the size of its livestock and land holding, respectively. These most important determinants of households' farm income can also have a consequence on a household's decision to save. Income from such activities is usually collected in kind, so if households decide to save, the probability of saving in kind will be high. Teshome (2013) shows the significant and positive relationship between the size of livestock and households' decisions to save and the amount of saving. Our regression results also accord with such findings, and we found that when the size of livestock increases by one, the probability of a household's decision to save in kind increases by about 0.2 percent. When a household's land holding increases by one hectare, the likelihood of the household deciding to save in-kind increases by 3.8 percent. Even though the results of livestock and land holdings are consistent with theory, the impacts of financial knowledge and distance to FFIs on kind savings are at odds with prior expectations. More specifically, knowledge of the services of FFIs increases the probability of in-kind savings by 21.2%. This may be due to the fact that stocks of financial knowledge help rural households not only save but also save in the form of those portfolios with higher returns (that is, save in kind).

We conducted focus group discussions (FGDs) with selected rural households and key informant interviews (KIIs) with managers and senior financial sector experts to assess the existing institutional challenges to mobilize cash savings in formal financial institutions. Accordingly, participants reported that this effort is limited by several supply-and demand-side institutional challenges. On the supply side, inadequate all-weather roads and a lack of internet services in rural areas hinder MFIs and banks from expanding their outreach. Moreover, in some areas, the existing financial products do not fit the demand from the respective farmers. On the demand side, limited financial knowledge about the services and products of formal financial institutions (FFIs), a high cost to reach the nearest FFIs, poor trust in the services and workings of FFIs, and the availability of local and informal financial service providers such as Iqqub, moneylenders, 'Tsewa Mahber', and so forth, have negatively impacted the opportunity to exploit the services of formal financial institutions.

6. Conclusions and Recommendations

Results of the current study show that nominal savings per household have increased in the past decade. However, most of the improvements have come from in-kind savings, which are destined for informal mechanisms. As a result, the major source of finance for rural households (MFIs) has faced difficulty meeting loan demand with mobilized savings. The rise in inflation, especially in recent years, forced households to reduce cash savings (whose real returns are mostly negative) and hold assets whose prices rise with inflation. This calls for the implementation of both fiscal and monetary policies that can reduce inflation. Moreover, lowering prices increases real income for a given nominal income and hence boosts saving, as our finding signals a strong correlation of income with savings.

Furthermore, based on the results of our study, one can suggest that it is possible to channel more savings to formal financial institutions by enhancing access, knowledge, awareness, and trust in these institutions. The results suggest that building trust in the services of FFIs is more crucial, since increasing awareness and outreach alone will not result in the intended outcome of higher savings.

Ensuring access to savings services in rural settings is costly since saving mobilization in such settings requires physical presence in a wider geographic area, which involves higher administrative costs as households residing in a given village save smaller amounts. Hence, innovative approaches such as agent banking, postal banking, and so forth may be potential and feasible options as they can help mobilize savings at a lower cost by avoiding the costly physical presence of FFIs in each village.

Financial education, such as the basic skills of managing expenditure and revenue, knowledge of the services of financial institutions, and so forth, increases the probability of saving among rural households. The role of the government in creating and enhancing financial knowledge is irreplaceable by any of the other actors, such as commercial banks or microfinance institutions. This is because once this knowledge is created, it will be a public good and hence may not compensate those FIs that invested in it. The skills that should be rendered include, among others, income-expenditure management, services and benefits of saving in formal and semi-formal institutions, and so forth.

Directly or indirectly, ensuring access to financial education for rural households improves ***trust*** in these institutions and their services. Moreover, building trust would be more successful if efficient and trustworthy channels of disseminating financial information were identified and targeted.

Last but not least, formal financial institutions should keep an eye on cash deposits by informal financial institutions as a potential resource that can be brought to their accounts through awareness creation and the provision of convenient services to rural households.

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Appendix A: Random effect probit estimation of probability of saving

Variables	Coefficient	Std. err.	z	P>z
Family size within a HH	0.016	0.023	0.69	0.49
Sex headed HH	-0.02	0.14	-0.14	0.889
Age of the HH head	-0.003	0.021	-0.15	0.882
Square of age of HH head	0	0	-0.29	0.77
Participation in off-farm activity	0.034	0.129	0.26	0.793
Receipt of remittance	-0.428	0.152	-2.82	0.005
Household income(ln)	0.077	0.019	4.05	0
Basic financial knowledge of HH head	0.478	0.111	4.31	0
Trust on formal financial institutions (FFIs)	0.07	0.103	0.68	0.496
Distance measured in KM from FFIs	-0.005	0.011	-0.5	0.615
Number of livestock	0.003	0.004	0.79	0.428
Amount of land size measured in Ha.	0.015	0.065	0.22	0.824
Membership to local saving institutions	-0.012	0.138	-0.09	0.93
Ecology_n				
Desert	-0.412	0.212	-1.95	0.052
Kola	0.07	0.197	0.36	0.721
Woyina dega	0.04	0.177	0.23	0.819
Avlny	0.007	0.039	0.18	0.855
Avfmsize	0.041	0.044	0.93	0.353
Avdisffi	-0.035	0.019	-1.9	0.057
Avlivestock	-0.001	0.005	-0.18	0.853
Avland	0.187	0.112	1.67	0.094
_cons	-0.242	0.646	-0.38	0.707
/lnsig2u	-15.14	21.225		
sigma_u	0.001	0.005		
Rho	0	0		

test avfmsize avlny avdisffi avlivestock avland

(1) [savdum]avfmsize = 0

(2) [savdum]avlny = 0

(3) [savdum]avdisffi = 0

(4) [savdum]avlivestock = 0

(5) [savdum]avland = 0

chi2(5) = 7.74

Prob > chi2 = 0.1714

Appendix B: Random effects Tobit regression with inverse mills ratio

Variables	**Coefficient**	**Std. err.**	**z**	**P>z**
Family size within a HH	0.0109	0.1056	0.1	0.918
Sex of the HH head	0.3622	0.5508	0.66	0.511
Age of the HH head	0.0567	0.0835	0.68	0.497
Square of age of HH head	-0.0004	0.0009	-0.49	0.625
Participation in off-farm activity	-0.4296	0.4910	-0.87	0.382
Receipt of remittance	-0.5329	1.2841	-0.41	0.678
Household income(ln)	0.1009	0.2460	0.41	0.682
Basic financial knowledge of HH head	0.2504	1.1997	0.21	0.835
Trust on formal financial institutions (FFIs)	-0.4077	0.4297	-0.95	0.343
Distance measured in KM from FFIs	0.0009	0.0630	0.01	0.988
Number of livestock	0.0121	0.0120	1.01	0.311
Amount of land size measured in Ha.	0.1336	0.2712	0.49	0.622
Membership to local saving institutions	0.4978	0.4925	1.01	0.312
Ecology_n				
Desert	-0.2138	1.5353	-0.14	0.889
Kola	-0.5964	0.6993	-0.85	0.394
Woyina dega	-0.7013	0.6312	-1.11	0.267
Mills	-7.9097	5.7254	-1.38	0.167
_cons	6.6592	5.4711	1.22	0.224

Random-effects probit regression — Number of obs = 906
Group variable: unique_id2 — Number of groups = 302

Random effects u_i ~ Gaussian — Obs per group:
min = 3
avg = 3.0
max = 3

Integration method: mvaghermite — Integration pts. = 12

Wald chi2(16) = 88.94
Log likelihood = -483.62165 — Prob > chi2 = 0.0000

savdum	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
family_size	.0331543	.0195195	1.70	0.089	-.0051032	.0714117
sexdum	.0103116	.1372619	0.08	0.940	-.2587168	.27934
age	.0018791	.0209209	0.09	0.928	-.0391252	.0428833
age_sq	-.0001084	.000204	-0.53	0.595	-.0005082	.0002914
offfarmdum	.0599347	.1261774	0.48	0.635	-.1873684	.3072378
remit_dum	-.4236067	.1504366	-2.82	0.005	-.718457	-.1287564
lny	.0815509	.0161496	5.05	0.000	.0498984	.1132035
knowlefs_dum	.4234927	.1074938	3.94	0.000	.2128087	.6341768
trustfi_dum	.054686	.1020211	0.54	0.592	-.1452716	.2546436
distance_ffi	-.0188183	.0083087	-2.26	0.024	-.035103	-.0025337
numlivestock	.0025509	.0023459	1.09	0.277	-.002047	.0071488
landsize	.0810267	.0526982	1.54	0.124	-.0222599	.1843133
localmeb_dum	.0176289	.1339933	0.13	0.895	-.2449931	.280251
ecology_n						
Desert	-.5104869	.1956804	-2.61	0.009	-.8940134	-.1269604
Kola	-.0718386	.1869463	-0.38	0.701	-.4382466	.2945693
Woyina dega	-.0279187	.1724023	-0.16	0.871	-.365821	.3099837
_cons	-.1646149	.5738667	-0.29	0.774	-1.289373	.9601431
/lnsig2u	-13.8721	26.12362			-65.07344	37.32925
sigma_u	.0009721	.0126974			7.40e-15	1.28e+08
rho	9.45e-07	.0000247			5.48e-29	1

LR test of rho=0: chibar2(01) = 4.1e-05 — Prob >= chibar2 = 0.497

Spatio-temporal Economic Sustainability Convergence in Koga Irrigation and Watershed Project, Amhara Region, Ethiopia

Abebe Belay[1] *, Belay Simane[2], and Ermias Teferi[2]

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Abstract

The spatio-temporal economic sustainability convergence of twelve irrigation blocks in the Koga irrigation and watershed project was tested in this study. Data on technical efficiency were used to examine the expected growth and speed of convergence in order to reach the production frontier and achieve similar economic sustainability. The study used inefficiency parameterizations, convergence theory, and scenario development as a methodology on a survey questionnaire that includes household demography, operational, and farm-specific data in a trans-log stochastic frontier model. The efficiency parameterization was used to identify the level of economic sustainability, and the convergence theory and scenario development were used to calculate the expected growth rate of efficiency and the speed of convergence in years. The main findings are that a household at the project level requires 9.42 percent growth to achieve optimum efficiency over ten years, and a farmer requires 15.46 years if the minimum reasonable growth rate of 6 percent per year is assumed. The findings that policymakers appear to be increasingly emphasizing efforts to improve the efficiency of less efficient farmers rather than investing in new technologies and inputs to ensure higher levels of economic sustainability highlight the critical role of efficiency improvement. Over a five-year period, the economic sustainability catch-up effect requires a growth differential of 2.11 - 9.45 percent. Household size, frequency of consultation visits, male household heads, the sharecroppers' mentality, and non-farm income are thought to facilitate convergence at the frontier while fostering experience sharing towards a similar level of sustainability. On various grounds, the expected growth rate and speed of convergence were discovered to be reasonable targets in the study area. The calculated expected growth rate was very close to what other studies confirmed. As a result of the findings, local governments should consider convergence at the frontier as a long-term plan and catch up for short-term goals.

Keywords: Technical efficiency; economic sustainability; convergence
JEL Classification: O47, R11

[1] CONTACT Abebe Belay; Email: abebe.belay@aau.edu.et
* Addis Ababa University, P.O.Box: 1176 Addis Ababa, Ethiopia
[2] PhD, Addis Ababa University, P.O.Box: 1176 Addis Ababa, Ethiopia

1. Introduction

Ruttan (2002) classified agricultural productivity growth into three stages. The first two stages focused on measuring single-or partial-factor productivity and then total factor productivity (TFP), while the third stage focuses on agricultural convergence tests in productivity and efficiency. The findings of efficiency studies are not limited to calculating technical efficiency in microdata (firm-level), but also involve macrodata and advanced calculation methods, such as efficiency convergence testing (Kneller and Stevens 2003; Carvallo and Kasman 2017). Are farmers producing at maximum capacity? Are farmers held to the same standard of efficiency? Can the farmer catch up to the frontier or others? Are there any successful farmers to emulate? Is it possible to learn from model areas? Coelli et al. (2005) defined efficiency in a more specific context, stating that technical efficiency occurs when producers manufacture different products with minimal input or when they optimize input to produce more products. Inefficiency occurs when production operates within its frontier. Technical efficiency can be measured and may fall short of optimal levels. When this situation arises, there is technical inefficiency. Countries can be thought of as operating on or within the frontier, with the distance from the frontier reflecting inefficiency (Osiewalski et al., 1998).

Technical efficiency change is an indicator of country catch-up and convergence; it is an indicator of a country's performance in adapting global technology, and thus represents the catch-up factor (Rao and Coelli, 1998). Efficiency convergence raises some intriguing questions. (1) the efficiency convergence moment approach, which detects regional efficiencies moving toward or away from the frontier; (2) the efficiency catching up moment approach, which highlights the catching-up effect caused by regions with lower efficiency on regions with higher efficiency; and (3) the efficiency dispersed convergence moment, which shows regions' efficiency convergence to the average level (Purwono and Yasin, 2020). Meanwhile, efficiency convergence takes two forms: convergence among countries (Barro and Sala-i-martin, 1992) and convergence at the frontier (Battese and Coelli, 1995; Kumbhakar and Wang, 2005). Inefficiency occurs in both forms when production operates within the frontier line, which is the most optimal production rate, because output can still be increased using the same technology and input levels.

It is unrealistic to expect a given firm's inefficiency level to remain constant over time. According to Battese and Coelli (1995), time (t) was found to affect the inefficiency rate. If time negatively influences the inefficiency level, efficiency convergence is achieved. In other words, the inefficiency level decreases over the following time and eventually converges to the optimum efficiency level. Over time, a country can become less efficient or more efficient and catch up to the frontier. Growth in efficiency also indicates a more efficient use of existing technology over time. This indicates that there is a trend toward the frontier, which is the optimal value of production. However, the issue of inequalities in agricultural development among countries and regions also continues to capture public attention. Excessive developmental differences in spatial systems are now considered negative characteristics. Ethiopia is no exception to this rule. Regionally, average technical efficiency ranges from 50 percent in the South Nation Nationalities Region (SNNP), the lowest score, to 57 percent in the Amhara regions, the highest score. When we look at the zonal level, there is a significant variation in the average technical efficiency scores of the sample smallholder farmers, which range from 33 to 62 percent. Mekonnen (2013) and Tirkaso (2013) discovered significant variation in location-specific mean technical efficiency, which is consistent with this finding. One of the goals of improving technical efficiency is to achieve spatial convergence. Improving production efficiency at the regional level is often considered a means to reduce regional inequality. Furthermore, the degrees of convergence in different regions and groups of countries are critical. The question is, "When will all of this gap be closed?" It could be the fastest or the slowest. The speed of movement toward the frontier corresponded to the catching-up effect of provinces with lower efficiency scores. As a result, provinces not only successfully catch up in terms of efficiency score but also discourage efficiency inequality among provinces by demonstrating the efficiency score trend over the last 15 years (Purwono and Yasin, 2020). Carlos (2020) conducted yet another study on Indonesian provinces. The efficiency dispersion is decreasing over time. The average Indonesian province is rapidly approaching the frontier (9 percent per year in overall efficiency). On average, the least efficient provinces are catching up to the most efficient ones. Convergence in technical efficiency appears to be the quickest. It is expected to cut its efficiency differences in half over the next 5.6 years.

Finally, means of improving technical efficiency and thus, accelerating the rate of convergence remains a long-standing question in development economics. It would be beneficial to have some sort of experience or best-practice-sharing platform among regions so that smallholders in different locations can increase their productivity to the level of the best-performing farmers. According to Astewale (2018), based on the time-trend variable and estimated level of technical efficiency correlation, lessons from development initiatives' actions in each year must be documented, disseminated using appropriate communication tools, and scaled up to a wider range of farming communities. Further research into the major location-specific causes of such large gaps between the most technically efficient and inefficient stallholder farmers is recommended.

The last few years have given rise to a considerable amount of research analyzing the importance of technical efficiency as both a source of output growth and economic convergence. The rise in productivity issues has been accompanied by economic viability issues among farmers in various areas. Economic sustainability is generally viewed as economic viability; whether a farming system can survive in the long term as during the professional life of the farmer, or across generations is related to durability, that is, the capacity of a farm to be transferred to a successor in a changing economic context may be driven by variability in output and input prices, yields, output outlets, and public support and regulation. Profitability, liquidity, stability, and productivity are the primary indicators of economic viability (Van Cauwenbergh et al., 2007). Farms have been assessed in terms of their economic sustainability using the productivity and profitability of the factors of production (Wrzaszcz and Zegar, 2016). Productivity and efficiency analyses have important implications for the evaluation of their economic viability and sustainability. The measures of efficiency are more accurate than those of productivity in the sense that they involve a comparison with the most efficient frontier. Moreover, efficiency is a relative concept that is measured by comparing the actual ratio of outputs to inputs with the optimal ratio of outputs to inputs. Efficiency, on the other hand, can be technical, allocative, or economic. There is no a priori reason for both technical and allocative types of efficiency to increase or decrease simultaneously, and their relative contributions should not be of equal importance for output growth. It seems difficult, though, to achieve substantial output growth gains at very high levels of technical and/or allocative efficiency (Karagiannis and Tzouvelekas, 2001). The latter also considers how the intervention is distributed or stretched to benefit the community at large, widely seen as the benefit of society in welfare economics (Palmer and Torgerson, 1999). In measuring the efficiency of producers, the focus is mostly on technical efficiency, and achieving technical efficiency is perhaps the utmost concern (Tsionas and

Kumbhakar, 2006). A high technical efficiency measure that ensures the economic viability and sustainability of a farm is a pre-requisite for economic sustainability (Gusmi, 2013). Furthermore, literature shows that technical efficiency has gained relative importance as a measure of economic sustainability in comparison to other indicators. Despite its importance, technical efficiency was studied separately, with no implications for economic sustainability. Despite efforts to investigate technical efficiency and the factors that influence it, the relationship between economic sustainability and technical efficiency has yet to be thoroughly investigated. Little attention has been paid to the role of technical efficiency in economic sustainability and convergence. Our approach addresses a previously overlooked aspect of economic sustainability convergence. Previous research has emphasized the importance of improving efficiency, but it is critical to go deeper to account for economic sustainability and convergence. It has been widely documented that there are technical inefficiencies in production. There have been a significant number of studies on efficiency convergence, but very few on regional and local technological efficiency variations, and none on economic sustainability convergence. They also lacked a detailed analysis of how long it takes for a farmer to become fully technically efficient if they work hard on determining variables and minimize differences with other farmers if the crop grows at a faster rate. The previous literature also lacked information on the expected rate of change in technical efficiency for convergence. However, this study goes beyond identifying farmers' inefficiency by investigating the required efficiency growth rate and time to achieve optimum and comparable economic sustainability across different blocks in the Koga irrigation and watershed project. The variation in efficiency over time is used to predict sustainability (Gomes et al., 2009). In this study, an increase over time indicates improved economic sustainability, indicating temporal convergence. Improvements in technical efficiency enable not only economic growth and prosperity but also the reduction of unnecessary resource waste. This waste of resources is emphasized in our paper in terms of resource availability for future production during a farmer's professional life or across generations related to a farm's ability to be transferred to a successor. Reduced regional inequalities, on the other hand, are critical for long-term development, indicating spatial convergence in economic sustainability in the Koga irrigation and watershed project.

The current study is an attempt to utilize convergence theory to test economic sustainability convergence using technical efficiency values. The overall economic sustainability level at the project level is found to be low, with significant differences between the most economically sustainable and unsustainable households (ranging from 21 to 84 percent) or blocks (ranging from 33-53 percent). and the potential for increasing output with existing inputs and technology without scaling them up, that is, technical efficiency improvement pays off much more in terms of economic sustainability than investing in new technology and utilizing more inputs in agriculture, prompting us to conduct additional research on the following research questions: (1) How much efficiency improvement is required for blocks to achieve an optimal level of economic sustainability?; (2) What is the rate of convergence for each block in order to achieve maximum efficiency or economic sustainability?; (3) What rate of efficiency growth differentials are required for blocks to catch up with the most economically sustainable block?; (4) How quickly does each block reach the most economically sustainable region?; (5) What rate of differential growth in efficiency and speed is required for the cross-over or leapfrogging phenomenon? The study is based on a deductive approach that is designed to answer convergence questions using a convergence theory that defines the relationships between two or more economies. The theory is also known as the catch-up effect in economics, and it primarily addresses the relationship between less developed and more developed areas. It basically states that less-developed areas will grow faster than more developed areas. This progress is primarily due to advanced technologies, production, and establishments in developed areas. Because developing areas lag behind developed areas, they can simply replicate developed areas' technologies, methods, and establishments. Such replications could include utilizing developed areas' production technology as well as implementing their advanced services.

There is a lot of interest in agricultural productivity growth projections. Solid projections for this variable, however, have proven difficult to come by, particularly on a local level in Ethiopia. This is due, in part, to the difficulty in calculating historical productivity growth. As a result, scenario-based analysis was used in conjunction with cross-sectional data. Cross-sectional studies are more common than longitudinal studies because they are easier to conduct. Cross-sectional data, on the other hand, lack the temporal information needed to study the evolution of the underlying dynamics. In order to do so, we create several scenarios that logically assume data from surveys (as in so many real instances). There appear to be few, if any, papers technical efficiency that use panel data to estimate the technical efficiency of Ethiopian smallholders. Despite this, a significant proportion of farm technical efficiency studies in Ethiopia used cross-section data, most likely due to data limitations.

This study demonstrates the convergence of economic sustainability among the twelve blocks of the Koga irrigation and watershed project command areas in terms of the use of technical efficiency. This research is organized as follows: Section 2 introduces relevant literature on technical efficiency and convergence. We begin by defining terms and concepts related to convergence and efficiency measures. They discuss theoretical and empirical literature in the field. Finally, we reviewed other related models, theories, and concepts and demonstrated how our work differs from others. Section 3 provides a brief description of the technical efficiency estimation technique and growth convergence model utilizing an inefficiency parameterization, which we use to validate the problem statement related to convergence theory. Then, we create a scenario and conduct a systematic analysis of the convergence performance of each block. Section 4 presents the major results and discussion, as well as the study's major findings. Section 5 presents the study's conclusion and policy implications.

2. Literature Review

Three major strands of literature can be identified in the analysis of the economic performance of nations (Rao and Coelli, 1998). The first, and most typical, approach focuses on growth in real per capita income or real GDP per capita. This indicator can be considered a proxy for the standard of living achieved in a country. The second approach is to examine the extent of convergence achieved by the poor countries and measure disparities in the global distribution of income. The third and recent approach, which is also used in this study, is to consider productivity performance based on partial measures, such as output per person employed or per hour worked, and multi-factor productivity measures based on the concept of total factor productivity and its components, such as technical efficiency change and technical change. In terms of sustainability, various researchers have attempted to quantify it through various methods and indicators. Some indicators found in the literature to understand economic sustainability are: A cost-benefit analysis was then performed using the indicators of Net Present Value (NPV) and Benefit to Cost ratio (B/C ratio), which can rise even more if producers rely on optimal resource use (Deka and Goswami, 2021). Hepelwa (2013) focuses on technical efficiency, as the ratio between the farmer's actual production and the optimal production to measure sustainability. A significant amount of environmental damage could be avoid if the causes of inefficiency in crop production were addressed. The level of sustainable income was used as a measure of economic sustainability in agricultural enterprises in the study by Bayramoglu et al. (2018). The study defined economic sustainability as the generation of income by an agribusiness that covers its costs: people's livelihood, depreciation, and interest on fixed capital used in production. In terms of the correlation between efficiency and sustainability, Pourzand and Bakhshoodeh (2014) classified regions in Iran into three groups: sustainable, relatively sustainable, and unsustainable. The technical efficiency estimate depicts the potential for environmental improvement by reducing these polluting inputs (Piot-Lepetit, Vermersch, and Weaver 1997). Farmers can achieve both economic and environmental goals by improving the technical efficiency with which they use polluting inputs (De Koeijer et al., 1999). Environmental performance is solely determined by the environmental impact of polluting inputs, whereas reducing the use of polluting inputs (technical efficiency) is one method of improving environmental performance (De Koeijer et al., 2002). As a result, the emphasis on effective input use and sustainability principles must be a fundamental part of agricultural policy in order to incentivize and create a situation in which sustainable resources can be conserved.

Productivity gains are frequently entirely attributed to efficiency gains, while this is frequently incorrect. Agricultural policies tend to emphasize increasing productivity through technological change rather than making better use of existing technology. However, given the limited availability of natural resources such as land and water and the need to reduce agricultural production's environmental footprint, agricultural policies must be rebalanced to improve efficiency. Better use of existing technology may result in equivalent physical productivity gains and possibly even larger economic gains than switching to new technology. The latter may boost productivity temporarily, but at the expense of higher production and environmental costs (FAO, 2017). As a result, higher technical efficiency indicates better economic performance. A high level of technical efficiency is required for economic sustainability. To quantify technical efficiency, several methods can be used. They all follow roughly the same logic: identifying the share of productivity growth caused by efficiency changes by measuring the difference between observed productivity and theoretical, optimal, or average productivity. Measurement methods have traditionally been classified based on whether they rely on assumptions about the functional form of the production frontier: those that are considered parametric, while those that are considered non-parametric. Malmquist-type approaches based on Data Envelopment Analysis (DEA), for example, are non-parametric; whereas, approaches based on econometric estimation of a production function are parametric. Although these methods utilize different approaches of computation and assumptions, it is worth noting that the results are no frequently significantly different. For many agricultural commodities across multiple regions and countries as well as across various production systems and agro climatic regions, production frontier analysis has been widely used to estimate technical efficiency.

Farmers' efficiency differences persisted both within and between years. Reducing technical inefficiencies has always piqued the interest of economists, now it is even more important given the environmental case for lowering emissions and waste. The technical efficiency estimation has been designed to serve primarily two purposes, that is, identifying where farmers are in terms of resource utilization and testing efficiency convergence. The theory of convergence evolved from the Neoclassical Sollow growth model (Sollow, 1956), which asserts that a country's per capita economic growth has a negative relationship with its initial output and income levels. Furthermore, the convergence trend includes income using GDP per capita, inflation convergence, and efficiency convergence, which have been applied across various sectors at the national, regional, and local levels. Meanwhile, efficiency convergence can be divided into two types: convergence among countries (Barro and Sala-i-Martin, 1992) and convergence at the frontier (Battese and Coelli, 1995; Kumbhakar and Wang, 2005). Inefficiency occurs in both patterns when production operates within the frontier line, which is the most optimal production rate, because output can still be increased using the same technology and input levels (Margono et al., 2011). The production frontier is the set of inputs that results in the highest possible output. As a result, the best practice frontier is the production frontier (Charnes et al., 1978). It varies across countries and regions due to differences in the nature, quality, and availability of inputs such as soil quality, precipitation levels, and workforce qualification.

Three types of convergence tests are used to determine the occurrence of global agricultural catch-up and the degree of convergence across different groups of countries. The empirical results of a balanced panel of 126 countries from 1970 to 2014 show that there has been no global agricultural convergence. International trade, irrigation systems, and structural transformation will be used to improve agricultural efficiency and narrow the efficiency gap between countries in the future. On the one hand, groups of lagging countries such as Sub-Saharan African countries, low-income countries, less developed countries, and agriculture-based countries have achieved convergence. This suggests that the gap within each group is closing, which appears to be a good sign of catch up. However, all of the lagging country groups manifested a significant decrease in average efficiency, implying that they are now even further behind advanced countries than they were in 1970. Leaders in these lagging country groups are less efficient, reducing the gap within-group. The findings suggest that more countries are closing at the frontier. As a result, agricultural catch-up can be achieved if lagging countries improve their irrigation systems, international trade, and crop-livestock structure based on relative advantages. Countries with lower agricultural efficiency, on the other hand, may be unable to improve their level of relevant efficiency determinants on their own and thus, fail to close the efficiency gap (Yuan et al., 2021).

Using provincial data from 2002 to 2017, Indonesia's efficiency convergence, as well as catching-up patterns, were accelerating towards the frontier. It has numerous practical implications: one of which is that it can inform economic development policymakers. It could also assess how macroeconomic performances are expanded, either in specific provinces by emphasizing productivity growth or in simultaneous analyses by emphasizing the efficiency convergence point so that proposed policies can be tailored to the specific situation of each province. Furthermore, the findings could highlight Indonesia's current policies, such as investment intensification, allowing Indonesia to serve a model for other developing countries around the world (R. Purwono and M. Z. Yasin, 2020).

A study that looked at relative productivity levels and decomposed productivity change in European agriculture between 2004 and 2013 tested whether or not TFP is converging among member countries. The findings lend support to the productivity convergence hypothesis across a member of countries. Policies should also pay close attention to the learning process as a key driver of differences in TFP levels between countries, particularly, in laggard regions (Barath et al., 2016).

Improving regional production efficiency is frequently regarded as a means of reducing regional inequality. A study of regional efficiency convergence across provinces in Indonesia from 1990 to 2010 found that there is regional convergence in the overall efficiency, pure (technical) efficiency, and scale efficiency measures on average. These regions are more likely to reduce inefficiencies by coordinating inter-regional policies that encourage technology transfer from their closest and most technologically advanced neighbors (Carlos, 2020).

According to a study on Russian agriculture based on data from 75 territorial units from 1993 to 1998 focusing on technical efficiency (TE), there was a growing TE gap between regions. The results show that agricultural technical efficiency and technological progress vary dramatically across regions; there are some regions with a notable positive development of performance (improvement of technical efficiency and or substantial progressive technological change) and a wide range of regions with reverse trends (two digits negative). This demonstrates the existence of divergence in agricultural sector performance. When it comes to the development of efficiency, the initial conditions are the most important. Those regions with favorable initial conditions prosper and their technical efficiencies grow over time, while marginal regions become increasingly inefficient (Uvarovsky et al., 2000).

Different studies in the field with two forms are identified based on a thorough literature search. The first type of study utilizes technical efficiency as an indicator of overall sustainability including the environmental pillar. The studies of Aloyce S. Hepelwa (2013), F. Pourzand and M. Bakhshoodeh (2014), T. J. De Koeijer et al. (2002), and Gomes et al. (2009) can be cited in this category that use efficiency and a combination of two land and labor agricultural productivity measurements to determine sustainability. Despite the identification and discussion of the ecological, technical, social, and economic components of agricultural sustainability, the importance of economic sustainability in achieving total sustainability has been emphasized (Zeki Bayramoglu et. al., 2018). There were some beliefs and the importance of economic sustainability in achieving total sustainability was stressed. However, economic sustainability is not explicitly investigated in the context of technical efficiency in the first category of literature. The second type of study employs indicators other than efficiency to assess economic sustainability (income related variables such as cost-benefit analysis and benefit-to-cost ratio, sustainable income/revenue, permanent income parity and profitability, and partial productivity measures of sustainability). This category includes studies by Deka and Goswami (2021), Zeki Bayramoglu et al. (2018), J. Wisniewska (2011), J. Spicka et al (2019), and W. Wrzaszcz and J. St. Zegar (2016). As a result, our approach, which can be considered unique and a third form of examining efficiency and economic sustainability convergence, attempts to reconcile the two forms further. The current approach in the this study is another method of measuring economic sustainability through technical efficiency, and it emphasizes technical efficiency as the most important factor in economic sustainability convergence. It is based on the concept of crop production, which is the primary source of income for the study area's residents. If the causes of crop production inefficiency are addressed, significant amounts of inputs could be saved for future use. Our study's approach, on the other hand, recognizes this imbalance and takes economic sustainability into account on its own. As a result, our approach seeks to fill methodology gaps in the literature regarding measures of economic sustainability.

3. Methodology and Data Description

3.1. Description of the study area

The Koga River is used for irrigation and sand mining (Dagnew et al., 2014). The river is 64 km long and joins the Gilgel Abbay River after crossing the Debre Markos-Bahir Dar road downstream from the town of Wetet Abbay. The study area, including the irrigation dam site and some irrigation blocks, is given in Figure 1. The Koga irrigation and watershed project, built on Koga River, is an attempt by the government of Ethiopia to develop a large-scale irrigation scheme for rural farmers. It is with the support of the Ethiopian government and the African Development Fund that the construction of the Koga irrigation infrastructure was made so as to irrigate 7004 hectares of land, with the total size of the project being about 10,000 ha (Endrie et al., 2016).

3.2. Data type, source and description

The present study employed a household survey in the case of twelve irrigation blocks of the Koga irrigation and watershed project to understand economic sustainability convergence indicated by technical efficiency convergence. A list of blocks with irrigation potential measured in hectares was prepared prior to the start of data collection for the study. The list was prepared based on information from summarized irrigation block data obtained at the project office. It consists of twelve blocks with different irrigation potentials (see Table 17). The data were collected through a survey questionnaire designed to include household demography, operational, and farm-specific data to put it into a technical inefficiency model on one hand and output, revenue, and factors of production based on microeconomic theory of production to employ them in a trans-log stochastic frontier model for analysis on the other hand (see data type, description, and selection under Table 11). Some variables that proved to be statistically insignificant were ignored and eliminated during the regression process for both stochastic production frontier and technical inefficiency effect models. The accuracy and consistency of surveys form a significant aspect of research methodology. We used test-retest reliability for the questionnaire. This involves administering the survey to a small group of respondents and repeating some questions in the survey with the same group at a later point in time. We then, compare the responses at the two time points.

3.3. Sample size and sampling procedure

Reaching out to all twelve blocks would have been challenging due to the greater distance away from the main dam (it ranges from 3-19.7 km). However, utmost effort has been made to collect survey data from all twelve blocks. To determine the appropriate sample size, the basic factors to be considered are the level of precision required by users, the desired confidence level, and degree of variability. Cochran pointed out that if the population is finite, then the sample size can be calculated using two formulas given below. Where, n0 is sample size given in eq. 1 when population is infinite, z is the selected critical value of desired confidence level, p is the estimated proportion of an attribute that is present in population, q =1-p and e is the desired level of precision. Assuming the maximum variability, which is equal to 50 percent (p = 0.5) and taking the 95 percent confidence level with 5 percent precision, the calculation for the required sample size will be as follows: p = 0.5 and hence q =1-0.5 = 0.5 ; e=0.05; z=1.96 so that n0 = 384. While, the correction formula to calculate the final sample size is given by eq. 2: Here, n0 is the sample size derived from eq.1, and N=12000 is the population size. Since no/N is negligible, n0 =384 is a satisfactory approximation to the sample size. In this case, the sample size (384) less than 5 percent of the population size (12000). So, the researcher does not need to use the correction formula to calculate the final sample size.[3]

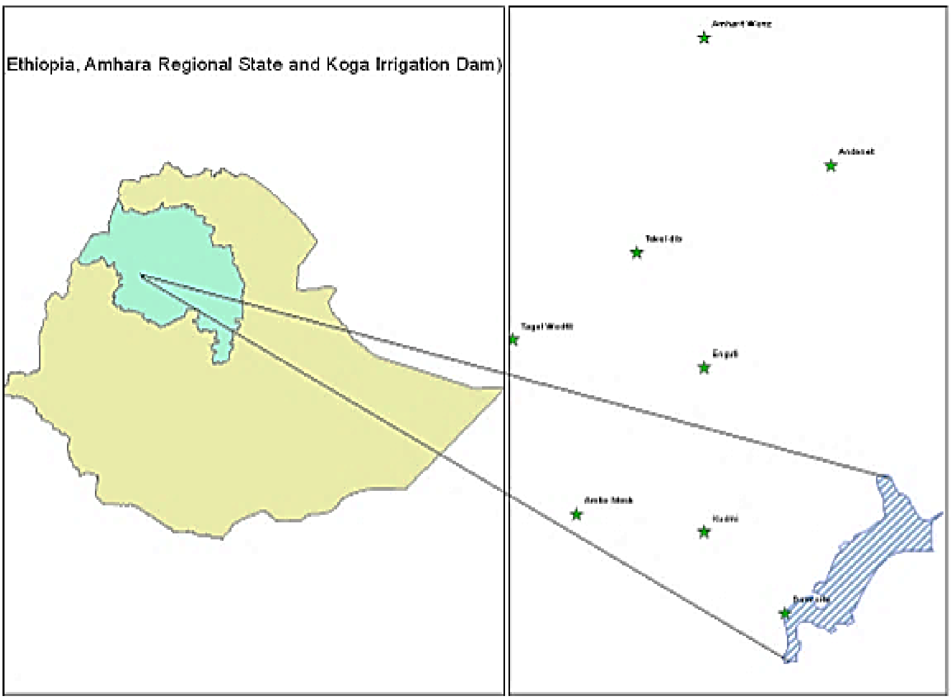
$$n_0 = \frac{z^2pq}{e^2} \tag{1}$$

[3] LaTex typesetting System is utilized to generate all equations, tables and graphs

$$n = \frac{n_o}{1 + \frac{n_o - 1}{N}} \quad \textbf{(2)}$$

Once the sample size is determined using Cochran's formula, the basic factors to consider in determining the appropriate sample size in each block are the estimated 12000 households in the twelve command areas and the irrigation potential of each irrigation block. The irrigation potentials were used to guide the sample allocation procedure in each block. Samples were allocated according to the proportion total hectares of land in each block given in Table 17. Therefore, the sample size in each block and the proportion of the total sample are given in Table 1 and Fig. 2.

Figure 1: Study area (Koga Irrigation Dam, Dam Site and Command Areas)

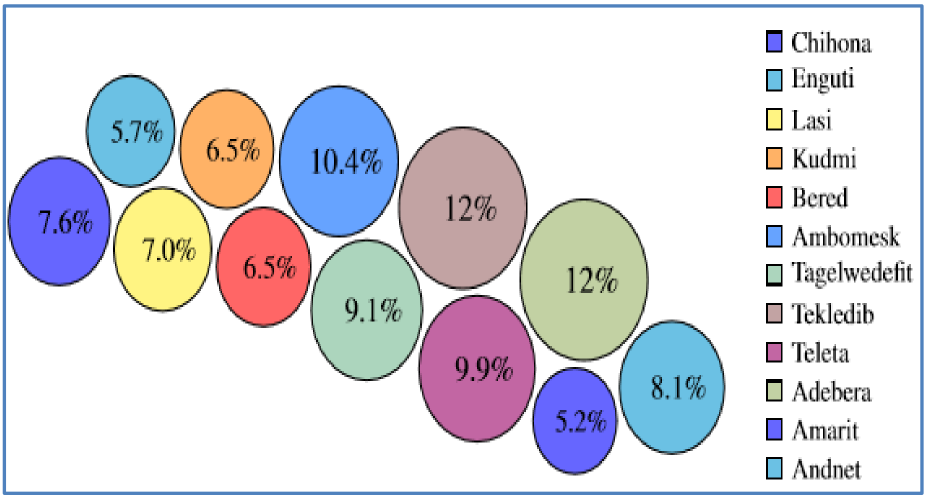


As a result, the largest sample (about 12 percent each) was taken from two regions: Tekledib and Adbera, the two largest irrigation land abundant regions in the study area, based on the stratified random sampling technique adopted based on sample size through the proportional allocation method. Indeed, the Amarit sample represents only 5.2 percent of the total sample size.

Table 1: Proportion of sample size in each block

Block	Sample size	(%)
Bered	25	6.5
Adebera	46	12
Enguti	22	5.7
Amarit	20	5.2
Kudmi	25	6.5
Tekel dib	46	12
Lasi	27	7
Ambo mesk	40	10.4
Andenet	31	8.1
Chihona	29	7.6
Tagel wedefit	35	9.1
Teleta	38	9.9
Total	384	100

Figure 2: Proportion of sample size in each block



3.4. Model specification and estimation techniques

3.4.1. Technical efficiency estimation procedure

The basic Stochastic Frontier Model developed concurrently by two groups of researchers, Aigner et al. (1977), in the first group and Meeusen and Broeck (1977) which considers deviation from the frontier to be due to the effects of technical inefficiency and random noise, was used as an estimation technique for technical efficiency. The true nature of production is stochastic, especially in agriculture. The choice of this technique is made on the basis of the variability of agricultural production, which is attributable to climatic hazards, plant pathology, and insect pests on the one hand, and management inefficiencies on the other.

$$Y_i = f(X_i;\beta)exp(V_i - U_i), i = 1, ...n \quad \textbf{(3)}$$

Based on eq. 3 Yi is the output produced on the i*th* plot/farmer, Xi is a vector of inputs used on the ith plot, and β is a vector of parameters to be estimated. Aigner et al. (1977) proposed stochastic models assuming that the disturbance term has two components, that is, Vi + Ui. The error component Vi represents the symmetrical disturbance that captures random errors caused outside the firms control such as measurement errors, random shock, and statistical noise. The Ui component of the error term is the asymmetrical term that captures the technical inefficiency of the observations and assumed to be independent of Vi, and also to satisfy that Ui ≥ 0. The non-negative component (Ui) reflects that the output of each firm must be located on or below its frontier. Hence, the stochastic production frontier at a technically efficient plot would represent the maximum attainable output (Yi*) as eq. 4:

$$Y_i* = f(X_i;\beta)exp(V_i), i = 1, ...n \quad \textbf{(4)}$$

This can then be used to measure the technical efficiency of all other plots, relative to this efficient plot. The technical efficiency of the plot (TEi) is given by in 5: Where TEi may be defined as the capacity of a producer i to produce relative to a maximum output from a plot using a certain amount of input and available technology.

$$TE_i = [Y_i/Y_i*] = exp(-U_i), i = 1, ...n \quad \textbf{(5)}$$

Before estimating model parameters using the Maximum Likelihood Estimates (MLE) method, the stochastic frontier production function using the flexible Translog (TL) specification in eq. 6 found to be more appropriate than Cobb-Douglas based on log-likelihood ratio test (see : LR ratio test results in Appendix 18).

$$LnY_i = \beta_o + \sum_{k=1}^{n} \beta_k Ln(X_{ik}) + \frac{1}{2} \sum_{k=1}^{n} \sum_{j=1}^{n} \beta_{ij} LnX_{ik} * LnX_{ij} + V_i - U_i \quad \textbf{(6)}$$

Where ln is the natural logarithms, β's are coefficients of parameters to be estimated, Yi is the total value of output. X is are factors of productions, Vi is the idiosyncratic error that arises from measurement errors in input use and/or yield of production and Ui is the non-negative random variables in measuring the technical inefficiency of individual household. lnXik includes the squares and interaction terms of the input variables. The estimation of determinants of technical efficiencies, the inefficiency model (Ui) was estimated based on eq. 7 and the variables given by Table 11.

$$U_i = \delta_o + \sum_{i=1}^{n} \delta_i Z_i + W_i \quad \textbf{(7)}$$

Where, Zi s are various operational and farm specific variables describe70d. Since the dependent variable in eq. 7 is defined in terms of technical inefficiency, a farm-specific variable associated with the negative (positive) coefficient have a positive (negative) impact on technical efficiency. Given different facts explained in literatures which favored one step estimation, the maximum likelihood estimates (MLE) of the parameters of stochastic frontier production function and the inefficiency model were simultaneously obtained. The stochastic production frontier approach is also used to estimate capacity utilization. Full efficiency capacity output (potential yield) was estimated by scaling up actual output by the efficiency score generated from this estimation process (by dividing current output or actual output by the efficiency score) through the following formula in Equation 8.

$$Potentialyield_i = \frac{100}{Technicalefficiencyindex} * Actualoutput \quad \textbf{(8)}$$

3.4.2. Level of economic sustainability

The analysis mostly followed technical efficiency estimation (see Table 12, Table 13, and Table 14), and thereby, compare the economic sustainability of Koga irrigation and watershed project (see Table 15). Furthermore, to understand the economic sustainability level of the project, capacity utilization and inefficiency loss measures using both output and input orientation was performed using indicators of cost (input) saving by considering method from Kibret et al. (2016), output loss measured as proportion of potential output, output growth potential and loss in Millions of Ethiopian Birr (METB) (see: Table 16) . Finally, we used these data to for economic sustainability convergence. Hence, the economic sustainability level in each region is measured by technical efficiency indices during the time. Economic sustainability is the ability of an economy to support a defined level of economic production indefinitely. The core idea is how organizations stay in business by linking economic sustainability with productive efficiency (Jeronen, 2020). Farmers' technical efficiency is a proxy for economic sustainability (Ait et al., 2022). Technical efficiency can be taken to be a universal goal that is applicable in any economic system. On the other hand, allocative and overall economic efficiency presume the objective is profit maximization. The performance standards derived on the assumption of profit maximization should not be used to measure the performance of organizations whose objective functions include other elements than profit. Thus, the proposition that it is valid to estimate a producer's performance in terms of technical efficiency is usually accepted. In particular, measures of technical efficiency rely less heavily on the assumptions of perfect knowledge, perfectly competitive markets, and the profit maximization objective. (Uvarovsky et al., 2000). Hence, the production frontier is reached when available inputs are used optimally. A farm that reaches its production frontier has also reached its maximum level of technical efficiency (FAO, 2017). The production frontier is a theoretical concept and, as noted by Sadoulet and de Janvry (1995), represents the optimal productivity target and has to be compared to observed productivity to measure the degree of technical efficiency (or inefficiency) at the farm-level. Contextually, a farmer is said to be optimally economically sustainable if he reaches the optimal level of efficiency.

3.4.3. Spatio-temporal economic sustainability convergence

In a seminal paper by Kumar and Russell (2002), economic growth convergence can be viewed as countries' movements toward the world production frontier. Economic sustainability in terms of technical efficiency measures is interpreted in the context of growth convergence in this model, and the paper adopted an efficiency parameterization from which the rate of efficiency improvement and speed of convergence for economic sustainability can be assumed and computed. Thus, efficiency improvements are also explicitly related to economic sustainability improvement and convergence in this model.

A block's economic sustainability performance must be compared to a standard or norm. To examine the tendency of blocks to become optimum and two or more blocks to become similar in terms of economic sustainability levels measured by technical efficiency indices, including crossover or leapfrogging phenomena, the identification of each blocks' production frontier and best-practice frontier for analyzing temporal and spatial convergence in economic sustainability was initially done using technical efficiency estimation in Tables 15 and 16. Then, one can start with the relations given by the exponential growth in eq. 9 and eq. 10 concerning the actual level of economic sustainability measured by output per potential output, that is, the technical efficiency of two entities with different initial levels and annual expected average growth rates of efficiency improvement. The exponential growth is used to model various real-world phenomena, such as the population growth of bacteria, compound interest, economic growth, etc. Economic growth is generally modeled exponentially; our economic output grows by a set percentage every year, and while that percentage varies, it also compounds on itself. With a variable that is central to explaining long-run growth: productivity is usually modeled the same way.

$$Y_{t_c} = Y_{o_c}(1 + g_c)^n \quad \textbf{(9)}$$

$$Y_{t_T} = Y_{oT}(1 + g_T)^n \quad \textbf{(10)}$$

As a result, the current study is an attempt to apply the concept of growth and technical efficiency catching up for the temporal and spatial dimensions of economic sustainability convergence by identifying the rate of growth in efficiency improvement and speed of convergence that blocks with low initial levels of economic sustainability grow at such a faster rate in technical efficiency to overtake the level of economic sustainability of the benchmark block or blocks.

The inefficiency term ($Ui \geq 0$) measures the distance from the frontier for each region in the area, and economic sustainability convergence implies a shrinkage of Ui over time. For temporal economic sustainability convergence, Yoc is the initial level of economic sustainability measured by the actual level of income relative to potential or technical efficiency, and YoT is the targeted level of economic sustainability for the accession block, gc is the expected average annual efficiency growth index for the accession block, gT is the expected average growth efficiency at the optimal level of economic sustainability (i.e gT=

0). Therefore, temporal economic sustainability is achieved when the technical efficiency index is one, i.e Fully-efficient. Hence, for temporal seasons, since the target level of economic sustainability is to attain the optimum level where the technical efficiency index is one, convergence is achieved when the Ytc curve exactly touches the optimum economic sustainability line, a value of one, according to Equation 11.

$$Y_{o_c}(1+g_c)^n = 1 \quad \textbf{(11)}$$

Therefore, the temporal economic sustainability methodology tries to answer the following two questions that were put forward to guide the temporal convergence, that is, (1) What rate of efficiency improvement is needed for regions to attain an optimum level of economic sustainability?; (2) What is the speed of convergence for each region to attain an optimal level of economic sustainability?

For spatial convergence, however, Yoc is the initial relative economic sustainability level (that is, relative technical efficiency), YoT is the targeted level for the accession block, gc is the expected average annual efficiency growth index for the accession block, gT is the expected average growth efficiency of the most economically sustainable region. Spatial economic sustainability is achieved when the level of economic sustainability measured by technical efficiency is equal over time. Catch up for spatial is achieved when the values of the two relations become equal and the curves of YtT and Ytc meet at the balance point according to Equation 12:

$$Y_{o_c}(1+g_c)^n = Y_{o_T}(1+g_T)^n \quad \textbf{(12)}$$

By taking the logarithm and rearranging the terms, the time n is usually in years when the economic sustainability balance of two regions or the optimum level of sustainability will be achieved according to eq. 13. This time frame of economic sustainability convergence is determined by the initial or relative level of economic sustainability as well as the growth differential between accession and benchmark regions. This methodology answers the following three convergence question, that is, 1) What rate of growth differentials in efficiency is needed for two or more regions to catch up with the most economically sustainable region in the area? 2) Speed of convergence for each block to the most economically sustainable region? 3) What is the required rate of growth differential in efficiency and speed for the cross-over or leapfrogging phenomenon? To answer each of the spatio-temporal convergence questions, economic sustainability data from Table 15 and the spatio-temporal convergence methodology, including scenario development, were used.

$$n = \frac{log(Y_{oT}) - log(Y_{oc})}{log(1 + g_c) - log(1 + g_T)} \quad \textbf{(13)}$$

3.4.4. Scenario development

Scenario planning enables us to respond to an unknown future in real time. One type of methodology used in this study for forecasting the future expected growth rate of efficiency is scenario development. It is based on a literature analysis of the current situation, the development of informed assumptions about the expected growth rate of efficiency in the future, and government plans. The study's scenarios gain rigor through analysis. We incorporate logic into the analytical process. The scenario development process involves two plans: one for short-term planning (five years) and one for long-term planning (ten years). The short-term strategy corresponds to spatial economic sustainability convergence, whereas the long-term strategy corresponds to temporal economic sustainability convergence.

4. Results and Discussion

4.1. Descriptive statistics

4.1.1. Demographic variables

This section describes the demographic characteristics of the survey's sample respondents, such as age, gender, and household size. The goal of defining those variables is to understand the decision-making environment in which agricultural production takes place. More than 98 percent of respondents are over the age of 30. This indicates that the majority of the sampled farmers are of an active and energetic age, and they are regarded as an economically active force capable of performing its tasks effectively and efficiently. The average number of people in a household was six. Most of them were regarded as being in the labor force. Most rural Ethiopian children under the age of 14 are actively engaged in farming. It did not adhere to the labor force agreement group. In terms of the gender of the household head, 67 percent of the sampled households were male, while the remaining 33 percent were female farmers (see Table 2). This implies that male household heads dominate agricultural production in the survey. This could be because females are more responsible for the care and maintenance of the household and its members, including childbirth and care, food preparation, water and fuel collection, housekeeping, and family health care, than agricultural activity. Even when men and women are engaged in productive activities, their responsibilities and functions frequently differ.

Table 2: Socio-economic characteristics of farmers

S.N	Characteristics	Number	Proportion %
1	Average land size (hectare)	1.39	
2	Average household size(number)	6	
3	Male household head	257	66.9%
4	Age of household head	Number	Proportion %
	(a) ≥30	379	98.7%
	(b)≥40	323	84%
	(c) ≥50	132	34.4%
	(d) ≥60	27	7%
5	Average year of schooling for head	1.33 years	
6	Off-farm income	192	50%
7	Manure	217	56.5%
8	Water & soil conservation	203	52.8%
9	Membership in farmers' association	238	62%
10	Access to credit	58	15%
11	Land tenure arrangement	Number	Proportion %
	(a)Own land	314	81.8%
	(b) Rented land	55	14%
	(c) Own & rented land	3	0.8%
	(d) Sharecropping	12	3%

4.1.2. Socioeconomic variables

The average total land size of the households sampled was approximately 1.39 hectares. The irrigation blocks with the most and least irrigation land abundance, respectively, are Tekledib (864 hectares) and Amarit (290 hectares) (see Table 3). The Tekledib block has the highest proportion of land (12.3 percent) of the total potential 7004 hectares of irrigation land in the Koga irrigation and watershed project, while the Amarit block has the lowest (4.2 percent) (see Figure 3). The 384 households studied to collect farm and household-related variables for estimation farm on approximately 533.13 hectares, or 7.6 percent of the total potential of 7004 hectares of irrigation land. The highest proportion of sample farm land size, approximately 13.8 percent, was found in the Tagelwedefit region, and the lowest, approximately 5.1 percent, was found in the Enguti and Amarit regions (Figue 4). Table 3 also shows the total landarea in hectares investigated in each block. When technical efficiency values and land size were considered, the results of correlation tests revealed a weak correlation. When the Pearson coefficient value is less than 0.29, it is said to be a small correlation. Spearman rho's and Kendal-tau correlations were also weak (Table 20 in the Annex Part). As a result, there was little evidence to support the positive correlation between land size and efficiency improvement (Figure 5). The land size has a negligible effect on the economic sustainability level. Off-farm income is critical for contributing to agricultural product production in Ethiopia. Off-farm income activity participation was obtained by 50 percent of the sampled farmers. This demonstrates that farmers participated in off-farm income-generating activities in a moderate manner. In terms of education, the average year of schooling for a household head was approximately 1.33 years.

The majority, if not all, of the sampled farmers are not receiving formal education, with only a small percentage receiving basic education. Manure is a major input for crop production in the area. The majority of farmers (56.5 percent) used various fertilizer combinations, including organic fertilizer. In terms of farming management, they used various water and soil conservation mechanisms, even though farmers had fertile or good soil, in order to become more productive. This implies that the majority of farmers (52.8 percent) use good soil conservation practices in the study areas. During the survey, only 15 percent of respondents had access to credit. The majority of farmers (81.8 percent) were engaged in farming using only their own irrigated lands. The majority of farmers were members of farmers' associations (see Table 2).

Figure 3: Proportion of irrigation land in each block

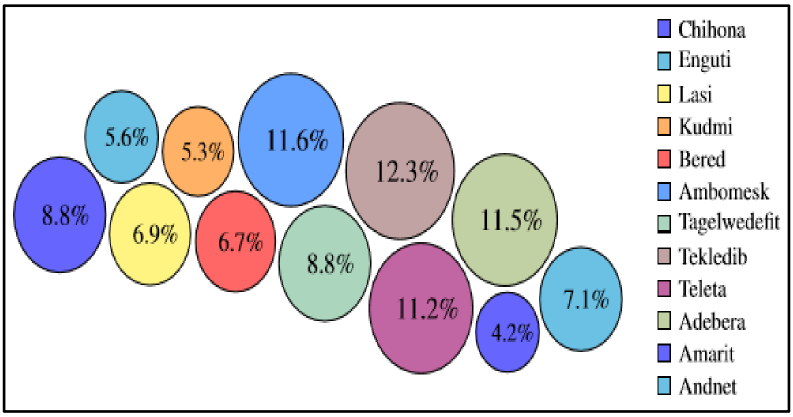


Figure 4: Proportion of sample land size in each block

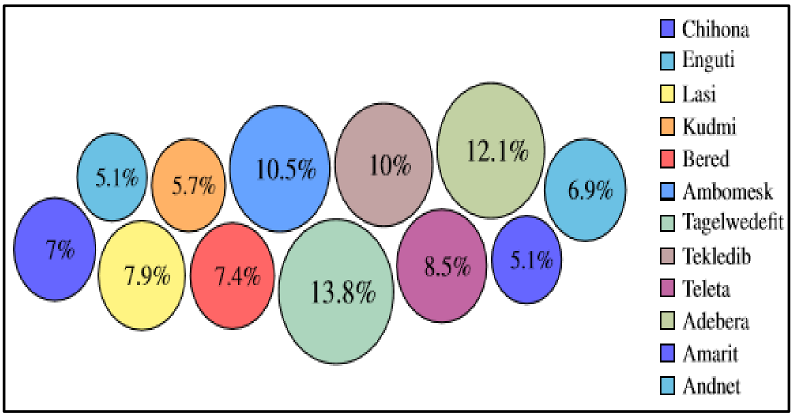
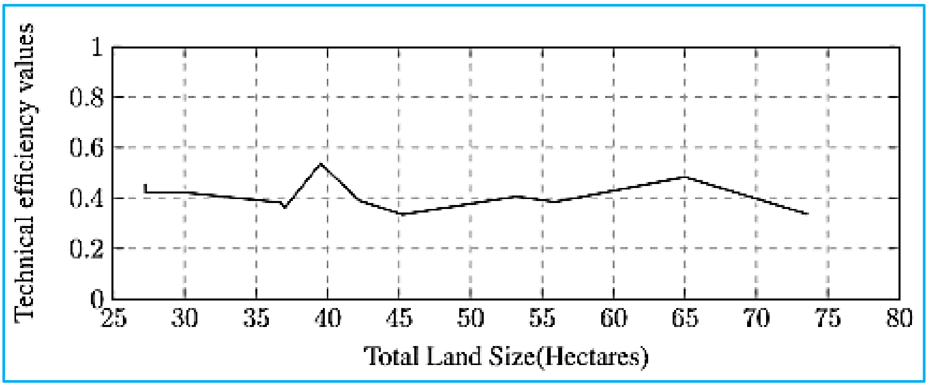


Table 3: Sample and sampling procedure

Blocks	Total land	%	Sample size	%	Sample land	%
Chihona	617	8.8	29	7.5	37	6.9
Enguti	393	5.6	22	5.7	27.25	5.1
Lasi	484	6.9	27	7.0	42.25	7.9
Kudmi	373	5.3	25	6.5	30.18	5.66
Bered	468	6.68	25	6.5	39.5	7.4
Ambo mesk	812	11.59	40	10.4	55.9	10.48
Tagel wedefit	616	8.79	35	9.1	73.6	13.8
Tekel dib	864	12.3	46	11.97	53.25	9.98
Teleta	787	11.2	38	9.89	45.25	8.48
Adebera	803	11.46	46	11.97	65	12.1
Amarit	290	4.1	20	5.2	27.25	5.1
Andenet	497	7.09	31	8.07	36.7	6.89
Total	7004	100	384	100	533.3 (7.6%)	100

Figure 5: Total sample land size in each block and technical efficiency values



4.2. Spatio-temporal economic sustainability convergence

4.2.1. Scenario 1: Temporal convergence to optimum level of economic sustainability

The study employs convergence as a condition of movement toward a specific point; the concept of optimum level economic sustainability is derived from the concept of optimum efficiency, contextualizing efficiency convergence, which is defined as the condition of an increased efficiency level approaching optimum efficiency. This section is also related to the convergence of efficiency, which predominantly followed the classical literature of Barro and Sala-I-Martin (1992), who defined general convergence as a condition of movement toward a point resulting in the elimination of distance from the production frontier. In other words, the inefficiency level decreases over time and eventually converges to the optimum efficiency level, indicating optimum economic sustainability in this study. Each block's level of economic sustainability as measured by the technical efficiency index is much lower than the optimum level. The dynamics of the temporal and economic sustainability convergence of each block show the expected growth rate in technical efficiency and speed of convergence to this optimum level. The graphical illustration represented by the intersection between the exponential growth of each block's technical efficiency curve and the optimum economic sustainability line determines the speed of convergence and the expected growth rate of efficiency improvement. As stated in Table 4, data on the initial level of economic sustainability measured by the relative actual output to potential (Technical efficiency (TE)) (the actual and potential outputs based on a sample are given in millions of Ethiopian Birr, or METB), the speed of convergence, and results showing the expected annual growth rates in efficiency with their adjusted growth indices required to achieve convergence to the optimum level of economic sustainability for each block is provided. According to Table 4 and Fig. 6, households, on average, need to grow at 9.42 percent for the next 10 years of the planning period in the agricultural sector to reach the optimum level. The regional analysis, on the other hand, revealed that the farther a country is from the optimal level, the higher the growth indices are expected to be, and vice versa. The most unsustainable block, Teleta, is expected to grow annually at 11.56 percent (which is 1.81 times faster than the Most Economically Sustainable Block (MESB)) for the next 10 years of the planning period to reach an optimum level of economic sustainability. On the contrary, the most sustainable region, Bered, is expected to grow relatively at a lesser rate of 6.41 percent to reach the optimum level. However, direct comparison of these indices is misleading and inaccurate because the starting conditions (that is, the initial level of economic sustainability in the study) differ significantly from block to block. For policy implications, the most adequate picture can be obtained only after the catch-up effect is taken into consideration[4].

Table 4: Expected annual technical efficiency growth indices & temporal convergence

Block Name	Actual Output (METB)	Potential Output (METB)	Relative Actual output (TE)	Relative Target level (TE=1)	Annual growth Indices	Adjusted growth indices
Bered	2.1734	4.047265144	0.5370046	1.00	0.064148407	0.064148407
Adebera	2.3254	4.812266956	0.4832234	1.00	0.07543757	0.067882471
Enguti	1.046075	2.291610394	0.4564803	1.00	0.081577878	0.069345205
Amarit	1.26545	2.993109781	0.4227877	1.00	0.089902793	0.070781135
Kudmi	0.7052	1.675871045	0.4207961	1.00	0.090417542	0.070851067
Tekel dib	1.65294	4.069024785	0.4062251	1.00	0.094267056	0.071309714
Lasi	0.810005	2.083461941	0.3887784	1.00	0.09908122	0.071732418
Ambo mesk	1.88311	4.903713923	0.3840171	1.00	0.10043639	0.071823018
Andenet	1.06684	2.795965344	0.3815641	1.00	0.101141801	0.071865456
Chihona	0.731	2.024301028	0.3611123	1.00	0.107224716	0.07210397
Tagel wedefit	0.967015	2.882879687	0.3354337	1.00	0.11542232	0.072097215
Teleta	0.738	2.205024887	0.3346901	1.00	0.115669893	0.072091688
Overall	15.364435	37.82625576	0.4061844	1.00	0.09427802	0.071310862
Assuming	the speed of	convergence	n = 10 Years			

[4] It is based on the hypothesis of the proportional offset hypothesis, or the proportional overlap hypothesis: "If the level of economic development of one country is times higher than the level of economic development of another country, achieving the same economic growth in the former will be times more difficult than in the latter"

To make comparison more meaningful and accurate, the proportional offset of the catch-up effect contextualized for the study, αij, in eq.14 according to (Papava 2012; Papava (2014)) is calculated as,

$$\alpha_{ij} = \frac{TE_i}{TE_j} \quad \textbf{(14)}$$

Where, TE is technical efficiency for block j (the less sustainable blocks) and i (the reference block, Bered). If the expected efficiency growth of block j is equal to rj, then the efficiency growth of block j, corresponding to the efficiency growth in block i, under the catch-up effect hypothesis, that is, the adjusted efficiency growth of the j th blocks (less sustainable blocks (rij∗), is given by eq.15:

$$r_{ij}* = \frac{r_j}{\alpha_{ij}} \quad \textbf{(15)}$$

Consequently, rij∗ is the hypothetical efficiency growth of block j which can be used to measure relative economic growth against block i. If we divide the hypothetical efficiency growth quotient for block j (rij∗) by the expected efficiency growth of block i (ri) in eq.16, we obtain a value that indicates how many times the efficiency growth of block j really exceeds that of block i for convergence analysis.

$$\beta_{ij} = \frac{r^*_{ij}}{r_i} = \frac{r_j}{r_i}\alpha_{ij} \quad \textbf{(16)}$$

Thus, the study indicates that after taking into account the catch-up effect, in terms of economic sustainability, other less sustainable blocks exceed growth in Bered by a range of 1.06 to 1.124 times: for example, Adebera by 1.06 times and Tagelwedefit by 1.124 times to achieve temporal convergence. These can be compared with before taking into account the catch-up effect. It ranges between 1.18 to 1.8 times that Adebera exceeds by 1.18 times and Teleta by 1.8 times. The dynamics of the economic sustainability of convergence of each block and the optimum level of economic sustainability concerning the same six percent[5] efficiency growth rates is shown in Table 5 and Fig. 7. The abscissa in

[5] However, under the proportional overlap hypothesis, Adebera's, Enguti's, Amarit's, Kudmi's, Tekledib's, Lasi's, Ambomesk's, Andenet's, Chihona's, Tagel's, Teleta's and Overall 6 percent growth corresponds to (5.4),(5.1),(4.72),(4.7),(4.54),(4.34),(4.3),(4.26),(4.0),(3.75),(3.74) and & (4.53) percent growth in Bered respectively, that is, in real terms Bered is growing faster than other regions.

Fig. 7 contains the time (number of years) necessary to achieve convergence, and the ordinate indicates the evolution of economic sustainability where inputs are being used to their utmost capacity therein in each block and overall at project level at the same 6 percent efficiency growth rate or approximately at 5.82 percent growth differentials with growth at optimum efficiency. Accordingly, if all blocks are growing at 6 percent, the overall farming system at the household level would need 15.46 years to become optimally economically sustainable. Whereas, the most economically sustainable block would need only 10.67 years and the most unsustainable would need about 18.78 years.

Figure 6: Expected growth rates for temporal economic sustainability convergence

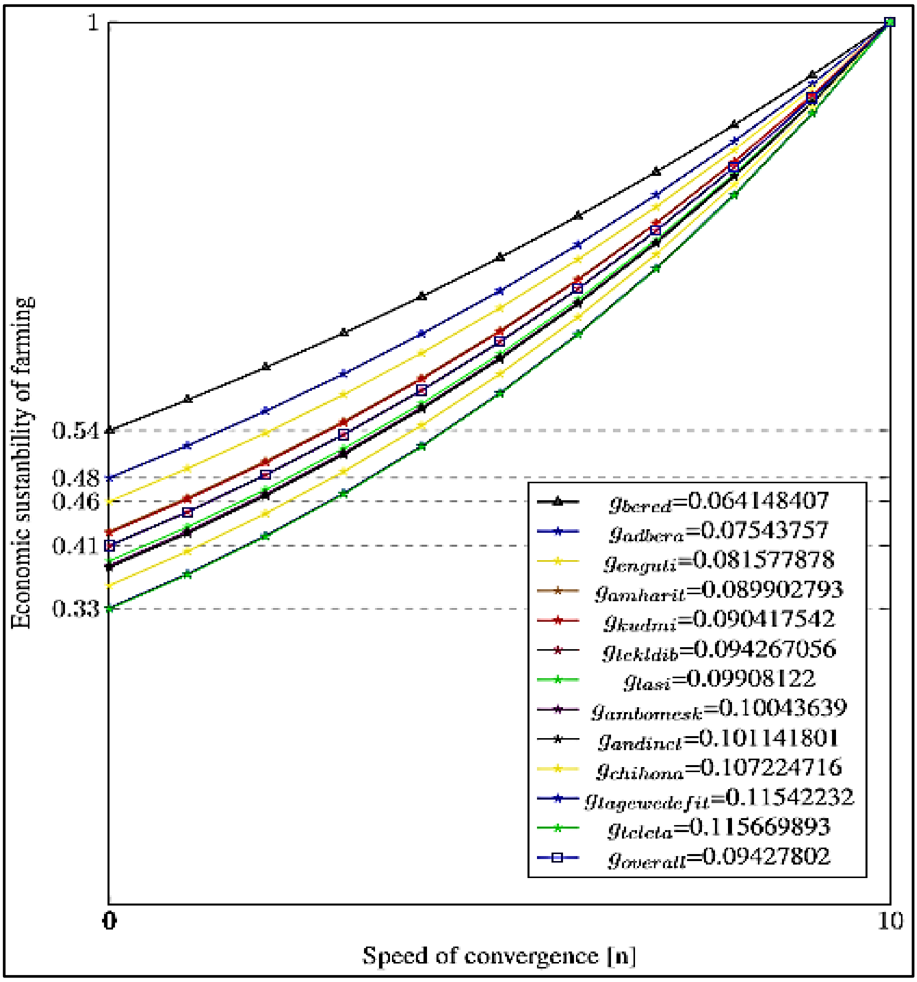
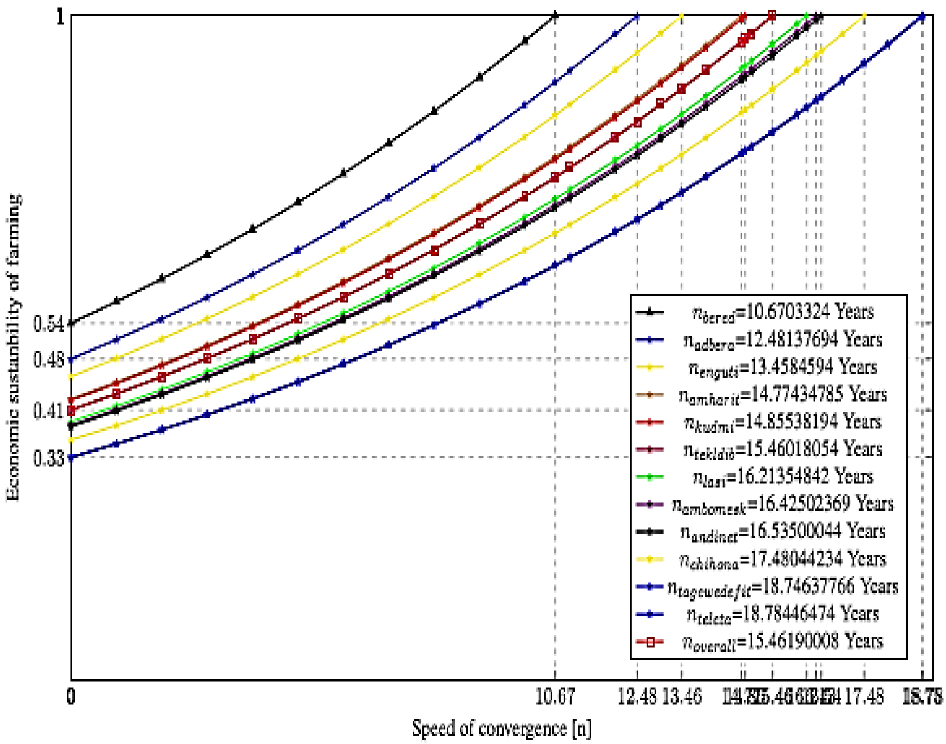


Table 5: Speed of temporal convergence to opt

Block Name	Relative Actual output (TE)	Relative Target level (TE=1)	Speed of Convergence [n]
Bered	0.5370046	1.00	10.6703324
Adebera	0.4832234	1.00	12.48137694
Enguti	0.4564803	1.00	13.4584594
Amarit	0.4227877	1.00	14.77434785
Kudmi	0.4207961	1.00	14.85538194
Tekel dib	0.4062251	1.00	15.46018054
Lasi	0.3887784	1.00	16.21354842
Ambo mesk	0.3840171	1.00	16.42502369
Andenet	0.3815641	1.00	16.53500044
Chihona	0.3611123	1.00	17.48044234
Tagel wedefit	0.3354337	1.00	18.74637766
Teleta	0.3346901	1.00	18.78446474
Overall	0.4061844	1.00	15.46190008
Assuming	g_c=6%, g_T=0%		
Growth differential	[ln (1 + g_c)-ln (1 + g_T)]	= 0.058268908	

Figure 7: Speed of temporal economic sustainability convergence



4.2.2. Scenario 2: Spatial economic sustainability convergence

The literature on catching-up suggests that due to the international diffusion and imitation of knowledge, technology, and innovation (for example R and D), including managerial procedures or organizational capabilities, relatively low-productive and low-economically sustainable states have the opportunity to adopt the techniques of the leader and hence catch-up with the higher productivity or economically sustainable states. The argument advanced in this debate is that, while technology adoption varies greatly across different segments of the same state or region, small farmers have reaped the benefits of new technology.

The technical efficiency indices, moreover, at the project level have a standard deviation (Std. Dev.) of 0.1069547, reflecting unbalanced economic sustainability among farmers in the project. Table 6 and Fig. 8 provide the concept of convergence as used in the current study, which refers to the tendency of two or more blocks to become similar in terms of economic sustainability levels through technical efficiency measures. Therefore, if the low levels of the economically sustainable block at the beginning of the period grow more rapidly in technical efficiency than those with high levels of sustainability, then convergence occurs, implying that the less economically sustainable blocks are catching up. The distance that separates it from the best practice block (that is, Bered) explains the relative performance of each block in economic sustainability. The growth differentials and the speed of convergence were calculated in order to perform a convergence analysis between accession blocks and best-performing blocks, that is, economic sustainability convergence to the most economically sustainable block (MESB) in terms of efficiency measure.

Wibisono (2005) regards technological transfer as the primary driver of regional income convergence and contends that government policies have a significant impact on technological diffusion among regions in order to achieve rapid and sustainable regional economic growth. Table 6 includes data on the initial level of relative economic sustainability of each block to the most economically sustainable, the target level of the relative sustainability, the five-year speed of convergence, and the results showing the expected annual growth differential efficiency, which is the difference in the efficiency growth rates between two blocks to achieve spatial economic sustainability convergence. Overall, regions need 5.58 percent growth differentials, that is, they have to register a 5.58 percent higher efficiency growth rate of MESB to catch up for the next five years. While the second most economically sustainable block, Adebera, need only a 2.11 percent higher efficiency growth rate and the most unsustainable block needs a 9.45 percent higher efficiency growth rate for spatial convergence in the next five years. According to Fig. 8, a 6 percent efficiency growth rate of the most economically sustainable block and about 8.26 percent of the second most economically sustainable, the convergence point between these regions, that is, curve intersection between the exponential growth of technical efficiency curve for two blocks after five years will be achieved at technical efficiency of about 0.72, and for the most unsustainable block, the same point of convergence will be achieved at a rate of 16.51 percent. Overall at the project level, it needs 12.08 percent growth rate to catch up with the level of economic sustainability of Bered at 0.72 states of efficiency. However, taking the catch-up effect into account to compare efficiency growth rate across blocks, that is, the relative efficiency growth against Bered[6], the second most economically sustainable block's 8.26 percent growth corresponds to 7.43 percent growth in Bered (8.26: 1.111= 7.43). The most unsustainable block's 16.51 percent corresponds to 10.29 percent growth in Bered.

Table 6: Growth differentials & spatial convergence to MESB

Block Name	Technical efficiency Relative to MESB level	Target relative Technical efficiency level	Growth Differentials $[\ln(1+g_c)-\ln(1+g_T)]$
Bered	1	1	-
Adebera	0.899849647	1	0.021105518
Enguti	0.850049143	1	0.032492223
Amarit	0.787307409	1	0.0478273
Kudmi	0.783598688	1	0.048771653
Tekel dib	0.756464842	1	0.055819844
Lasi	0.723975921	1	0.064599429
Ambo mesk	0.715109517	1	0.067063916
Andenet	0.710541586	1	0.068345561
Chihona	0.672456623	1	0.079363534
Tagel wedefit	0.624638411	1	0.094116468
Teleta	0.623253693	1	0.094560326
Overall	0.756389051	1	0.055839883
Assuming	the speed of	convergence	n = 5 Years

[6] The numbers given in Table 7 are based on region-standard, which in this example is Bered. For a "region-standard" one could select the region that has the highest economic sustainability index in Koga irrigation and Watershed project, and following this standard, the rates of efficiency growth in other regions would be adjusted similarly

Figure 8: Spatial economic sustainability convergence

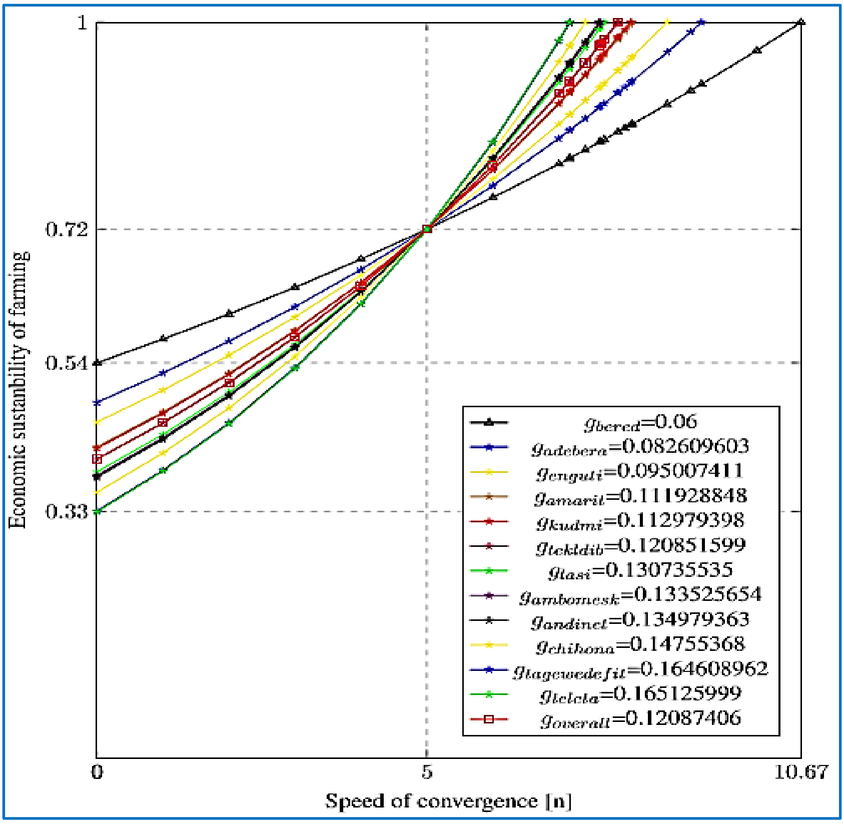


Table 7: Real efficiency growth rates adjusted for the catch-up effect

Block Name	Expected efficiency growth rate for next 5 years	Ratio of expected growth in a given block to that of Bered	Level of economic sustainability indices i.e. TE	Proportion of catch up effect(α_{ij}) i.e. ratio of sustainability of Bered to that of a given block)	Hypothetical efficiency growth rate i.e. after adjustments (r_{ij}*)	Ratio of a given block's hypothetical growth to Bered (β_{ij})
Bered	0.06	1	0.5370046	1	0.06	1
Adebera	0.082609603	1.376826717	0.4832234	1.111296763	0.074336222	1.238937036
Enguti	0.095007411	1.58345685	0.4564803	1.176402574	0.080760968	1.346016138
Amarit	0.111928848	1.8654808	0.4227877	1.270151899	0.088122411	1.468706854
Kudmi	0.112979398	1.882989967	0.4207961	1.276163444	0.088530508	1.475508467
Tekeldib	0.120851599	2.014193317	0.4062251	1.321938502	0.091419986	1.523666429
Lasi	0.130735535	2.178925583	0.3887784	1.381261408	0.094649379	1.577489657
Ambomesk	0.133525654	2.225427567	0.3840171	1.398387207	0.095485466	1.591424432
Andenet	0.134979363	2.24965605	0.3815641	1.407377162	0.095908451	1.598474177
Chihona	0.14755368	2.459228	0.3611123	1.487084766	0.099223449	1.653724157
Tagel wedefit	0.164608962	2.7434827	0.3354337	1.600926204	0.10282108	1.713684674
Teleta	0.165125999	2.752099983	0.3346901	1.604483073	0.102915389	1.715256478
Overall	0.12087406	2.014567667	0.4061844	1.322070961	0.091427816	1.523796926

Table 8: Speed of spatial convergence to MESB

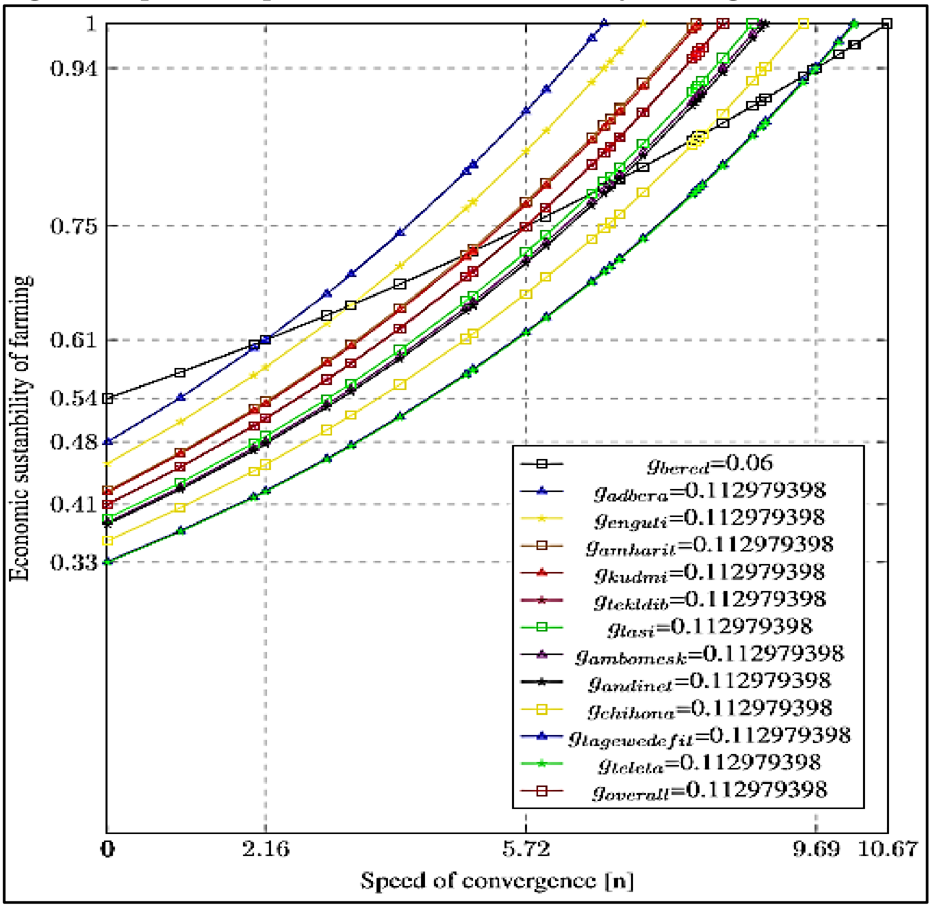
Block Name	Technical efficiency Relative to MESB level	Target relative Technical efficiency level	Speed of Convergence [n]
Bered	1	1	-
Adebera	0.899849647	1	2.163707401
Enguti	0.850049143	1	3.33105613
Amarit	0.787307409	1	4.903186191
Kudmi	0.783598688	1	4.999999978
Tekel dib	0.756464842	1	5.72257039
Lasi	0.723975921	1	6.622640834
Ambo mesk	0.715109517	1	6.875296459
Andenet	0.710541586	1	7.006688872
Chihona	0.672456623	1	8.136235712
Tagel wedefit	0.624638411	1	9.648685329
Teleta	0.623253693	1	9.694189063
Overall	0.756389051	1	5.724624775
Assuming Growth differential	g_c =11.2979398 % , 0.048771654	g_T=6%	

The dynamics of the spatial economic sustainability convergence with the same 11.29 percent [7] average efficiency growth rates of blocks as against 6 percent growth rate of Bered is shown in Table 8 and Fig. 9. Accordingly, the second most economically sustainable block, the most economically unsustainable block and overall at project level needs about 2.16, 9.69 and 5.72 years to catch up the level of economic sustainability of the benchmark block respectively. Generally, given about 4.87 percent growth differentials between “accession blocks” and the most sustainable block, it needs about 2.16,9.69 and 5.72 years to catch up for Adebera, Teleta, and Overall respectively. Fig. 9 also contains the time (number of years) necessary to achieve spatial convergence, and evolution of economic sustainability in each block where inputs are being used to their utmost capacity therein, as given by the same 11.29 percent efficiency growth of “accession blocks” and benchmark block growing at 6 percent. Accordingly, the curve of intersection between exponential efficiency growth rate curve of two blocks will be achieved at technical efficiency of about

[7] Under the proportional overlap hypothesis, Adebera’s, Enguti’s, Amarit’s, Kudmi’s, Tekledib’s, Lasi’s, Ambomesk’s, Andenet’s, Chihona’s, Tagel’s, Teleta’s an overall 11.29 percent growth corresponds to (10.17),(9.6),(8.9),(8.85),(8.54),(8.18),(8.08),(8.03),(7.6),(7.06),(7.04) and (8.55) percent growth in Bered, respectively

0.61,0.94 and 0.75 for Adebera, Teleta, and the overall project level is about 2.16,9.69, and 5.72 years respectively.

Figure 9: Speed for spatial economic sustainability convergence



4.2.3. Scenario 3: Cross-over or leapfrogging phenomenon in economic sustainability

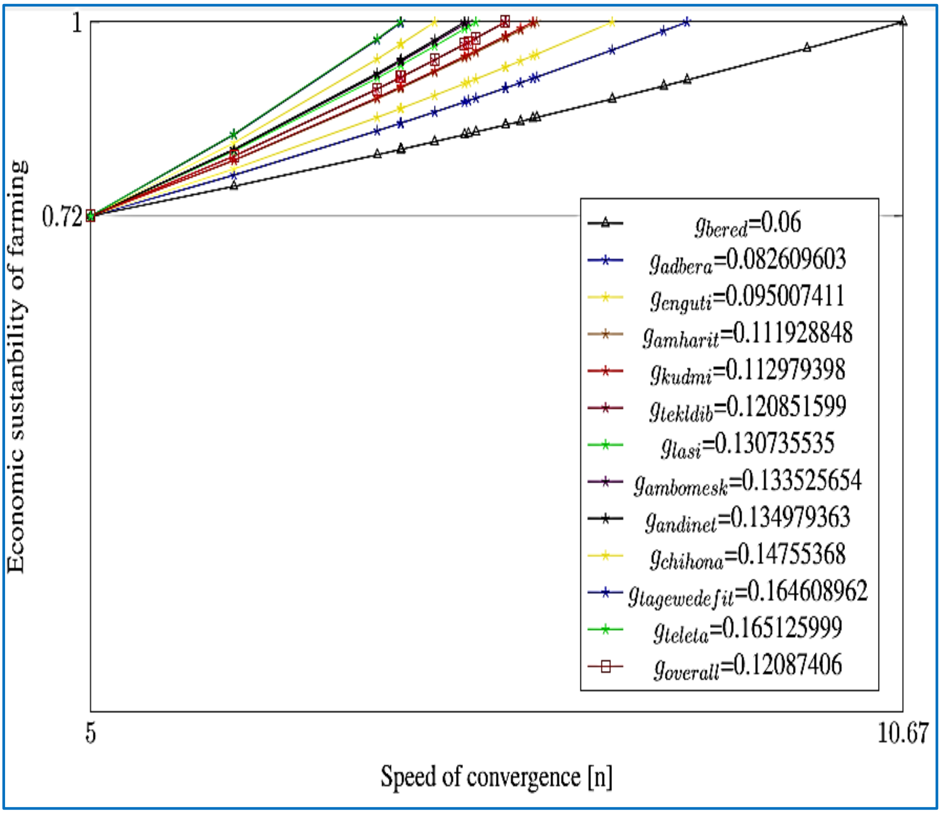
Initially, economically less sustainable blocks may not only manage to catch up with more sustainable ones, indicating convergence, but they may also cross over and continue to surge ahead. The crossover scenario, thus, could again cause an increase in the dispersion of economic sustainability levels. Table 9 and Figure 10 show the cutoff points of technical efficiency state (can be considered as state of economic sustainability in this study) and growth differentials[8] given five years of the speed of convergence and a 6 percent efficiency growth of the most economically sustainable block. It will take only slightly greater than 2.11 percent higher efficiency growth rate of Bered for Adebera to surge ahead in terms of economic sustainability, similarly, the cutoff point technical efficiency is about 0.72 beyond which the Adbera will become more economically sustainable than Bered. However, for the most economically unsustainable block, it requires more than 9.45 percent higher efficiency growth rate of Bered to surge ahead to become the most economically sustainable after five years. At the project level, overall it needs more than 5.58 percent higher efficiency growth rate to surge ahead of the most economically sustainable block.

Table 9: Growth differentials for cross-over or leapfrogging phenomenon in economic sustainability

Block Name	Growth Differentials [$\ln(1+g_c)$-$\ln(1+g_T)$]	State of Technical efficiency [TE]
Bered		
Adebera	0.021105518	0.718633291
Enguti	0.032492223	0.718633291
Amarit	0.0478273	0.718633291
Kudmi	0.048771653	0.718633291
Tekel dib	0.055819844	0.718633291
Lasi	0.064599429	0.718633291
Ambo mesk	0.067063916	0.718633291
Andenet	0.068345561	0.718633291
Chihona	0.079363534	0.718633291
Tagel wedefit	0.094116468	0.718633291
Teleta	0.094560326	0.718633291
Overall	0.055839883	0.718633291
Assuming	g_{bered} =6%	Speed of convergence = 5 years

[8] There was a little deviation of growth differentials as a result of exponential function and its log-transformations

Figure 10: Growth differentials for cross-over in economic sustainability

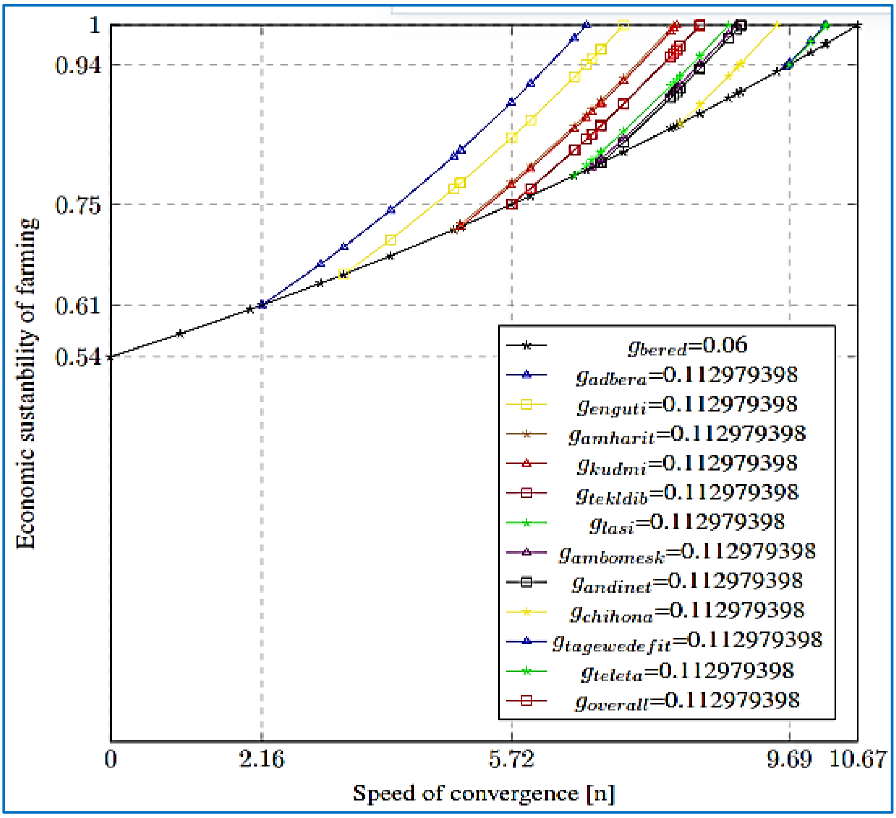


As far as leapfrogging time is concerned in Table 10 and Figure 11, with growth differentials of about 0.0487 (provided that all blocks are growing at a rate of about 4.87 percent higher than the most sustainable block) and two growth rates given in Table 10, overall at project level it will take more than 5.72 years to surge ahead (that is beyond 0.75 level of efficiency). The second most economically sustainable block surge ahead of Bered after 2.16 years with 0.61 states of efficiency beyond which Adebera will become the most sustainable block in the project area. For the most economically unsustainable block, it will take more than 9.69 years, that is, beyond 0.95 states of efficiency to surge ahead of Bered in the level of economic sustainability.

Table 10: Speed of cross-over or leapfrogging phenomenon in economic sustainability

Block Name	Cross-over/ leapfrogging time [n]	State of Technical efficiency [TE]
Bered		
Adebera	2.163707401	0.609161565
Enguti	3.33105613	0.652038536
Amarit	4.903186191	0.714590725
Kudmi	4.999999978	0.71863329
Tekel dib	5.72257039	0.74953618
Lasi	6.622640834	0.789895542
Ambo mesk	6.875296459	0.801610379
Andenet	7.006688872	0.807771136
Chihona	8.136235712	0.862725213
Tagel wedefit	9.648685329	0.942207022
Teleta	9.694189063	0.944708555
Overall	5.724624775	0.74962591
Assuming Growth Differentials	g_c =11.2979398% ,g_{bered} =6% =0.048771654	

Figure 11: Speed for cross-over phenomenon in economic sustainability



In Figure 11, for "accession blocks" growing at a rate of about 11.29 percent and the most economically sustainable block growing at a rate of 6 percent, the abscissa points of 2.16, 5.72 and 9.69 and the ordinates 0.61, 0.75 and 0.94 are showing cutoff leapfrogging times and states of economic sustainability beyond which Adebera, overall at project level, and Teleta respectively surge ahead.

4.3. Discussion of results

It is argued that individual farm- and farmer-specific characteristics determine economic sustainability. Such characteristics can be divided into two categories: demographic characteristics, which dominate the farmer's decision-making process, and socioeconomic and institutional characteristics, which influence a farmer's ability to apply farm-level decisions. This variation in the degree of economic sustainability was caused by socioeconomic variables. Differences in economic sustainability have been attributed to characteristics that are expected to differ between households and blocks.

Before estimating model parameters with the Maximum Likelihood Estimates (MLE) method, it is critical to test the model's specification and validity. Unfortunately, none of them are known a priori; instead, they must be determined from the available data. The study used flexible Trans-log (TL) specification to specify the stochastic frontier production function and then performed a log likelihood ratio test to see if the Trans-log (TL) reduces to the CD production function. As a result of the log-likelihood ratio test, the TL functional form was found to be more appropriate than Cobb-Douglas Table 18 in Annex Part. Cobb-Douglas is a special case of the trans-log production function in which the coefficients of the squared and interaction terms of the trans-log frontier input variables are assumed to be zero. The diagnostic test in the functional specification demonstrated that the squared and interaction terms of the trans-log frontier input variables are not equal to zero. At the 5 percent level of significance, the null hypothesis that all determinant variables in the inefficiency effect model are simultaneously equal to zero is rejected in Table 19 in the Annex Part. The explanatory variables associated with the inefficiency effect model are all greater than zero. As a result, these variables explain differences in farmer inefficiency.

The positive coefficients of access to credit and the two types of land ownership (that is, own and rented land) in the model, reveal that variables reduce the farmer's level of sustainability in the analysis of the technical inefficiency effects model. Other statistically significant variables that influence convergence positively include household size, frequency of consultation visits, male household head, and non-farm income. The discussion of these farm-specific demographic and socioeconomic variables follows. Households with larger families are economically more sustainable in terms of technical efficiency, indicating the benefit of increased labor supply during peak farming season, as confirmed by Tekalign (2019), Andaregie, A., and Astatkie, T. (2020). The impact of household size could indicate labor-intensive crop production. Because of the block's traditional production system, the most labor-intensive and time-consuming harvesting and threshing operations are performed solely by human and animal power. The study also confirms that advisory services improve farmers' technical efficiency. Access to advisory services provides farmers with enormous productivity and efficiency gains by facilitating the introduction of new technologies and providing access to technical knowledge and new skills. Marios (2006), Zewdie et al. (2021), Tekalign (2019), and Andaregie, A., and Astatkie, T (2020) all agree that extension services contribute positively to efficiency improvement (2020). As a result, our findings imply that if more resources are invested on extension services, farmers' economic sustainability will improve and converge as technical efficiency will converge to the frontier level and to the most sustainable block. Off-farm income (also known as non-farm income) by easing financial restrictions on the timely purchase of inputs such as labor, capital, and fertilizers helped improve economic sustainability. The positive impact of off-farm income also confirmed by Tekalign (2019), Andaregie, A., and Astatkie, T. (2020). In contrast to the availability of off-farm income as an alternative to credit, access to credit has a positive impact on technical inefficiency unlike a study by Marios (2006), Tekalign (2019). Thus, credit lowers the level of economic sustainability of farmers. The money received in the form of loans was not used for productive activities. Farmers were reluctant to return it. Political instability and unrest in Ethiopia during this time may contribute to this effect. In terms of household head gender, women are technically less efficient than men. Households led by female heads were economically less sustainable.

Farmers in the Koga Irrigation and Watershed Project's adjacent Kebeles support the project because they expect to participate in irrigation-based sharecropping arrangements and benefit from the project's specialization and diversification. The share cropping agreement is very efficient in comparison to other types of land ownership agreements in the Koga watershed and irrigation project. The vast majority of farmers (81.8 percent) farmed exclusively on their own irrigated lands. Sharecropping takes a little share (3 percent). Farmers must use resources wisely and conduct business in accordance with the performance of share croppers. In the farming business, they must develop the share cropping mentality. They must learn and share experiences from share cropping arrangements in order to close the efficiency gap between themselves and their more efficient counterparts and become more sustainable.

Although the twelve blocks are close together and face similar natural and market conditions, economic sustainability varies. In the inefficiency effects model discussed above, the differences can be attributed to farm and farmer's characteristics, which are expected to vary from household to household and from block to block. The plot analysis also confirmed the inefficiency model's variation in economic sustainability. The trend line for the plot analysis shows that, with the exception of household size, all of the above statistically significant farm and household specific variables contributed to the variation in the degree of economic sustainability. As a result, large household size, extension and training services, non-farm income, and production activities led by male heads must be used in the future to improve agricultural efficiency (temporal economic sustainability convergence) and close the efficiency gap between blocks (to achieve spatial economic sustainability convergence). All of these factors, including the sharecropping work spirit, aid in the convergence of temporal and spatial economic sustainability.

Farmers' perceptions of current production levels, the source of production loss, perceptions of efficiency improvement, and satisfaction with current farm performance may all be related to technical efficiency. In contrast to the quantitative results of the maximum likelihood estimates, the majority (45 percent) believed their land was performing to its potential. The majority of farmers (61 percent) also believe it is possible to improve efficiency without changing the amount of inputs and technology. As a result, farmers should be communicated well in order to become aware off their level of efficiency. In a broader sense, not only demography but also socioeconomic characteristics, and perceptions are important for temporal and spatial convergence. The spatial-temporal economic sustainability of the Koga irrigation project could be achieved if the government at the local level emphasized the role of various demography, socioeconomic characteristics, and perception-related issues discussed above for economic sustainability convergence in the project's command areas.

The five convergence questions were guided by the following scenarios in terms of short- and long-term plans, as well as reasonable growth rates and growth differentials. The study separated the convergence analysis into short-and long-term goals. The short-term (5-year plan) goal is to achieve a comparable level of economic sustainability through technical efficiency measures, that is, the catch-up effect. A growth rate that makes farmers fully efficient within 10 years is taken as long-term plan. While the long-term plan (ten years) seeks to achieve fully technical efficient farms in each block (temporal convergence. For the long-term goal, growth rates were calculated, and the lowest possible growth rate (that is, 6 percent) was assumed, which was triangulated with other studies used to calculate the rate of convergence to their respective frontiers. As a short-term plan for catching up, the expected growth differential for the MESB was calculated, and a relatively higher growth rate for other blocks and a minimum possible growth rate of 6 percent for the MESB were assumed to calculate the speed of convergence for catch up.

The first scenario for long-term planning considers the growth rate of efficiency farmers becoming optimally economically sustainable after ten years and the speed of convergence for each region to achieve an optimal level of economic sustainability if a minimum growth rate of 6 percent is assumed. According to our findings, in order to reach the optimal level, technical efficiency should increase at a rate of 9.42 percent per year on average over the next ten years. To achieve the optimal level, it ranges from 6.4 to 11.56 percent per year for the most and least sustainable blocks. By connecting the realities, we attempted to provide clear justification for the finding. When compared to the 10 percent assumed technical efficiency change by Birhanu et al. (2021) and the technical efficiency of Ethiopian farm households over years in the Time-varying Inefficiency Effects (TIE) model between 1994-2004 of 16.4 percent, and 1999-2009 of 19.4 percent (Tenaye, 2020), the 9.42 percent expected growth rate at the project level in the first scenario result is not overly ambitious and is attainable.
The majority of the increase in productivity can be attributed to improved technical efficiency. When the source of the change is broken down, an increase in technical efficiency is the main contributor. The efficiency trend in 2013 was 61 percent, which showed a 7 percent improvement compared to 54 percent in 2011 (Wendimun, 2016). Increasing efficiency is the primary driver of agricultural productivity. The majority of the productivity increase can be attributed to increased technical efficiency. When the source of the change is examined, the main contributor is an increase in technical efficiency. According to Prime Minister Abiy Ahmed’s (Ph.D.) parliamentary report, the target

agricultural growth rate for 2021 was 5.9 percent, with a potential of 8 percent. According to Mellor and Dorosh (2010), non-agricultural sectors grow faster than agricultural sectors during the normal process of economic growth. Agriculture's slower growth, its relative decline, concerns about the difficulty of modernizing agriculture, and pessimism about the potential for technological change in agriculture all suggest to some that agriculture should not be prioritized for scarce resources in the interests of rapid overall growth. Maintaining a six percent growth rate in agricultural GDP (the Comprehensive Africa Agriculture Development Programme's (CAADP) target of six percent per year) would provide enough employment growth to contribute to the economy's rapid economic transformation and rapid decline in poverty. Fast agricultural growth countries, which are typically middle-income countries, grow agriculture at a four-to-six percent annual rate. Despite its lower-income status, Ethiopia has significant productive agricultural resources and has made a good start in institutional development. Between 2011 and 2013, the efficiency trend improved by 7 percent (Wendimun, 2016). Based on Wendimun (2016) target agricultural growth rate and its potential, following Mellor and Dorosh (2010) and Tenaye (2020), we took a 6 percent increase in efficiency as a reasonable minimum target to calculate speed for catch up effect. If blocks grow at the minimum rate, it takes 10.7 to 18.9 years for a block to become economically sustainable.

Ethiopia also has a five-year development plan. This study's short-term goal is to calculate growth differentials and achieve economic sustainability convergence among blocks in the Koga project. The most sustainable block grows at the lowest reasonable rate; other blocks require a 2.1-9.4 percent growth differential, or 8-16.5 percent. However, assuming 11.29 percent growth in other blocks and the MESB growing at the lowest reasonable level, it will take 2-10 years to catch up. Between 1994 and 1999, technical efficiency of Ethiopian farm households was 11.23 percent in the True Fixed Effect (TFE) model, and 11.6 percent in the Time-varying Inefficiency Effects (TIE) model (Tenaye, 2020). According to Tenaye (2020), a 5-year growth rate of 11.29 percent is a reasonable goal.

5. Conclusions and Policy Implications

This study has many practical implications, one of which is informing economic sustainability policymaking. It could also assess how economic sustainability is being expanded in specific regions, either by emphasizing technical efficiency growth or by emphasizing the efficiency convergence point, so that proposed policies can be tailored to the condition of each block. The economic sustainability level of blocks in the Koga irrigation and watershed project as measured by the extent to which observed output deviates from the potential output, called “frontier,” varies across blocks. Twelve blocks are further categorized as more sustainable and less sustainable blocks. Despite the twelve blocks being nearby and facing similar natural and market conditions, there is momentous variation in economic sustainability attributed to differences in farm and household characteristics, which are expected to vary from household to household and region to region. The dynamics of temporal economic sustainability convergence show that the farmer in the agriculture sector needs to grow at 9.42 percent for the next 10 years of the planning period to reach the optimum level despite the fact that observed output is significantly lower than the optimum level. If they are growing at 6 percent normal high growth (or approximately with 5.82 growth differentials), the farming system would need 15.46 years to become optimally economically sustainable. The tendency of the farming system in the area to become similar in terms of economic sustainability levels makes the most economically sustainable block require 2.11 to 9.45 percent growth differentials for the next five years. Based on the study’s scenarios, the expected growth rate and speed of convergence were feasible in the study area. Furthermore, statistically significant variables that positively influence convergence include household size, frequency of consultation visits, male household heads, sharecroppers’ mentality, and non-farm income, which are thought to facilitate convergence at the frontier. Experience sharing from the most sustainable blocks is being put forward for spatial convergence in order to close the efficiency gap between themselves and their more efficient counterparts. The policy implication is that the local government can consider spatial economic sustainability as a short-term goal (a five-year plan) in the agriculture sector in the study area, while temporal sustainability is a long-term goal (a ten-year plan) in the sector. Such plans have numerous reasonable grounds.

Understanding the drivers of convergence at the temporal and spatial levels can give policymakers valuable insights into the conditions needed for faster economic sustainability and balanced community development. Current efficiency testing methodologies, on the other hand, are based on cross-sectional data and generally rely on comparing results across farmers and identifying determinate variables. Future research should place more emphasis on estimating convergence at the panel data level rather than relying on scenario development as a methodology. To comprehend the dynamism of agricultural production efficiency and identify trends in the sector, more research is required to be carried out.

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Annex

Table 11: Trans-Log stochastic frontier & inefficiency model variable

Variables	Variable Description
Trans-Log Stochastic Frontier Model Variables	$X_i s$
$Output$	Most crops in area are potato, onion, cabbage, maize, and wheat produced for cash crop. Since farmers are producing quite a mix of crops value of output instead of physical quantity is taken.
$Labor_{hec}$	Labor is measured by the total maximum hrs per hectare during peak farming
$Seed_{hec}$	Seed of dominant crop type measured by kg per hectare.
$Agrochemicals_{hec}$	Agrochemicals including pesticide,insecticide & herbicide measured in litters
$Fertilizer_{hec}$	Fertilizer is measured by quantity of DAP & UREA applied in kilograms.
$Wateruse_{hec}$	In absence of volumetric measure, water schedule from farmers' points of view measured by hours of water release in a week as proxy is used.
$Manure$	A dummy variable with "1" if a farmer used manure as a fertilizer
$Soilconservation$	A dummy variable with "1" if soil & water conservation were applied in production during the period.
$Landsize$	It is measured by the area under cultivation in hectare. During survey the data on size of land was collected in terms of"qada" (one forth of a hectare) which later converted to hectare.

Variables	Variable Description
Inefficiency Model Variables	$Z_i s$
Household size	Total number of family members in a household
Extension visits	Frequency the extension agent i.e. Development agents visited the farmer in a month (Days per Month)
Male household head	A dummy variable with "1" if household head was Male
Membership in farmers' association	A dummy variable with "1" if a household was member of farmers' cooperatives
Credit access	A dummy variable with "1" if household had access to credit
Tenure system(Own land)	A dummy variable with "1" if household own land (different arrangements like own land,rented land, both & share cropping arrangements)
Tenure system(Rented land)	A dummy variable with "2" if household rented land

Table 12: Trans-Log Stochastic Frontier Model Results

Frontier/Value of output	Coef.	Std. Err.	P-Value
$\text{Ln}(Labor_{hec})$	3.625255	1.02259	0.000
$\text{Ln}(Agrochemicals_{hec})$	-11.08138	3.712087	0.003
$\text{Ln}(Fertilizer_{hec})$	2.512799	.8501957	0.003
$\text{Ln}(Wateruse_{hec})$	-5.473264	1.331143	0.000
$Manure$	-2.876573	1.399952	0.040
$Soilconservation$	-8.503961	3.435358	0.013
$\text{Ln}(Landsize)\text{Ln}(Agrochemicals_{hec})$	3.404723	1.16034	0.003
$\text{Ln}(Landsize)\text{ln}(Fertilizer_{hec})$	-1.097369	.3766584	0.004
$\text{Ln}(Labor^2_{hec})$	-.0696968	.043328	0.108
$\text{Ln}(Labor_{hec})\ \text{Ln}(Fertilizer_{hec})$	-.6958222	.2420711	0.004
$\text{Ln}(Seed^2_{hec})$	-.8346883	.23753	0.000
$\text{Ln}(Seed_{hec})\ \text{Ln}(Agrochemicals_{hec})$	3.276398	1.00768	0.001
$\text{Ln}(Seed_{hec})\ \text{Ln}(Wateruse_{hec})$	1.078865	.3731038	0.004
$\text{Ln}(Agrochemicals^2_{hec})$	.8316063	.3809571	0.029
$\text{Ln}(Agrochemicals_{hec})\text{Ln}(Fertilizer_{hec})$	-.6817744	.42198	0.106
$\text{Ln}(Agrochemicals_{hec})\ \text{Ln}(Wateruse_{hec})$	-1.119857	.3388904	0.001
$\text{Ln}(Fertilizer_{hec})\ \text{Ln}(Wateruse_{hec})$	.76498	.2570212	0.003
$\text{Ln}(Wateruse^2_{hec})$	-.2023842	.0781978	0.010
$Manure^*\ \text{Ln}(Landsize)$	.8216497	.4461063	0.066
$Manure^*\ \text{Ln}(Agrochemicals_{hec})$	.5849126	.3822614	0.126
$Manure^*\ \text{Ln}(Fertilizer_{hec})$	.4598834	.2622536	0.080
$Manure^2$	-9.39e-11	(omitted)	-
$Manure^*\ \text{Ln}(Wateruse_{hec})$	-.2889632	.1158822	0.013
$Soilconservation^*\ \text{Ln}(Landsize)$	2.345885	.882956	0.008
$Soilconservation^*\ \text{Ln}(Seed_{hec})$	2.173058	.877671	0.013
$Soilconservation^2$	-2.86e-11	(omitted)	-
Cons	11.68523	3.682887	0.002

Table 13: Output elasticities and returns to scale

Inputs	Output elasticity
$Labor_{hec}$	0.274151733
$Agrochemicals_{hec}$	3.378649967
$Fertilizer_{hec}$	0.652794115
$Wateruse_{hec}$	0.154369789
$Manure$	-0.961085255
$Soilconservation$	0.443043276
$Landsize$	-1.535831718
$Seed_{hec}$	-1.180356717
Returns to scale	1.74377717

Table 14: Technical Inefficiency Model Results

MU	Coef.	Std. Err.	P-Value
Household size	-.0476679	.0172186	0.006
Frequency of extension visits(Days/month)	-.1153604	.0388855	0.003
Male household head	-.1135847	.0568521	0.046
Off-farm income	-.1170705	.0575086	0.042
Membership in farmers' association (cooperatives)	.0787286	.0687057	0.252
Credit access	.1654055	.0796441	0.038
Land ownership type(Own land)	.6409611	.3055769	0.036
Land ownership type (Rented Land)	.7841473	.31047	0.012
Cons	.8017508	.7114188	0.260
Usigma	-2.709232	1.134694	0.017
Vsigma	-1.73559	.430366	0.000
sigma-u	.2580463	.1464018	0.078
sigma-v	.4198765	.0903503	0.000
lambda	.6145767	.2352024	0.009

Table 15: Level of economic sustainability indicated by technical efficiency indices

Block	Obs	Mean	Std. Dev.	Min	Max	Economic Sustainability Rank
Bered	25	.5370046	.138557	.3830217	.8023841	1
Adebera	46	.4832234	.133429	.2731431	.8448437	2
Enguti	22	.4564803	.1291142	.2107766	.7098315	3
Amarit	20	.4227877	.1075114	.2441547	.6254351	4
Kudmi	25	.4207961	.0631542	.3087295	.5657611	5
Tekel dib	46	.4062251	.0681146	.2763674	.6655779	6
Lasi	27	.3887784	.078006	.2618589	.5877768	7
Ambo mesk	40	.3840171	.0923274	.2466739	.6325205	8
Andenet	31	.3815641	.0819283	.2589183	.680037	9
Chihona	29	.3611123	.0740531	.2377005	.6303187	10
Tagel wedefit	35	.3354337	.0516425	.2533908	.4817964	11
Teleta	38	.3346901	.0424171	.2663759	.4612831	12
Overall TE	**384**	**.4061844**	**.1069547**	**.2107766**	**.8448437**	**Low**

Table 16: Capacity utilization, and inefficiency loss measures

Block Name	Actual Output (METB)	Potential Output (METB)	Inefficiency Loss(METB)	Growth potential [[(1/TE)-1]*100%]	Cost/input saving [[1-(TE/1)]*100%]
Bered	2.1734	4.047265144	1.873865144	86.21814413	46.29954
Adebera	2.3254	4.812266956	2.486866956	106.9436207	51.67766
Enguti	1.046075	2.291610394	1.245535394	119.0675041	54.35197
Amarit	1.26545	2.993109781	1.727659781	136.5253294	57.72123
Kudmi	0.7052	1.675871045	0.970671045	137.6447881	57.92039
Tekel dib	1.65294	4.069024785	2.416084785	146.1689344	59.37749
Lasi	0.810005	2.083461941	1.273456941	157.2159359	61.12216
Ambo mesk	1.88311	4.903713923	3.020603923	160.4050705	61.59829
Andenet	1.06684	2.795965344	1.729125344	162.0791631	61.84359
Chihona	0.731	2.024301028	1.293301028	176.9221652	63.88877
Tagel wedefit	0.967015	2.882879687	1.915864687	198.1215066	66.45663
Teleta	0.738	2.205024887	1.467024887	198.7838601	66.53099
Overall	15.364435	37.82625576	22.46182076	146.1936007	59.38156

Table 17: Summarized date of irrigation blocks

Region/	Section	Distance	Min.									Ir. size
Block	of work	away	level of water									
Block	of work	from	storing capacity	Sec.	Sec.	Ter.	Ter.	Quat.	Quat.	Ter.	Ter.	Ha.
Block	of work	main dam	of night	canal	canal	canal	canal	canal	canal			
Block	of work	Km	storages(m^3)	Num.	leng.	Num.	leng.	Num.	leng.	Num.	leng.	
Kudmi	3	3.238	20,006	1	0.875	7	9.0	31	47.9	3nr	4.6	373
Chihona	3	9.76	33,593	1	3.756	9	14.5	47	68.5	6nr	15.7	617
Ambo mesk	4	10.804	40,176	1	7.186	15	12.4	54	95.6	10nr	20.9	812
Adbera	4	11.0	40,747	1	8.054	15	13.1	53	90.0	5nr	4.4	803
Lasi	5	13.780	25,195	1	2.505	5	8.8	31	59.2	5nr	12.2	484
Enguti	4	11.94	19,700	1	0.779	3	7.3	26	44.7	4nr	13.4	393
Tagel wedefit	6	11.94	37,727	1	4.472	11	8.8	41	75.1	8nr	9.7	616
Bered	5	14.85	24,728	1	2.875	6	8.0	30	52.8	3nr	6.3	468
Andenet	5	17.34	40,695	1	2.641	4	6.3	33	46.1	4nr	7.9	497
Amarit	5	17.34	-	1	0.868	4	5.6	19	27.1	2nr	4.4	290
Tekel dib	6	-	44,064	1	5.53	9	12.1	53	91.4	11nr	19.6	864
Teleta	6	19.7	41,887	1	2.841	7	11.1	51	84.6	6nr	11.9	787
Total			662,518	12	42.382	95	117.0	469	783.0	67	131.0	7004

nr	/per command area
Sec.	Secondary
Ter.	Tertiary
Quat.	Quaternary
Leng.	Length
Ir.	Irrigation
Ha.	Hectars

Table 18: Optimal model and appropriate functional form

Assumption: CD nested in TL	Likelihood-ratio test
LR chi2(33) =	72.11
Prob > chi2 =	0.0001

Table 19: Determinants in inefficiency model are simultaneously zero

Result	Likelihood-ratio test
LR chi2(33) =	44.87
Prob > chi2 =	0.0000

Table 20: Land size and technical efficiency test for correlation

Results	Pearson (pw)	Spearman's rho	Kendal-tau
Coef.	0.1555*	0.2120	0.1439/0.1546
Prob	0.0022	0.0000	0.0000

Households’ Willingness to Pay for Water Hyacinth Control in Lake Tana

Seid Ebrahim[1], Ermias T. Teferi[2*], Solomon B. Wassie[3]

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Abstract

This study analysed rural households’ WTP for control of water hyacinth (Eichhornia crassipes) infestation in Lake Tana in terms of cash and man-days. A contingent valuation method through double bounded dichotomous choice was used to elicit WTP of 276 households in Fogera district, western Ethiopia. It was found that initial bid price, age of household head, labour availability, trust in the government, place of residence, household size, and income to influence the probability of households WTP for control of water hyacinth. The mean WTP was estimated to be 26.41 ETB and 3.23 man-days per month per household with welfare aggregation of ETB 19,671,963 *and 2,404,441 man-days per year. The study underscores that in utilizing the public resource for water hyacinth control activities, accountability and transparency should be strengthened.*

Keywords: Lake Tana, Man-days, Labour contribution, Water Hyacinth control, Contingent valuation method
JEL Classification: Q51

1. Background

The environment has a remarkable value to humanity, from the natural resources that give the basic inputs for the economy to the ecological services (Haris, 2006). Lakes and rivers are some of the environmental goods and they are the most available water resources for human utilization and for maintaining the

[1] Department of Agricultural Economics, College of Agriculture, Woldia University, Ethiopia Email: seidebrahim2000@gmail.com Phone: +251902715974
[2] Blue Nile Water Institute, Bahir Dar University, Bahir Dar, Ethiopia Email: ermiastesfaye61@gmail.com Phone: +251913232142
[*] Corresponding Author
[3] Blue Nile Water Institute, Bahir Dar University,
Ethiopia Email: sbizuayehu@gmail.com Phone: +251938965895

balance of the whole ecosystem (Rientjes et al., 2011). Lake Tana is the largest freshwater resource in Ethiopia and is the third largest lake in the Nile Basin countries. Over half a million people directly or indirectly dependent on the lake and its wetlands (Vijverberg et al., 2009). It renders essential services for the riparian societies as a source of water for drinking, cattle watering, irrigation, recreation, and transportation service that links islands and lake shore towns (Goshu & Aynalem, 2017). Generally, the lake is an essential environmental good that has economic, social, political, religious, and ecological benefits.

It is the source of the Blue Nile River, a huge habitat for diverse species of birds and fishes (Aynalem & Bekele, 2011; Nagelkerke et al., 1995; Shiferaw & Yazezew, 2021; zur Heide, 2012). Asmare (2017) claims that there are 10 prospective fishing districts in which more than 5400 fishermen work both full- and part-seasons to support their families. Additionally, a significant portion of low-income households depend primarily on the lake's fish supply, while other households turn to wetland farming as a secondary source of income.

The lake region with over 37 islands is a UNESCO's biosphere reserve which has high tourist attractions in Ethiopia (Danbara, 2014; Goshu & Aynalem, 2017). Moreover, the wetlands of the lake have socio-economic and ecological benefits such as food and water supply, provision of construction materials, erosion regulation, water purification and storage, habitat for birds and pollinators, flood control, and climate regulation (zur Heide, 2012). The lake supplies irrigation water for the country's largest rice production region (Vijverberg et al., 2009). The water hyacinth (Eichhornia crassipes) is currently a significant issue in Lake Tana (Firehun, 2017; Van Oijstaeijen et al., 2020). The infestation is a current occurrence that has rapidly expanded throughout several parts of the lake's shorelines (Fahser et al., 2015). The dense carpets of water hyacinth disrupt economic activities and negatively influence the indigenous aquatic biodiversity since they block sunlight from reaching the aquatic ecosystem (Gichuki et al., 2012). It also disrupts transportation and seriously affects urban and industrial water supply and irrigation through clogging pipes and canals (Patel, 2012).

The assessment of water hyacinth coverage conducted in August 2017 revealed 5,396 ha of land coverage, of which 481 ha of water were covered only in the two communes of the Fogera district, Nabega and Wagetera (Environment, Forest, and Wild Life Protection and Development Authority, 2018). Besides, the weed can grow throughout the entire year in the tropical and subtropical climate zones, and its seed can stay viable for up to 28 years (Shaohua Yan & Jun Yao Guo, 2017).

The infestation of freshwater bodies with the weed poses different problems for many human uses (Kateregga & Sterner, 2009). Once established, it is extremely difficult to eradicate because of its fast growth rate in which its size of infestation can double as little as in 8 days at favourable circumstances (Australian Weeds committee, 2012; Villamagna & Murphy, 2010).

Additionally, it affects hydro-power operations, tourism and its dense mats influence fish production by either diminishing fish population or obstructing the way to fishing grounds (Shaohua Yan & Jun Yao Guo, 2017). Nowadays, in the north-eastern part of Lake Tana, particularly, around the shore areas, fishing has become tiresome as a consequence of this invasive weed. Since the weed expansion hinders fishing activities, for instance, fishers in Nabega village in Fogera district shift their landing site to the nearby district of Libokemkem (Asmare, 2017). The weed also creates favourable growth condition for mosquitoes, and snail species known to host a parasitic flatworm which causes bilharzia (zur Heide, 2012).

Consequently, in the efforts of water hyacinth control in Lake Tana, health problems such as threats of bilharzia, leech bites, and malaria were observed (Edward R., 2013). It also created an extra burden on the inadequate health services and facilities available to the rural communities in least-developed countries like Ethiopia (Firehun, 2017). Furthermore, if a well-designed and organized preventive strategy is not followed, the expansion of water hyacinth could endanger the sustainability of Lake Tana (Asmare, 2017). The infestation also results in high wastage of water through evapotranspiration, which can be up to three times greater than the normal evaporation of open water (Sasaqi et al., 2019).

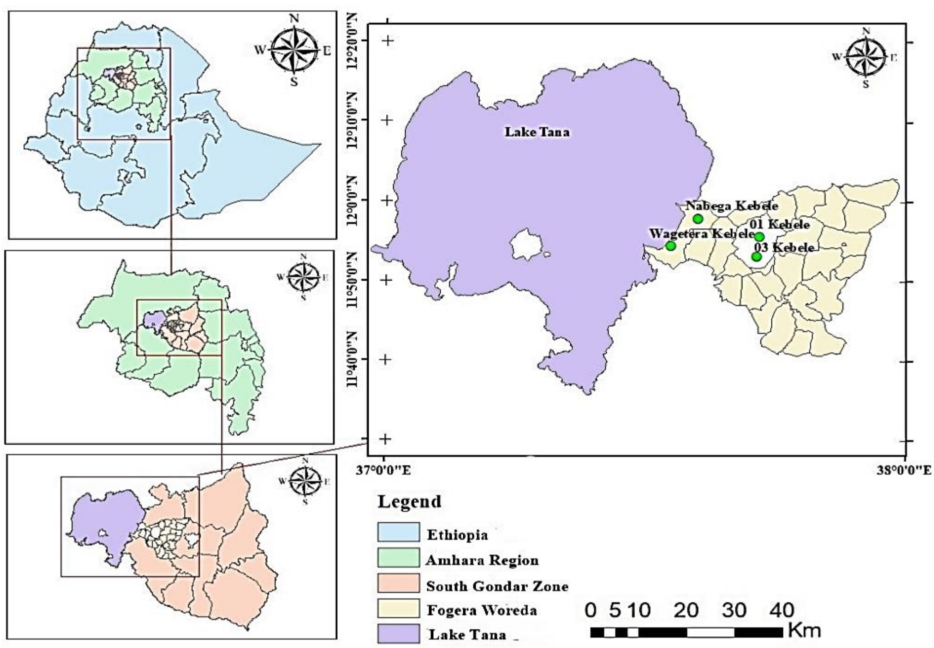
The manual removal of water hyacinth is one of the most efficient weed control methods. . However, using labor to control the weed requires careful planning and sustained effort (Australian Weeds Committee, 2012). Wassie et al. (2015) suggested that a significant amount of public resources, including money and labor, are needed to manage the weed in Lake Tana. Once during the first year of the study, district officials conducted a water hyacinth clearing effort. During the course of the operation, it was discovered that removing the weed from the lake in a single campaign was difficult due to its quick development and spread. Yet, good coordination of the utilization of the available resources, such as money and manpower, by the locals is necessary if the weed is to be properly controlled for a longer period. Through the purchase of additional weed harvesters, the hiring of additional experts to manage the weed, and the hiring of full-time workers to physically remove the weed, the creation of public awareness about the dangers of water hyacinth using various media, labour and financial resources can contribute to improving water hyacinth removal. Yet, prior actions taken by the local administration apparently failed to consider how willing the local people were to contribute time, labour and money to the weed eradication effort. Therefore, this study aims to identify determinants that influence households' willingness to pay (WTP) for the intervention and to estimate the mean monthly amount of cash and man-days they are willing to pay or contribute for the control of water hyacinth weed on Lake Tana.

2. Methodology

2.1. Description of the study area

The study was conducted in Fogera district, in the South Gondar administrative zone of the Amhara National Regional State of Ethiopia (Figure 1). The district comprises a huge portion of the Lake Tana and Fogera floodplain. The floodplains is an important international ecological resource recognized by the Important Bird Areas (IBAs) for its support of globally threatened bird species (zur Heide, 2012). According to the report of the Amhara Region Environment, Forest, and Wild Life Protection and Development Authority (2018), the district is one of the six water hyacinth-infested districts where the two sample *kebeles*, namely *Wagetera* and *Nabega*, are located.

Figure 1: Map of the study area



2.2. Data source and sampling

Primarily, the data used in this study were collected using face-to-face interviews, focus group discussions (FGD), and key informant interviews. The face-to-face interview was conducted using structured questionnaire. The survey questionnaire was pre-tested on a few pilot households. Then, the final survey was administered on January 2018. A secondary set of data, obtained from the Fogera Woreda Office of Agriculture (FWOA) and the Woreta town administrative office, was also used to complement the primary data.

Sample households were drawn using a two-stage sampling technique. In the first stage, two *kebeles*, namely, Wagetera and Nabega *kebeles*, were selected from a total of 33 rural *kebeles* of Fogera district purposively for their larger water hyacinth coverage. Moreover, two additional *kebeles* (01 and 03) were selected from four *kebeles* of Woreta town, which is the capital of the district, randomly. In total, the study covers two *kebeles* from the rural population and two from the urban community. In the second stage, a simple random sampling technique was utilized to draw representative households.

The study used 276 representative samples from 62,293 total households of Fogera district including Woreta town. Sample size was determined using Yemane formula (1967) With a 95% confidence level and ± 6% margin of error, the sample size was determined as follows:

$$n = \frac{N}{1 + N(e^2)} = \frac{62{,}293}{1 + 62{,}293(0.06^2)} = 276.54 \approx 276 \; - - - (1)$$

Where n= Sample size, N= total household, e = the sampling error or the level of precision (0.06).

Table 1: Proportion of sampled households in the sampled kebeles

Sampled kebeles	Total household size	Sampled households
Nabega	2,246	67
Wagetera	2,871	53
01 kebele	4,773	110
03 kebele	1,970	46
Total	**11,860**	**276**

Source: Survey data, 2019

Three FGDs were conducted in December 2018. FGD 1 was conducted in Wagetera kebele with 15 individuals including 2 district leaders and one kebele leader, FGD 2 was conducted in Nabega kebele with 10 individuals, and FGD 3 was held in 01 kebele with 11 individuals from different age, sex, and literacy groups. Besides, five key-informant interviews were also conducted. The key informant interview was conducted to get in-depth information regarding the water hyacinth removal efforts, experience, and problems caused by the weed expansion. The participants were selected in collaboration with Fogera district office of Agriculture, Water hyacinth control wing of the Amhara region Environment, Forest and Wild Life Protection and Development Authority, and development agents in Nabega and Wagetera *kebeles*. The main survey was conducted from January 02, 2019 to January 27, 2019.

Furthermore, a pilot survey was conducted on 17 randomly selected households to develop a hypothetical market scenario for the contingent valuation method (CVM). Following the survey, three initial bid values for both payment methods (cash and man-days) were identified as ETB 10, 20, and 30 per month, and 2, 4, and 6 man-days per month to be extended for two consecutive years. These initial bid values were equally distributed among the questionnaires. Then, the questionnaires were randomly distributed among the respondents. This will allow the researchers to trace out the distribution of WTP for the proposed project (Carson, 2000).

The elicitation of the WTP for controlling water hyacinth in two consecutive years for this proposed project was initially adapted from the five-years (2012-2015) management plan of the Lake Tana Biosphere Reserve (Fahser et al., 2015). In this plan, the scheme of removing of water hyacinth was planned to be applied for two consecutive years. Moreover, before adopting it for this study, it was discussed with FGDs and pretested to check its relevance.

2.3. Estimation strategy

Recently, households' WTP for water hyacinth control was investigated by Tasew (2019) on Lake Tana, Ethiopia, and John et al. (2019) on Lake Victoria, Kenya. These studies mainly examined the WTP in terms of money but not labour. However, rural households are highly cash-constrained decision-making units with regard to nature conservation (M. Tilahun et al., 2015). Unlike most related preference valuation studies, which were conducted either using monetary payment (Berhan.Asmamaw et al., 2017; John et al., 2019; Mezgebo et al., 2013;

Tasew, 2019) or labour contribution (Asmamaw et al., 2016; Belay, 2018), this study used both cash and labour contribution as payment vehicles to elicit households' WTP. The reason to use labour contribution as an alternative payment method is to address the issue of cash scarcity in the study area context, which may mislead the study result to an underestimation of its value. The addition especially provides more flexibility to the resource exchange scenario in cash-scarce rural contexts, as suggested in the study (Gibson et al., 2016; Schiappacasse et al., 2013). Besides, the study used urban and rural households together to examine their preferred mode of payment for the proposed water hyacinth control strategies. As suggested by Tasew (2019), about 98% of the households near Lake Tana had positive WTP for water hyacinth control. Similarly, a CV study by John et al. (2019) estimated the willingness to pay of Fisher Folks' in Lake Victoria, Kenya found out that a mean WTP of US$1.75 per month was needed for the improved management of water hyacinth. The study also indicated that income, sex, and perceptions about water hyacinth infestations had a positive influence on maximum WTP, whereas age, experience, distance from the place of residence to the nearest fishing ground, and membership in a fishing group had a negative influence on WTP of the Fisher folks.

Use and non-use values of ecosystem services can be measured using conjoint, choice experiments, and contingent valuation methods (CVM) (Loomis et al., 2000). However, CVM was used in this study as it is the most widely used valuation technique and has the ability to estimate total values by directly asking the respondents about the value of the good to be used for economic analysis (Carson, 2000; Van Oijstaeijen et al., 2020). It is called “contingent” since individuals are asked to state their WTP contingent on a hypothetical scenario presented in a survey (Anderson, 2013). This method requires respondents to directly state their WTP for non-use values rather than infer them from observed behaviours in regular marketplaces (FAO, 2000).

According to Barry (2016), the basic steps in a CVM are: identification and description of the environmental quality characteristics or change, identification of sample respondents; design and application of a survey questionnaire; and investigation of results and aggregation of individual responses to estimate values for the group affected by the environmental change. Following this, we developed a double-bounded elicitation question format followed by an open-ended question to elicit the WTP of respondents. The repeated question that comes from this method increases the efficiency of WTP elicitation (Hoyos & Mariel, 2010). According to Haab and McConnell (2002), the double-bounded format is statistically more efficient than the single bounded format for three reasons. Firstly, the number of responses increases due to repeated questions. Secondly, it is used to constrain the distribution of WTP even when it does not bind it completely (in the case of Yes-Yes or No-No). Finally, in the case of Yes-No or No-Yes responses, there is a clear bound in WTP responses.

The double-bounded questions were asked to the respondents, starting with asking whether they would be willing to pay an initially offered bid amount, requiring a "yes" or "no" response. If the response was "yes" for the first offered bid, then the respondent will be asked if he or she will be willing to pay for a higher amount (the initial bid plus its half); but if the response is "no" for the first offered bid, then the respondent will be asked if s/he will be willing to pay for a lower value (half of the initial bid value). After these double-bound questions, an open-ended question was followed to capture respondents' maximum WTP in cash and man-days for the proposed project. This elicitation method is similar to the real market situation in Ethiopia, where buyers and sellers negotiate with each other on the price of a given good. The open-ended WTP question was used to elicit the maximum amount of cash and man-days they would like to pay for control of the water hyacinth weed infestation on Lake Tana. The result from this format was used for two purposes: (i) to compare the mean WTP with the result of the dichotomous choice elicitation format and (ii) to sketch the aggregate demand curve for the proposed hypothetical program. The dummy results from the first bid will be used to identify the determinants of households' willingness to participate in the proposed project.

A probit model was used to identify factors that affect households' WTP in terms of monetary payments and labour contributions. Assuming a normal distribution of the error term, following Hanemann (1984), the probit model can be specified as follows:

$$y^* = x \cdot \beta + \epsilon_i \quad \textbf{(2)}$$

$$Y_i = 1 \; if \; Y^* \geq t_i{}^* \quad \textbf{(3)}$$

$$Y_i = 0 \; if \; Y^* < t_i{}^* \quad \textbf{(4)}$$

Where: Y^* = unobservable (for the researchers) households' actual WTP for the proposed project. It is simply a latent variable, β' = a vector of unknown parameters of the model, x_i = is a vector of explanatory variables, Y_i = discrete response of the households for WTP, t_i^* = the offered initial bids assigned arbitrarily to the i[th] respondent, ε_i = unobservable random component of the model which is normally distributed.

To estimate the mean WTP from the double-bound dichotomous elicitation method, the bivariate probit model was used for WTP in cash and labour. Following Greene (2012), a bivariate probit model can be specified as follows:

$$y_1^* = \beta_1 x_1 + \varepsilon_1 \quad \textbf{(5)}$$

$$y_2^* = \beta_2 x_2 + \varepsilon_2 \quad \textbf{(6)}$$

$$E\,(\varepsilon_1 | x_1, x_2) = E(\varepsilon_2 | x_1, x_2) = 0 \quad \textbf{(7)}$$

$$Var\,(\varepsilon_1 | x_1, x_2) = Var\,(\varepsilon_2 | x_1, x_2) = 1 \quad \textbf{(8)}$$

$$Cov\,(\varepsilon_1, \varepsilon_2 | x_1, x_2) = \rho \quad \textbf{(9)}$$

Where, y_1^*= i^{th} respondent unobservable true WTP at the first pre-specified bid; y_2^* = i^{th} respondent unobservable true WTP at the second pre-specified bid ; x_1 *and* x_2 are the first and second bids offered to the respondents, respectively; ε_1 *and* ε_2 are the error terms that are identically and independently distributed random variables with zero mean; β_1 and β_2 are coefficients of the first and second bids offered, respectively and ρ (Rho) is the correlation coefficient, which is the covariance between the errors for the two WTP functions.
The mean WTP was estimated using the formula specified by Haab & McConnell (2002)

$$WTP = -\frac{\alpha}{\beta} \quad \textbf{(10)}$$

Where α = a coefficient for the constant (intercept) term, β = the coefficient of the 'bid' value posed to the respondent in the bivariate probit regression model. When the estimated correlation coefficients of the error terms in the bivariate probit model are assumed to follow normal distributions with a zero mean and are distinguishable from zero, the system of equations could be estimated as a seemingly unrelated bivariate probit (SUBVP) model. Therefore, in this study, we employed SUBVP to estimate the mean WTP of sampled respondents. For the open-ended CV survey data, the mean WTP can be calculated simply by averaging the maximum WTP amounts stated by the individual households for both cash and man-days. Moreover, data from this survey could possibly be used to draw the aggregate demand curve or latent demand curve by inferring households' WTP for the proposed project (Hanemann, 2018).

3. Results and Discussion

3.1. Description of responses

Before the WTP elicitation questions, individuals were asked if they would pay or contribute any amount of cash or number of man-days for the proposed project. Thus, yes-no questions were designed to assess the WTP status of the respondents in terms of cash and man-days. Based on the survey data, out of the total 276 randomly selected households, about 99.64% (275) of the respondents were willing to pay in terms of cash, labour-days and/or awareness creation (about the problem of water hyacinth and the benefit of environmental conservation). Thus, from a total of 275 willing households, 222 (about 81%) of respondents were willing to pay in terms of cash, 178 (about 65%) were willing to participate in terms of days of labour, and 96 (about 35%) households were willing to participate in terms of awareness creation (Table 2 and Figure 2).

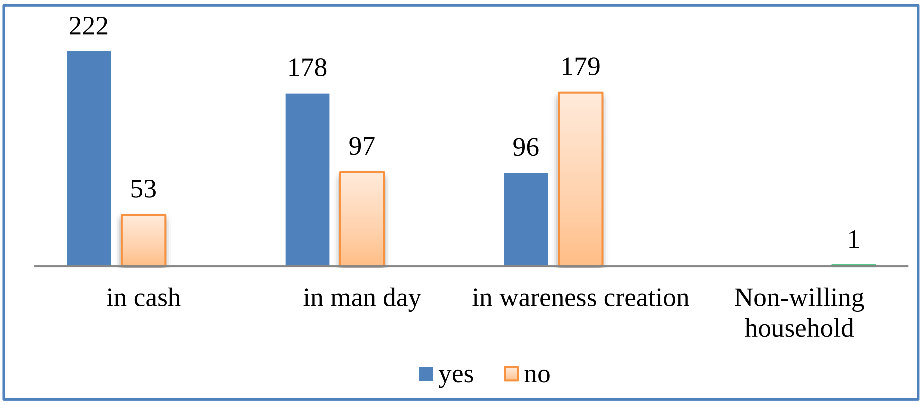
Table 2: Respondent's distribution in terms of their WTP status

Modes of participation for willing Households	Proportion of willing (%)
Money only	28.3
Money and Labor	18.8
Money and Awareness creation	6.9
Money + Labor + Awareness creation	26.5
Labor only	17.7
Labor and Awareness creation	1.4
Total	99.6
Non-willing to pay	0.4
Total	100

Source: Survey data, (2019)

Households were also categorized based on their joint responses to the initial and follow-up offered bids (the response to the three randomly distributed bid sets). Out of the total 275 respondents, 44% of households accepted both the initial offered bid and the increased follow-up bids (yes-yes) for WTP in cash, whereas about 26% of households accepted both bids (yes/yes) in man-days contribution. The percentage of households that accepted the initial bid but not an increased follow-up bid (yes/no) was found to be about 25% for WTP in cash and 21% for WTP in man-days contribution. The percentage of households that rejected the initial bid but accepted a decreased follow-up bid (no-yes) was found to be 12% for WTP in cash and 17% for WTP in man-days contribution. The last category in which respondents rejected both the initial bid and the discounted follow-up bid (no-no) accounts for 19% of the households for WTP in cash and 36% of the households for WTP in man-days contribution.

Figure 2: Respondent's distribution summary in terms of their WTP status



Source: Survey data, 2019

As a response to a separate question to identify the reasons for the refusal, 19% in the monetary case and 36% in the labour case responded that they had a low level of income and could not pay for the proposed project. As a result, they were categorized as genuine zeros.

3.2. Willingness to pay

Based on the formula specified by Haab and McConnell (2002), the mean WTP in cash for the removal of water hyacinth from Lake Tana was estimated to be ETB 26.41 per month per household to be extended for two consecutive years, with a range of ETB 25.03 to ETB 27.79 at a 95% confidence interval based on the result of a seemingly unrelated bivariate probit model (Table 3). In other words, the average respondent would be willing to pay ETB 26.41 per month of their total annual household income to support this proposed project.

Table 3: Seemingly unrelated bivariate probit model estimation for mean WTP in cash

Variables	Coefficient	Standard Error
Initial Bid (BID1)	-0.076***	0.011
Constant	2.100***	0.266
Second Bid (BID2)	-0.026***	0.006
Constant	0.651***	0.146
Rho	0.376	0.102
No. of observations	275	
Log- likelihood=-318.502	Likelihood-ratio test of rho=0:	
Wald chi2(2)=58.60	chi2(1) = 11.552	
Prob> chi2=0.0000	Prob > chi2 = 0.0007	

*** Represents statistical significant at 1% (Source: Survey data, 2019)

In the labour contribution case, the estimated mean WTP in man-days for control of water hyacinth weed infestation on Lake Tana was estimated to be 3.23 man-days per month per household, to be extended for two consecutive years. At a 95% confidence interval, the mean WTP for this proposed project varies from 2.93 to 3.52 man-days per month per household based on the result of a seemingly unrelated bivariate probit model (Table 4). That is, the average respondent would be willing to pay 3.23 man-days per month from their total annual working labour-days to support the proposed project.

Table 4: Seemingly unrelated bivariate probit model estimation for mean WTP in man-days

Variables	Coefficient	Standard Error
Initial Bid (l_Bid1)	-0.192***	0.044
Constant	0.678***	0.187
Second Bid (l_Bid2)	-0.205***	0.038
Constant	0.601***	0.163
Rho	0.692	0.100
No. of observations	275	
Log- likelihood= -351.938	Likelihood-ratio test of rho=0:	
Wald chi2(2)= 41.86	chi2(1) = 24.620	
Prob> chi2= 0.0000	Prob > chi2 = 0.0000	

*** Represents statistical significant at 1% (Source: Survey data, 2019)

3.3. Aggregate revenue and demand

The estimated mean WTP from money and labour contributions was used to estimate the aggregate benefits of this proposed project. The mean WTP was multiplied by the total number of households expected to have valid WTP responses in the aggregation of WTP for the sampled households and the total population of the study area. In other words, the proportion of the protest zero was omitted in the calculation of total WTP. Thus, the calculated total WTP amount from sampled households for each sampled *kebeles* of the study area is presented in Table 5. Thus, the total WTP for the four sampled *kebeles* was estimated to be ETB 3,745,365 per year and 457,784 man-days per year, which is equivalent to ETB 27,467,045[4] per year.

[4] It was calculated by multiplying the total WTP in man-days with the current minimum wage rate (ETB 60) in the study area at the time of data collection. In this study, all of man-days contribution was converted to ETB by using this wage rate.

Table 5: WTP aggregation in cash and man-days for sampled households by kebeles

Payment Mode	Kebeles	Total HHs	Expected HHs to have a protest zero[1]	Expected HHs with valid responses[2]	Mean WTP per month	Mean WTP per year	Aggregate benefit per year
Cash	Wagetera	2,246	8	2,238	26	316.94	709,327
	Nabega	2,871	11	2,860	26	316.94	906,469
	Keb. 01	4,773	17	4,756	26	316.94	1,507,400
	Keb. 03	1,970	7	1,963	26	316.94	622,167
	Total	11,860	43	11,817			3,745,365
Labor	Wagetera	2,246	8	2,238	3	38	86,698
	Nabega	2,871	11	2,860	3	38	110,794
	Keb. 01	4,773	17	4,756	3	38	184,244
	Keb. 03	1,970	7	1,963	3	38	76,045
	Total	11,860	43	11,817			457,784

Source: Survey data, 2019

[1] The proportion of a protest bidder in the sample (1/276 household in this study) times the total population of each sampled kebeles. For example, (1/276)*2,246=8 expected protest bidders in *Nabega kebele*.
[2] The total households of each kebeles minus the corresponding number of expected protest bidders.

Moreover, as shown in Table 6, extrapolating the estimated mean value to the whole households in the study area, aggregate WTP was estimated to be ETB 19,671,963 per year and 2,404,441 man-days per year, which is equivalent to ETB 144,266,489 per year.

Table 6: WTP aggregation in cash and man-days from close ended questionnaire format

		Modes of payment	
		Cash	Labor
Total HHs	62,293		
Expected HHs to have a protest zero[1]	226		
Expected HHs with valid Responses[2]	62,067		
Mean WTP per month		26.41	3.23
Mean WTP per year		316.94	38.74
Aggregate benefit per year		19,671,963	2,404,441

Source: Survey data, 2019

Besides, for comparison purposes, the aggregate benefits were also computed from the open-ended CV data. The result demonstrated that the amount of cash that the households would contribute for the proposed project ranges from 0 to 100 ETB per month per household, to be extended for two consecutive years. In the case of labour contribution, the number of man-days that the households would contribute to the proposed project ranges from 0 to 10 person-days per month per household, to be extended for two consecutive years. The average amount of money that respondents were willing to pay in the open-ended WTP format was estimated to be ETB 19.24 per household per month. On the other hand, the mean WTP in man-days was 2.89 per month per household.

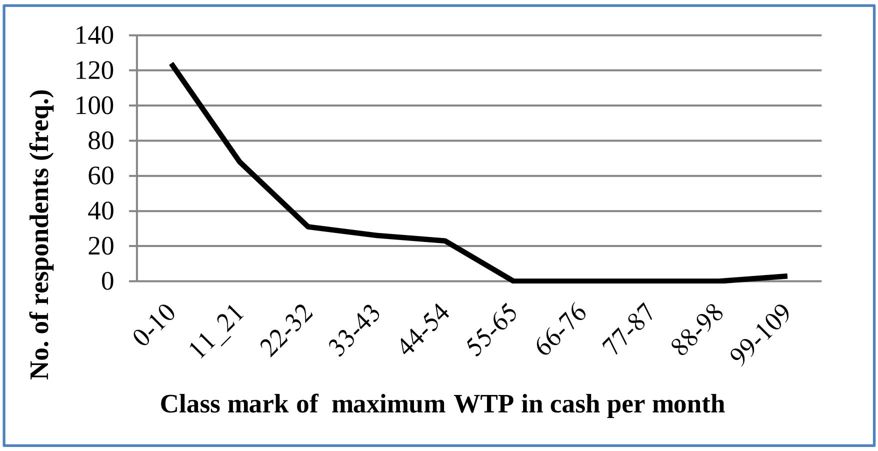
According to Cameron et al. (2002), the result from dichotomous choice methods produces estimates that tend to be larger, and the WTP ratio between dichotomous choice and open-ended methods generally seems to range between 1.1 and 5, even if there are some exceptions. Thus, from this study, we can notice that the WTP amount from the result of the dichotomous choice method was larger than the WTP amount from the result of the open-ended method in both

[1] The proportion of a protest bidder times the total population (1/276)*62,293 =275.699≈276
[2] 62,293-276 = 62,067

payment mechanisms. This might be due to the human beings free-riding behaviour, enjoying the benefits of conservation activities at the expense of others. Moreover, the mean WTP ratios between dichotomous choice and open-ended formats were 1.37 and 1.12 for the WTP in cash and the WTP in man-days, respectively.

The open-ended CV data were used to estimate the latent aggregate demand curve for the proposed project in Figures 3 and 4 for cash payment and labour contribution, respectively. In the two figures, the frequency curve measures the total number of households along the vertical axis and the amount of birr, or number of man-days per month, stated by the households along the horizontal axis.

Figure 3: The frequency curve from elicited maximum WTP in cash

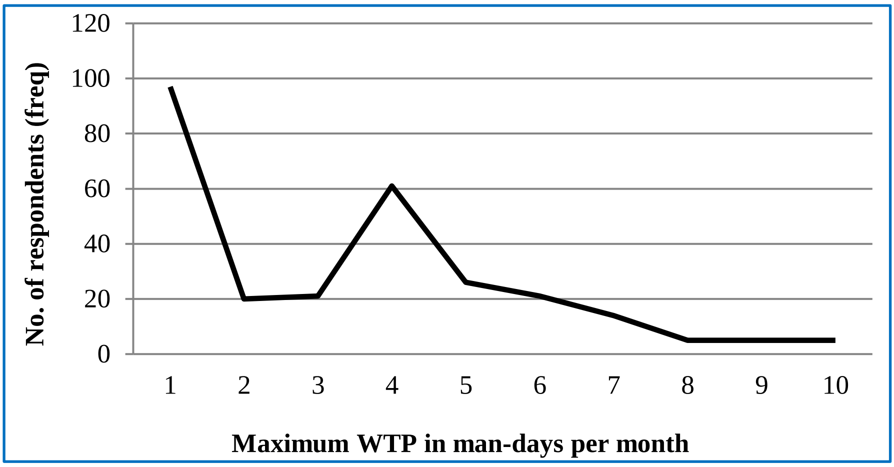


Source: Survey data, 2019

Nevertheless, the demand curves sketched from this study did not look like the usual aggregate demand curve since WTP responses are likely to vary depending on an individual's characteristics. However, in the case of marketable goods, the price of the good is equal to its marginal value, which is consistent across individual characteristics. In figures, the fitted linear trend line shows that, on average, the proportion of respondents gets lower when the bid amount in both cash and man-days gets higher which conforms to the law of demand.

From the open-ended data format, the total perceived welfare benefit in cash for the proposed project of the total population of the study area was computed to be ETB 1,122,171 per month and ETB 13,466,056 per year. On the other hand, the aggregate WTP in man-days for this proposed project for the total population of the study area was computed to be 109,689 man-days (ETB 6,581,359) per month and 1,316,271 man-days (ETB 78,976,307) per year. It is summarized in Table 7 and Table 8 for WTP in cash and man-days, respectively.

Figure 4: Frequency curve of respondents for maximum WTP in terms of man-days



Source: Survey data, 2019

Table 7: WTP aggregation in cash from open-ended questionnaire format

Class limit (WTP in cash/month)	Class mark	Sample HH		Total HHs	
		Freq.	%	Freq.	Total WTP
0-10	5	124	45.09	27,986.6	139,932.87
11-21	16	68	24.72	15,347.5	245,559.62
22-32	27	31	11.27	6,996.64	188,909.37
33-43	38	26	9.45	5,868.15	222,989.80
44-54	49	23	8.36	5,191.05	254,361.85
55-65	60	0	0	0	0
66-76	71	0	0	0	0
77-87	82	0	0	0	0
88-98	93	0	0	0	0
99-109	104	3	1.09	677.09	70,417.83
Total		275		62,067	1,122,171.36
WTP per year					13,466,056.32

Source: Survey data, 2019

Table 8: WTP aggregation in man-days from open-ended questionnaire format

No. of man-days/month	Sample HH		Total HHs	
	Freq.	%	Freq.	Total WTP
0	97	35.27	21,892.72	0
1	20	7.27	4,513.96	4,513.96
2	21	7.63	4,739.66	9,479.32
4	61	22.18	13,767.58	55,070.35
5	26	9.45	5,868.15	29,340.76
6	21	0	0	0
7	14	0	0	0
8	5	0	0	0
9	5	0	0	0
10	5	1.81	1,128.49	11,284.90
Total	275		62,067	109,689.32
WTP per year				1,316,271.79

Source: Survey data, 2019

3.4. Determinants of WTP

From the binary probit model estimations, the initial bid value (BID1) and total household size (HH_SIZE) were found to have a significant influence on both the probability of households' WTP in cash and labour. However, the age of the household head (AGE) and trust in the government (TRUST) had a significant effect merely on households' WTP in cash, whereas the dependency ratio (D_RATIO), annual household income (INCOME), and households' place of residence (RESIDENCE) had a significant influence only on the probability of WTP in labour (Table 9).

The result has revealed a negative and significant effect of the initial bid value in cash and man-days at the 1% level of significance. This tells us that with an increased initial bid, households would be willing to pay less for the proposed project. This result was consistent with the economic theory of the law of demand, in which the quantity demand for a good (water hyacinth control) decreases with an increased price of that good (cash and man-days). The marginal effect has revealed that as the initial offered bid increases by one unit, the probability of the households' WTP will decline, on average, by about 2.9%, keeping the effects of other things constant. The result of this study on the initial bid was similar to the findings of (Gowing et al., 2020; Mezgebo et al., 2013;

Wheeler & Damania, 2001). Adamu et al. (2015) noted that an increase in the initial bid amount results in a decreased level of WTP for the conservation of Yankari Game Reserve in Nigeria. Belay (2018) also found a similar result in his economic valuation of soil conservation in communal lands in terms of labour contribution. Moreover, the study by Tilahun et al. (2020) reported a negative influence of the bid price in cash and in the number of working days on WTPs reliability of irrigation service.

Total household size had a negative effect on households' WTP in cash, and it was statistically significant at the 1 % probability level. It might be due to the fact that an increase in household size leads to an increase in household expenditure, which might discourage respondents' WTP for this proposed project. As the results of the marginal effect revealed, holding other factors constant, an increase of 1 member in the household will decrease the probability of WTP, on average, by 6.6%. This result is in line with the findings of Dhungana (2018) and Walle (2015). However, solid waste management studies (Dika et al., 2019; Nkansah et al., 2015b) from Ethiopia and Metropolis, respectively, showed a positive effect of household size on WTP in cash. It was due to the fact that keeping a clean environment to protect the family from a disease may increase with an increase in the number of household members. On the other hand, total household size was found to have a positive and statistically significant effect on households' WTP in man-days at the 1% probability level. It might be due to the fact that an increase in household size leads to an increase in labour supply at the household level. This might make them willing to contribute more labour for the proposed project. As the result of the marginal effect output indicated, keeping other factors constant, an increase of 1 member in the household will increase the probability of WTP, on average, by about 6.6%. The study by Gebrelibanos (2016) found a similar result.

Age of the household head was found to have significantly a positive effect on the WTP in terms of cash at 5% probability level. This positive influence could be mainly due to the fact that older people might be more aware of the importance of environmental conservation due to their life experience and have an enhanced sense of place attachment and sense of ownership due to their longer residency in the area (Cheung & Hui, 2018; Song & Soopramanien, 2019). Moreover, they might have a chance to observe the deterioration of Lake Tana due to different factors, including water hyacinth weed. The marginal effect result revealed that, keeping the other factors constant at their mean value, an increase in the age of respondents by one year will increase the probability of WTP, on average, by about 1.1 %. Similar findings were found in Harun et al. (2015), Mamat et al. (2013) and Nkansah et al. (2015a) noting that the age of the household head had a direct effect on people's WTP. But a critical review of other previous studies indicated both a negative and a positive effect of age on WTP. (Dagnew et al., 2012) in their study of WTP for improved urban waste management, for example, and (Halkos & Matsiori, 2012) in their study of WTP for coastal zone quality improvement indicated an inverse effect of age on WTP. However, Lindsay et al. (1992) found that older people were willing to pay more than younger people for coastal beach protection.

The trust of a household head toward the collector of the fund (the government) was positively related to WTP in terms of cash, and it was statistically significant at the 1% probability level. The possible explanation is that the likelihood of WTP in cash for the proposed project increases as the households trust the collector of the fund to put the contributed money in the right place. The marginal effect for this explanatory variable showed that households that responded 'yes' to the trust variable were more likely to be willing to pay than those that responded 'no', on average, by about 20.3% by keeping other variables constant. The result from this paper is in line with the study of Cvetkovich and Winter (2003), which indicated that a high level of institutional trust produces a positive influence on the acceptance of environmental policy.

At a 5% probability level, dependency ratio had a significant negative effect on the probability of WTP in man-days. The marginal effect of this variable indicated that as the dependency ratio increased by one unit, the households' probability of WTP in man-days decreased, on average, by about 7%, holding the effects of other factors constant. The possible explanation could be that households with higher numbers of dependents might find it more tiring to help their dependents rather than participate in such environmental conservation activities. Similar findings were reported by other studies (Belay, 2018; Endalew & Assefa Wondimagegnhu, 2019). Tilahun et al. (2020) also showed that a higher dependency ratio may decrease the probability of willingness to contribute to reliable irrigation service in Ethiopia.

At the 1% probability level, total annual household income was found to have a positive significant effect on the probability of households' WTP in terms of labor. The result indicated that the household with a higher income level was more likely to be willing to pay in terms of labour contribution since they could have two alternatives: participate directly as a labour force or to hire labourers on their behalf of them in harvesting the weed on the lake. This result conforms to other studies (Kanyoka et al., 2008; Lagoon et al., 2019; Moffat et al., 2011) that found a positive influence of income on people's WTP. The study by Castro et al.(2016) reported that, as the level of income increased, people would be more willing to pay for ecosystem services among stakeholder groups in a south-central U.S. watershed.

Households' location of residence was found to have a positive and statistically significant effect on the probability of WTP in man-days at the 1% probability level. This indicated that rural residents were more likely to be willing to pay in labour than urban resident households for water hyacinth control in Lake Tana. Keeping the influences of other factors constant, the result of the marginal effect of the variable showed that being a rural resident household increases the probability of WTP in labour, on average, by about 7.4% relative to urban resident households.

Table 9: Determinants of WTP

	Probit			
Variables	**Money contribution**		**Labor contribution**	
	Coef.	**Marginal effect**	**Coef.**	**Marginal effect**
BID1	-0.092***	-0.029	-0.391***	-0.029
AGE	0.035***	0.011	-0.004	0.011
SEX	-0.168	-0.052	0.369	-0.052
MARITAL	0.252	0.083	-0.223	0.083
EDUCSTATUS	0.383	0.129	-0.289	0.129
HH_SIZE	-0.207***	-0.066	0.226***	-0.066
D_RATIO	0.220	0.070	-0.354**	0.070
INCOME	0.000	-0.000	1.233***	0.000
RESIDENCE	-0.231	-0.074	0.920***	-0.074
WH_VISIT	-0.296	-0.091	0.000	-0.091
TRUST	0.653***	0.203	-0.343	0.203
Constant	1.747***		-0.391	
No. of observations	275		275	
Chi-square	97.231		160.516	
Prob > chi2	0.0000		0.0000	

***, ** and * indicates statistical significant at 1%, 5% and 10%, respectively.

4. Concluding Remarks

Lake Tana is the largest freshwater resource in Ethiopia and the third largest lake in the Nile Basin (Vijverberg et al., 2009) It is an important environmental good that has economic, social, political, religious, and ecological benefits. Even if Lake Tana has great importance to Ethiopia and the globe, currently, it is infested by water hyacinth (Eichhornia crassipes) (Firehun, 2017; Van Oijstaeijen et al., 2020). The weed is spreading over many parts of the lake since it has a fast expansion rate and invasive behaviour (Anteneh, 2014b), and it poses different problems for many human uses in freshwater bodies (Kateregga & Sterner, 2009). Once established, it is extremely difficult to eradicate (Villamagna & Murphy, 2010). Thus, individual households should commit resources in terms of money and labour so as to reduce its effect on Lake Tana. Therefore, this study was aimed at examining households' WTP for control of water hyacinth in Lake Tana at *Fogera* district. The analysis was done at the household level using cross-sectional data from 276 randomly selected households. The study elicited households' WTP through the CV methodology using the double-bounded dichotomous choice format. The study used a binary probit estimation to identify the potential determinants of WTP for the proposed project. The result revealed that, from a total of 275 willing households, about 81% of respondents were willing to pay in terms of cash, about 65% were willing to participate in terms of days of labour and about 35% of households were willing to participate in terms of awareness creation.

The mean WTP in cash for this proposed project was estimated to be ETB 26.41 per month per household, to be extended for two consecutive years. Aggregate WTP was estimated to be ETB 19,671,963 per year. The average amount of money that respondents were willing to pay in the open-ended WTP format was estimated to be ETB 19.24 per household per month. From the open-ended data format, the total perceived welfare benefit in cash for the total population of the study area was computed to be ETB 1,122,171 per month and ETB 13,466,056 per year. The binary probit model estimation indicated that the age of the household head and trust in the government were found to have a positive influence on the probability of households WTP in cash whereas the initial bid price in cash and total household size were found to have a negative effect on the probability of WTP in cash. In the labour contribution case, the estimated mean WTP in man-days for control of water hyacinth weed infestation on Lake Tana was estimated to be 3.23 man-days per month per household to be extended for two consecutive years. Aggregate WTP in labour was estimated to be 2,404,441 man-days per year, which is equivalent to ETB of 144,266,489 per year. From the open-ended format, the mean WTP in man-days was 2.89 per month per household. From the open-ended WTP survey, the aggregate WTP in man-days for the total population of the study area was computed to be 109,689 man-days (ETB 6,581,359) per month and 1,316,271 man-days (ETB 78,976,307) per year. Moreover, the estimation revealed that the initial bid value in man-days and dependency ratio had a negative effect on the probability of WTP in labour. However, total household size, total annual household income, and households' place of residence were found to have positive influences.

From the result of this study, it could be concluded that there is a high degree of household willingness to participate in the proposed project in terms of cash and labour contributions. The estimated total WTP from this study can be considered the societal benefits of controlling this invasive weed on the lake and can be used in future cost-benefit analyses for policy formulation. However, the estimated mean WTP from the open-ended format was smaller than the close-ended format, which might be due to the human being's free-riding behaviour from the benefit of controlling water hyacinth at the expense of others. As the result of the econometric analysis indicated, households' WTP was negatively responded to with an increase in initial bid prices in terms of both cash and labour contribution, which is consistent with the economic theory of the law of demand. In addition to that, the income level of the households was positively related to the WTP in labour indicating that environmental good is a normal good for which demand increases with an increase in income level. Moreover, the place of residence makes a difference in choosing between money payment and labour contribution. The result indicated that rural households were more interested in labour contributions than in cash payments for water hyacinth infestation control in Lake Tana.

Following the findings obtained from this study, the following issues are forwarded as a recommendation.

1) The government should consider and design strategies to diversify households' income since it was positively related to WTP for the proposed project.
2) In valuing the conservation demand of Lake Tana from water hyacinth infestation, the policymakers should consider the modes of payments (cash and labour) in rural and urban areas, and elicitation formats of WTP.
3) The government also should consider its accountability and transparency in resource utilization for this proposed project since trust of households on the government was the most significant variable among the determinants of WTP in cash.
4) To suggest for future works, since this study was limited to the control of water hyacinth infestation in Lake Tana, it might be interesting to value on

the whole ecosystem of Lake Tana for its sustainable use. As this study indicated, there is a possibility of measuring households WTP in terms of awareness creation besides money payment and labour contribution. Thus, one can possibly use this methodology to measure WTP in terms of teaching per day. Moreover, since Lake Tana has a recognized national and international significance, one can measure the WTP of the people for the conservation of the lake beyond the near districts and towns as well as possibly outside Ethiopia. It is also interesting to study the impact of water hyacinth specifically on fishing, crop production, biodiversity, water transport and other benefits of Lake Tana or on the whole lake ecosystem in general.

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Determinants of Market Outlet Choices by Smallholder Tomato Producers in Mecha District Amhara National Regional State, Ethiopia

Tsigereda Sibhat[1], Asmamaw Alemu[2], Marelign Adugna[3], and Gebreegziabher Fentahun[4]

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Abstract

Tomato plays a significant role in increasing food security and income for the poor farmers of Ethiopia in general and Mecha district in particular. Tomato is a perishable vegetable product; market channel choice is a must to distribute the product in its freshness. To determine the sampling techniques used in the study, multi-stage sampling technique was applied. A simple random sampling technique was employed, to select 125 tomato producers in the study area. A multivariate probit model was employed to identify the factor affecting tomato market channel choices. The result of the multivariate probit model indicates that farming experience, total land size, distance to local markets, education level, land allocated for tomato, farm-gate price, non-farm activities, and market information have a significant impact on market outlet choices. The study findings highlight important development and policy implications include the need to improve farmers experience with tomato production and marketing, encourage adult education, expand the accessibility of market infrastructure and strengthen supportive institutions for credit access.

Key words: Tomato, Market outlet choice, multivariate probit model.
JEL Classification: Q1, Q2, Q3, Q4, Q5

[1] Department of Agricultural mics, Woldia University, Woldia, Ethiopia *(tsigeredasibhat04@gmail.com),
[2] Phd, Department of General forestry, University of Gondar, Gondar, Ethiopia.
[3] Department of Agricultural Economics, University of Gondar, Gondar, Ethiopia
[4] Department of Agricultural Economics, Bahir Dar University, Bahir Dar, Ethiopia

1. Introduction

Tomato (Lycopersicon esculuntum Mill) is one of the most popular vegetables in the tropics and sub-tropics have been grown all over the world (Geetha, 2011). The weather condition of Ethiopia is very important for tomato production and other vegetable crops, both during the rainy and dry seasons, by smallholder farmers, commercial state and private farms. It offers better economic returns to many farmers in Ethiopia, especially when it is grown during the wet season. It is mainly produced under irrigation during the off-season because, under rainy conditions, it is susceptible to a disease complex and perishable in nature. Successful cultivation of tomato is based essentially upon the choice of suitable varieties for a particular location (Desalegn et al., 2016).
Smallholder farmers produce tomato for long time for their livelihood needs and consumption since the start of its commercialization. But the average yield of tomato in Ethiopia is low, ranging from 6.5-24.0 Mg ha-1 compared with the average yields in most developed countries such as America, Europe, Asia, and the entire world; ranging from 51, 41, 36 and 34 Mg ha-respectively (FAOSTAT, 2010).

Tomato producers have also been challenged by inconsistent production and low yields due to seed type, lack of irrigation, biocide use, diseases, drought, and cold effects (Ambecha et al., 2015).

Mecha district is identified as one of the potential fruit and vegetable production areas in the West Gojjam zone due to its proximity to the Koga Irrigation and Watershed Management Project. Despite the huge production of tomatoes in the district, the value chain is not well developed. Given the perishable nature of the product and the absence of producers' organizations and a lack of corrective actions, the current marketing system might put smallholder producers in a disadvantaged position. The marketing linkage between actors is also not well developed. Huge post-harvest losses of the harvested tomato occur due to inadequate storage facilities, which bring substantial losses to the growers and hence to the national economy (Melaku and Getachew, 2016).

Various factors affect households' decisions to select market outlets for delivering their products to the market. Identifying these factors is very important in terms of identifying possible areas of intervention that may help farmers to maximize the benefits of their tomato marketing activities. Therefore, this study attempts to identify factors affecting market outlet choice decisions by tomato producers in the Mecha districts of West Gojjam zone Ethiopia.

2. Research Methodology

2.1. Description of the Study Area

The study was conducted in Mecha District, Amhara Regional State, due to the potential it has for tomato production. The district is known for its flat topography, which accounts for about 75% of the total area of the district. 13% of the area is characterized as undulating topography, and the remaining 8% and 4% of the area are covered by mountainous and valley topographies, respectively (Mola Tafere et al., 2011).

The total area of the study area (Mecha district) is about 156,027 hectares. From the total area, nearly 50% of this (72,178ha of land) is used for cultivation. Forest land and grazing land cover 18,547ha and 15,591ha, respectively. The land covered by water bodies' accounts for about 1,386 hectares. The soil type of the Mecha district is characterized as 93% red soil, 3% black soil, and 4% gray soil. The average land holding at the district level is 1.5ha per household and ranges from 0 to 3ha among the farmers in the district (Mecha district office of agriculture, 2018).

In the crop sub-sector, the main crops grown include maize, teff, finger millet, wheat, chickpeas, beans, and Niger seed. In the livestock subsector, cattle are dominant, and large numbers of poultry, sheep, and goats are also kept. Oxen, cows, heifers, bulls, calves, chickens, goats, and sheep are found in numbers in most households. Mecha has a production potential for vegetables because of the presence of irrigation water. The vegetables produced in this district are tomato, onion, pepper, shallot, potato, and cabbage (Fanos, 2014).

2.2. Source Methods of Data Collection, and Sampling Techniques

Both quantitative and qualitative types of data were collected from both primary and secondary sources. A cross-sectional survey was conducted using structured and semi-structured questionnaires. Key informant interviews and focus-group discussions were conducted with different stakeholders and organizations.

To draw the sampling units for the study, a multi-stage sampling technique was used. Mecha district has 33 kebeles, of which 7 kebeles are major growers of tomato. In the first stage, with the consultation of the district agricultural office experts, seven kebeles were selected based on the scope and gaps of research In the first stage, out of the seven major tomato growers, three kebeles in the district were randomly selected. In the second stage, from 4,100 tomato producers in the Mecha district (Mecha district office of agriculture, 2018), about 125 samples of household heads were randomly selected by using a simple random sampling technique.

A sample frame was developed by taking into account tomato collectors, retailers, and wholesalers in the main market sites: Merawi, Bahir Dar, and Bikolo. As a result, 50 tomato traders at different levels of the value chain nodes; 13 traders from Merawi, 29 from Bahir Dar, 8 from Bikolo were selected for this study according to the amount of tomato they have handled.

2.3. Method of Data analysis

Different studies used different empirical methods to analyze the determinants of the choice of marketing channels. Analytical approaches used to analyze the market outlet choice include discrete choice regression models such as the binary probit or logit (Bongiwe and Micah, 2013), multinomial probit or logit (Mamo and Degnet, 2012; Berhanu et al., 2013; Tewodros Tefera, 2014; Mukiama et al., 2014; Mekonen, 2017), and other empirical studies utilized Tobit (Anteneh et al., 2011).

In the study area, a multivariate probit model was applied for households choices of more than two market outlets and to jointly estimate several correlated binary outcomes also in this study. (Cappellari and Jenkins, 2003; Gujarati, 2004) on the choice of market outlets, while allowing for the potential correlations between unobserved disturbances as well as the relationships between the choices of different market outlets (Hailemariam et al., 2012).

Abay (2007) noted that in a multivariate model, where the choice of several market outlets is possible, the error terms jointly follow a multivariate normal distribution (MVN) with zero conditional mean and variance normalized to unity (for identification of the parameters) where (µy1, µy2, µy3) MVN~(0, Ώ) and the symmetric covariance matrix Ώ is given by:

$$\acute{\Omega} = \begin{Bmatrix} 1 & \rho y1y2 & \rho y1y3 \\ \rho y2y1 & 1 & \rho y2y3 \\ Py3y1 & \rho y3y2 & 1 \end{Bmatrix} \quad (1)$$

Consider the i^{th} farm household (i=1, 2…... N), making decisions on the choices of available market channels. Let U0 represents the farmer who directly sells for wholesalers, and let Uk represents the farmer who sells the tomato the Kth market outlet: where K represents a choice of wholesalers (Y1), retailers (Y2), and rural collectors (Y3). Producers who decide on choosing the Kth market outlet (maybe wholesalers, retailers, collectors, or consumers or all) if Y*ik = U*k-U0>0. The net benefit Y*ik that the farmer receives from choosing a market channel is an invisible (dependent) variable determined by the observed independent variable (Xi) and the error term (ϵi):

$$Y * ik = X'i\beta + \epsilon i \quad (K = Y1, Y2, Y3) \qquad \textbf{(2)}$$

Using the indicator function above, the unobserved preferences in equation (2) translates into the observed binary outcome equation for each channel choice of farmers as follows:

$$Yik = \left\{ \begin{array}{l} 1, \text{ if } \; Y^*ik>0 \\ 0, \text{ otherwise} \end{array} \right\} (K = Y1, Y2, Y3$$

2.4. Definition and Hypothetical Variables

Market outlet choices (MktC): It was measured by the probability of selling tomato to either of the markets involving different alternative outlets. It is represented in the model as Y0 for households who do not choose to sell tomato mainly to the base category, Y1 to that of tomato wholesalers, Y2 to that for retailers, Y3 to rural collectors.

Sex of the Household Head (SHH): Sex is a dummy variable that takes a value of 1 if the household head is male and 0 female. The variable is expected to have either a positive or negative relationship with market outlet choice. Both men and women participate in selling tomato using different market outlets to generate income. Bebe et al. (2012) indicated that the majority of female households in any farming area are resource constrained given that they do not own critical resources in vegetable marketing to obtain additional income. As a result, male household heads have more chances to choose the best market channel than female household heads.

Age of the household head (AGE): Age of the household, a continuous variable, is taken as one of the explanatory variables. The expected sign could be positive or negative; as age is one of the parameters of human capital. Households that are longer farmers in tomato production are believed to be wise in resource use, and it is expected to have a positive effect on the selection of the best marketing channel. On the other hand, older households may also be tradition-bound in taking up new technologies; in this sense, age may also negatively affect horticultural production and productivity.

Education level of the household head (EDUHH): **C**ategorical variable referring to the formal and informal education the household head attended. Educated people make better use of their time and available resources. Anteneh et al. (2011) studied whether the level of education of the household head significantly influenced the choice of coffee market outlet.

Land Size Allocated (AREATOM): This variable is assumed to have a positive relationship with the dependent variable and is a continuous variable measured in hectares. Solomon Asefa et al. (2016) found that total coffee land size is expected to have a positive effect on cooperatives and the formal market as compared to the informal market, which is also true for total land holding.

Improved seed (IMSED): It is a dummy variable that has a value of 1 if the HH uses an improved tomato seed variety and zero if not. The use of improved seed have a positive effect on the dependent variable in that if the farmer uses improved seed, the productivity is increased, and if the productivity is high, the farmer can produce more product and distribute it on the right channel. As noted by Arega (2006), almost all of the sampled farmers responded that, at present, new maize varieties are being used in the study area, which increases the productivity of their product. But if varieties with a low level of disease resistance give low yields per unit of area.

Chemical fertilizer (CHEMF): It is a dummy variable that has a value of 1 if a farmer uses chemical fertilizer and 0 if not. It has a positive relationship with the distributors in the selection of the best market outlet. Addisu (2016) found that the majority of producers used inorganic (chemical) fertilizer (DAP and Urea) depending on the land size allocated to vegetables and the soil fertility status as perceived by the producers, while some producers used organic fertilizer (manure and compost). The productivity status of both types of fertilizer is equal, but when we look at the cost-benefit analysis and the factor of fertilizer on soil fertility, organic fertilizer is chosen.

Distance to nearest market (DIS-MK): It is a continuous variable that is measured in kilometers, or the amount of time farmers waste selling their product to the market. Different studies (Adugna, 2009; Abay, 2007; and Rehima, 2006) indicated particularly, that rural communities in remote areas suffer from a lack of transportation facilities. If the producers are close to the market places, they would have minimized transportation costs and the time they spent selling the product. Therefore, it is hypothesized that this variable is negatively related to a marketable surplus of tomato and the best alternative market. Taye et al. (2017) stated that; farmers nearer to urban centers are more likely to be informed about the best destination and are willing to participate in the market and affect market outlets.

Farming experience (EXP): This is a continuous variable measured over a number of years. A household with a more experience in tomato production is assumed to produce more tomatoes and, as a result, to supply more tomatoes to the market. A study by Berhanu et al. (2013) explained that there is a positive relationship between experience in dairy farming and the choice of a more profitable milk marketing outlet. In this sense, farming experience affects the market outlet choice of producers.

Access to credit (CREDIT): This is a dummy variable that takes a value of one if farmers take the loan and zero otherwise, which indicates credit taken for tomato production and marketing. Access to credit would enhance the financial capacity of the farmer to purchase the inputs, thereby increasing tomato production and market share. Therefore, it is hypothesized that access to credit will have a positive influence on the level of production and sales. In this sense, farmers who could gain credit from different financial institutions can produce more. Adugna (2009) reported that credit is important to facilitate the introduction of innovative technologies and for input and output marketing arrangements.

Access to market information (MINFO): This is a variable proposed to influence the market supply of tomato positively. The variable is considered dummy. Assigning one if a farmer got information, and zero if not. A farmer who has better market information about the product market will make a better outlet choice. Mekonen (2017) found that access to market price information positively and significantly influenced the choices of both end consumers and cooperative outlets. This implies that a farmer who can gain coffee market price information increases the chance of choosing the best outlet.

Access to extension service (EXTENSTION): **T**his is a dummy variable that has a 1 value if a farmer had a contact with an extension agent for agricultural work supervision in production time and a 0 value otherwise. Mekonin (2017) stated that access to extension services negatively and significantly affected the choice of end consumer outlet.

Tomato lagged price (PRICETOM): This is also the variable measured in the log normalized price of tomato per quintal and is expected to affect the market outlet choice of tomato positively and significantly. Berhanu et al. (2013) found that milk prices affect accessing individual consumer milk market outlets positively as compared with accessing cooperative milk market outlets and negatively as compared with accessing hotel or restaurant milk market outlets.

Non/off Farm income (OFFARM): It is a dummy variable measured in terms of whether the household obtained income from farming and non-farming activities. It has the value of one if the household is involved in nonfarm activities and zero if not. The study hypothesized that earning from non-farm income is higher than vegetable production, primarily because farmers are shifting towards non-farm income activities. Farmers who gain more income from farming activities other than vegetables who would rather supply their vegetables to the nearest market outlet with low prices than go far. Hence, off/non-farm income is hypothesized to influence the farmers' decision in the choice of marketing channel. This is explained by the fact that as producers participate in non-farm activities, the time they have to spare for marketing agricultural activities and producing marketable surplus is less. This decreases the probability of participating in the whole sale market channel, which is a larger market compared to the retailer and assembler market outlet (Taye et al., 2017).

3. Results and Discussion

3.1. Characteristics of sampled households by market outlet choices

Sample households choose three alternative markets with different residents. About 109, 79, and 68 households have sold their products to rural collectors, wholesalers, and retailers alternative outlets, respectively. Out of those, about 32% select all three outlets to sell the product and to receive a better price from the alternative markets. Furthermore, 25% of the household chooses rural collectors due to proximity to the selling place (they purchase the product on the farm).

Table 1 depicts the proportion of smallholder farmers' characteristics by tomato market outlet choice. 52%, 44.8%, and 73.6% of male-headed households choose wholesalers, retailers, and rural collectors' outlets, respectively. Moreover, education level also affects the market outlet choice of the sample households. Also, education level and market information have a significant effect on the market outlet choice of the household head at a 5% and 1%

significant level, respectively. This indicates that most educated households (about 62.4% of them) choose rural farmers because most educated households produce different vegetables than tomato alone. Due to this reason, they have no time or effort to sell their products by transporting in long-distance markets.

Furthermore, a household with market information selects a wholesaler's market outlet over a household without market information because wholesalers purchase tomato in bulk and at a better price than traders and collectors.

Table 1: Proportion d household characteristics by tomato market channel choice

Variables	Category	Wholesalers (%)	Retailers (%)	Rural collectors (%)	χ2
Sex of the HHH	Female	11.2	9.6	13.6	
	Male	52.0	44.8	73.6	(1.40)
Education level	Illiterate	16.8	11.2	24.8	
	Read and write	33.6	33.6	45.6	
	Elementary	4.8	4.0	10.4	
	High school	4.0	3.2	4.0	
	College/university	2.4	1.6	1.6	(11.55)**
	Others/Religious	1.6	0.8	0.8	
Non/off farm activity	Yes	40.0	33.6	54.4	
	No	23.2	20.8	32.8	(1.00)
Market information	Yes	70.0	50.4	56.4	
	No	7.2	4.0	16.8	(10.80)***
Extension service	Yes	35.2	35.2	52.00	
	No	28.0	19.2	35.2	(1.26)

Note: ***, **, and* implies significant level at 1%, 5% and 10% respectively.

Table 2 also indicates that land allocated for tomato, distance to the nearest market, tomato lagged price, and farming experience affects the selection of market outlet choice statistically and significantly at a 10% significant level. It shows that a household with a large plot of land (about 0.87ha) selects the outlet that buys in bulk on the farm to reduce post-harvest losses during transportation. Also, households that produce tomato far from local markets (about 3.65km) select rural collectors rather than wholesalers and retailers (which are 3.53km and 3.49km away from the local market, respectively) to reduce transportation costs and the Perishability of the product.

The average lagged tomato market price offered by rural collectors market outlet was ETB 634.76ETB per quintal which is lower than the price offered by wholesalers and retailers lagged price of tomato which was 720.40ETB and 650.50ETB respectively. In terms of farming experience of household more experienced households in tomato production (about 7.63 years) select wholesaler market outlet chick offers a better price than other outlets.

Table 2: Mean household characteristics by tomato market channel choice

Variables	Mean (SD) of market outlet			
	Wholesalers	Retailers	Rural collectors	t-value
Land allocated for tomato	0.63(0.48)	0.54(0.50)	0.87(0.34)	9.88***
Distance to a local market	3.53(3.13)	3.49(3.28)	3.65(3.13)	31.85***
Tomato lagged price	720.40(305)	650.50(280)	634.76(205.98)	34.42***
Farming experience	7.63(1.48)	5.99(1.56)	4.54(1.51)	14.09***

Note: ***indicates at 1%, ** indicates at 5% and *implies at 10% significant level.

3.2. Marketing channels

Seven main alternative marketing channels were identified through which the tomato production in the study areas flows to the end users. These marketing channels were identified from the start of tomato production until the product reaches the end user of the product (the final consumer) through different intermediaries with a proportion of tomato marketed.

Channel I and Channel III were the dominant channels with the largest flows, where about 48.42% and 42.68% of the production flows to the end users, respectively. The smallest proportion of tomato (8.9%) was received by retailers (channel VII).

I. Producer → rural collector → wholesaler retailer → consumer
II. Producer → rural → collector → retailer → consumer
III. Producer → wholesaler → retailer → consumer
IV. Producer → rural collector → consumer
V. Producer → wholesaler → consumer
VI. Producer → retailer → processor consumer
VII. Producer → retailer → consumer

3.3. Determinants of market outlet choices

Empirical results of the multivariate probit models showed that the correlation coefficients of the error terms in the models had positive as well as negative signs, indicating that different market outlet choices are interdependent for the farmers. In other words, these opposite signs of the correlation coefficients revealed that there are complementarities (positive correlation) and competitive (negative correlation) between different market outlets option being used by the farmers.

Table 3 shows that the model fits the data and the Wald test was used to test the model fits, which was chi2 (27) =37.55, Prob > chi2= 0.0853 is significant at the 10% level, which indicates that the subset of coefficients of the model is jointly significant and that the explanatory power of the factors included in the model is satisfactory.

The likelihood ratio test of the null hypothesis of independence between the market channel decision ($\rho21 = \rho31= \rho32=0$) is significant at 1%. This shows that the goodness-of-fit of the model is hypothesized in that all the ρ (Rho) values are jointly equal to 0 is rejected, which implies that the decisions to choose these market channels are interdependent.

Table 3: Multivariate probit estimation for determinants of tomato market outlet choice

Variables	Wholesalers			Retailers			Rural collectors		
	Coef.	**Z**	**P>|z|**	**Coef.**	**Z**	**P>|z|**	**Coef.**	**Z**	**P>|z|**
Sex of the HHH (Male)	0.387**			0.095			0.152		
Education level	0.128			0.108			-0.362**		
Land allocated for tomato	0.134			0.679***			2.759*		
Farming experience	0.133*			0.066			-0.077		
Distance to local markets	-0.007			-0.185*			-0.085		
Extension service	-0.131			-0.129			-0.388		
Lagged price	0.001			0.001			0.004**		
Non/off-farm activities	0.216			0.117			0.749**		
Market information	-0.834**	-1.97	0.020	-0.806**	-2.18	0.034	0.727***	2.66	0.000
Constant	1.359	0.73	0.980	-0.288	-0.15	0.034	-3.128	-1.22	0.997
Predicted probability		0.632		0.544				0.872	
ρ 21									(0.510)***
ρ 31									(-0.395)**
ρ 32									(-0.730)***
Wald chi2(27)					37.55*				
Likelihood ratio test of independence				ρ21 = ρ31 = ρ32 =0, chi2(3) = 33.80 ***					
Joint probability (success)					0.331				
Joint probability (failure)					0.109				

Note: ***, **, and * significant at 1%, ** at 5% and * at 10% probability level respectively.

Therefore, the use of the multivariate probit model is justified to determine factors affecting the choice of market outlets. In addition, there are also differences in the decision-making behavior of marlet channel choice among farmers, which are reflected in the likelihood ratio statistics. The ρ values (ρij) indicate the degree of correlation between market outlet choice decisions.

The simulated maximum likelihood estimation results suggested that there was positive and significant interdependence between farmers selection of market outlet for wholesaler and retailers which implied that ρ21 (correlation between the choice of wholesaler and retailer market outlet) was positively significant at the 1% significant level. This indicates that farmers delivering to wholesalers are more likely to deliver to retailers than processors and consumers. The ρ31 (correlation between the choice for wholesaler and rural collector market outlet) and ρ32 (correlation between retailer and rural collector) are both negative and statistically significant at 5% and 1% significance levels respectively (Table 3). The study revealed that farmers who deliver to rural collectors are less likely to deliver to wholesalers (ρ31). Equally, farmers who are involved in the rural market outlet are less likely to send their tomato to the retailers (ρ32).

The simulation results indicate that the probability that tomato producers choose wholesalers, retailers, and rural collector market outlets was 63.2%, 54.4%, and 87.2%, respectively. The likelihood of choosing a retailer is relatively low (54.4%) as compared to the probability of selecting a rural collectors' market channel (87.2%) and wholesaler market channel (63.2%). This indicated that farmers were not interested in selling their products to the retailer market channel even if they got a better price than other market channels due to marketing costs such as transportation and to keep the product from damage (which may reduce post-harvest losses for producers).

The joint probabilities of success or failure in choosing the three market outlets suggest that households are more likely to jointly choose the three market outlets. The likelihood of households jointly choosing the three outlets is only 33.1%, but it's above the failure rate (10.9%). As depicted in Table 3 above, some of the variables used in the model were significant at more than one market outlet, while others were significant in one market outlet but not in the other outlet. This result indicates that choosing the right mix of market outlets is determined by different factors for each market channel. The finding was also consistent with Addisu Hailu's (2016) study on vegetable value chain analysis. He found that the joint probabilities of success and failure of the four variables also suggest that it would be unlikely for households to choose all four market outlets simultaneously.

Out of nine explanatory variables included in the multivariate probit model, three variables (sex, farming experience, and market information) significantly affected wholesaler market outlet; three variables (total land size, distance to local market, and market information) significantly affected retailer outlet; and five variables (education level, land allocated for tomato, tomato lag price, non-farm income, and market information) significantly affected collector market outlet choices at 1, 5, and 10 percent significant levels.

Sex of the households has a positive and significant value on choosing of wholesalers' market outlet at a 5% significant level. This indicates that as the number of male-headed households increased, the probability of smallholder farmers selling their product to wholesale market outlets would also increase by 0.387 percentage points. This is due to the fact that male-headed households have a large land size and near to information that brings them to produce much amount of tomato and selects best market channel than female-headed households. Mahilet et al. (2015) stated that male-headed households have better financial capability, better land size, better extension contacts, and better access to market information. Therefore, male-headed household heads supply more potato to the market as compared to female household heads.

Education level of households has a negative and significant effect at a 5% probability level on choosing rural collectors. This implies that, other things being equal, the probability of selling tomato to rural collectors' market channels would be decreased by 0.362 percentage points compared to the probability of selling to wholesalers and retailers market channels. The more educated a farmer is the less likely to sell their tomato through village traders because more educated farmers are close to market information on doing marketing activities. Rural collectors mostly purchase tomato on the farm at a cheap price to reduce other marketing costs like transportation. The negative relationship between education level and selling to rural collectors' outlets can be explained by the fact that being educated enhances the ability of farmers to make decisions with regard to the choice of marketing channel to sell their farm products based on the marketing margin and marketing cost. This is supported by Chala and Chalchisa (2017). Literacy decreases the probability of choosing the retailer channel for vegetable marketing and increases the probability of choosing the wholesaler market channel. This may be due to literate households being more aware of the market channel and able to get market information for their products and helps to choose the best market channel that expected to give better price for their produce.

Land holding for tomato production also affects the probability of choosing retailers and rural collectors' market outlets by 1% and 10% at significant levels, keeping other factors constant. An increase in land holding for tomato production by 1 hectar, increases the probability of choosing retailers and village traders' outlets by 0.679 and 2.759 percentage points, respectively. The positive sign on the land allocated for tomato variable showed that a farmer with large land allocated for tomato, compared to farmers with small tomato land sizes, would be more likely to sell to retailers and rural collectors. Retailers are large in number, and rural collectors purchase the product in bulk from farms. This is in line with Meron (2015) as the land holdings increase the farmers' plant more vegetables, yield increases, market participation also increases, and then the producers choose the best market channel. Solomon et al. (2016) found that the total coffee consumption of the household has a negative and significant effect on the preference for formal markets relative to informal markets.

The likelihood of choosing a wholesaler outlet was also positively and significantly affected by farming experience at 10% levels of significance. This result indicates that more experienced households in tomato production were more likely to deliver tomato to wholesaler outlets by 0.133 percentage points than the less experienced farmers. The more number of years engaged in tomato production and marketing gives the farmers a desire to adjust their market links; trying alternative marketing outlets to increase sales volume or better prices to maximize profits. Addisu (2016) found a similar result that experienced farmers had better knowledge on the cost and benefits associated with various potato marketing outlets; consequently, they are likely to increase the quantities supplied through the wholesalers' to benefit from economies of scale.

The likelihood of choosing a retailer's market outlet is statistically and negatively affected by distance to the local market at a 10% level of significance. This result shows that when the distance to the local market increased by one kilometer; the probability of choosing a retailer's market outlet would decrease by 0.185 percentage points while keeping other variables in the model constant. This is due to the fact that most producers prefer to sell their products at the farm gate without incurring transaction costs. They want to sell to wholesalers and rural collectors at the farm gate at fewer prices without marketing costs. But if they sold to retailers in the local market by incurring marketing costs, they would receive a large profit. As supported by Taye et al. (2017), the likelihood of choosing retailers and assemblers market outlets is statistically and negatively affected by distance to the nearest urban market at 10% and 1% levels of significance, respectively. This is due to the fact that most producers prefer to sell their products at the farm gate without incurring transactory costs. Delivering onion products to retailers requires transporting the product to urban markets to meet retailers. As a result, producers prefer to select other markets to deliver their products.

Lagged Price is associated positively and significantly at a 5% level of probability with choosing rural collectors outlet. A positive sign on its coefficient indicates that as last year's price of tomato increased by one birr, farmers were more likely to sell tomato to rural collectors by 0.004 percentage point while keeping other factors constant. This may be because producers choose to sell tomato to rural collectors on farm-gate to reduce marketing costs/transaction incurred on other outlets (wholesalers and retailers outlets). This is in line with Sigei et al. (2015): an increase in price by one birr increases the probability of selling the pineapple yield at the local market by 29.73%. This shows that farmers who sell their product at local market incur neither higher transaction costs nor poor prices such as urban traders and rural assemblers (farm-gate marketers).

Availability of off/non-farm income has a positive and significant relationship with the likelihood of choosing a rural collector outlet at 5% significant level. Farmers who have access to off/non-farm income have more probability (0.749 percentage points) to choose a rural collector outlet compared to those who have no access to off/non-farm income. The result may imply that producers with the availability of off/non-farm income have no time to sell their product to the nearest markets and sold to alternative outlets because of performing other off/non-farm activities instead of selling tomato on local market by taking full-time. Taye et al. (2017) found that an increase in cash resources will make the households invest more in onion production and marketing activities resulting to more surpluses driving them to sell to assemblers and retailers which is a larger market compared to a retailer.

Farmers' closeness to market information influences the likelihood of choosing wholesalers' outlet and retailers' outlet negatively at a 5% significant level, and influence likelihood of choosing rural collectors at 1% significant level positively. Households who are close to market information are less likely to sell their product to retailer (by 0.806 percentage point) and wholesaler (by 0.834 percentage point) outlets and are more likely to choose rural collectors market outlets (increased by 0.727 percentage point), keeping other factors constant. This shows that farmers close to price information, marketplace information, and information about customers want to sell their product to traders who buy in bulk and at a good price. Rural collectors buy a large amount of tomato on the farm without incurring marketing costs for producers. Contrary to this result, Kasa et al. (2017) found that access to current market information improves producers' selling prices, because market information helps producers to analyze the price difference between the local market and the nearby main market increases the probability of choosing outlets (retailers and consumers) which gives a relatively higher price to producers.

Alemayehu et al. (2016) found that access to market information has positively and significantly (at 5% level of significance) affected the amount of onion supplied to the market. This implies that if farmers get adequate, consistent, and timely price information, they will adjust their production accordingly and supply a sufficient amount of onion to the market.

4. Conclusions and Recommendations

The study focused on determining factors affecting tomato producers' market channel choices based on data collected from the smallholder producers in Mecha district, Amhara regional state, Ethiopia. Tomato market channel choice is the best way that the product gets to the consumers/end users through alternative outlets; and is also known as a distribution channel. A marketing channel is a useful tool for managing especially perishable farm products such as tomato, and is crucial to creating an effective and well-planned marketing strategy and marketing linkages in all areas. The main objective of the study is to investigate the factors that determine small-scale producers' marketing channel choices in the study area. Multivariate Probit Model (MVP) was employed to analyze the factors that determine the choice of tomato market channels. Tomato producers distribute their product through three alternative market channels according to their outlet choice decision but are correlated: the simulation results indicate that the probability that tomato producers choose wholesalers were (63.2%), a retailer (54.4%), and for rural collector market outlet (87.2%). The multivariate probit model results confirmed that sex, farming experience, distance to a local market, market information, education level, land allocated for tomato, tomato lagged price, non-farm income significantly affected the channel choices of tomato producers in the study area.

Based on the findings of the study, the following policy implications should be undertaken: establishment of farmers' cooperative organizations for marketing vegetables produced such as tomato in the study area and creating the linkage among the farmers and different financial institutions in the country to enable the access of raw materials used for tomato production and marketing of tomato where the demand for the product exists. Appropriate strategies and governmental and NGO policies should strengthen the existing provision of formal and informal education to the rural farming households in general and to the study area in particular; to improve the marketing alternatives among farmers the local government should facilitate rural infrastructures such as road, electricity, and health centers. Finally, improving the supply and demand of inputs and the end product is the most important element in strengthening the best alternative channels for distribution.

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