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Article

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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

Impacts of contract farming on asset accumulation of malt barley farmers in Northwestern Ethiopia

Abebe Dagnew^{1,2*}, Degye Goshu³, Lemma Zemedu⁴ and Million Sileshi¹

Abstract: Agriculture is the mainstay of the Ethiopian economy. Barley, including food and malt barley, is one of the major cereals produced by smallholder farmers. Though malt barley is the fastest-growing industry, demand is outpacing supply. As a result, Ethiopia is a net importer of raw malt barley. Recently, contract farming was implemented to address this issue in malt barley-potential areas. It has been one of the strategies utilized to enhance the commercialization of malt barley and replace imported malt barley, besides solving production and marketing challenges. The predicted results also include satisfying domestic malt barley demand, enhancing the welfare of smallholder farmers, and conserving the nation's foreign exchange. Although not thoroughly investigated, the research area has a low rate of CF participation and a low malt barley yield. Furthermore, previous research has focused on the CF impact of income, food security, and yield indicators of welfare, but no attention has been devoted to the implications of asset accumulation, which is a greater long-term indicator of welfare. Given the issues and research gaps identified, this study seeks to evaluate the impact of CF on malt barley farmers' asset accumulation in Northwestern Ethiopia. The data were collected from 398 samples in two districts, selected using multistage sampling techniques. The endogenous switching regression (ESR) model was used to account for bias coming from both observable and unobservable sources. For malt barley farmers, the average treatment effect on treated and untreated was 9652.7ETB and 7417.3ETB, respectively, and was significant at 1%. The base heterogeneities for CF participation and non-participation were 886ETB and -1349.4ETB, respectively. The average transitional heterogeneity was 2235.4ETB and statistically significant at 1%. Consequently, malt barley CF participation has a positive association with asset accumulation; this result supports transaction cost economic theory. Cooperative membership, off-farm employment, and age were all positively associated with the propensity to increase asset accumulation. The finding also reveals that land affected participants, whereas credit, household size, and farming experiences had a significant and positive effect on non-participants' assets. This shows that the asset accumulation of the two groups was determined by common variables with different magnitudes and different variables. Therefore, the concerned bodies should consider these heterogeneities to strengthen and improve the CF

participation of malt barley farmers as long as they are adjusted to local conditions. Furthermore, spillover effects of CF on other sectors (other crops and the environment) and non-participants should be considered to check whether it has negative or positive external effects.

Subjects: Agricultural Development; Agricultural Economics; Agriculture and Food

Keywords: malt barley; asset accumulation; contract farming; endogenous switching regression

1. Introduction

Agriculture has led to economic growth that is connected to better livelihoods, and it can be a long-term solution to persistent poverty, and food and nutritional insecurity despite the economy's ongoing structural shift from agriculture to industry and services. Agriculture contributed to 33% of the GDP, 66% of rural employment, and generates 76% of foreign exchange (Agricultural Transformation Institute [ATI], 2022). This suggests that the economy's most important sector is smallholder farmers. Of this, crop production contributed to 65% of the GDP, employs 60% of the rural labor, and covers 80% of the land under cultivation (International trade Administration [ITA], 2022). The majority of crops are cereals, accounting for 81.4% of all crop area and 88% of all outputs (Central Statistical Agency [CSA], 2018). However, Ethiopia has very low agricultural productivity and production as compared to other nations (Hannah, 2022). To address this issue, the Ethiopian government developed and put into action an economic transformation program based on the framework of agricultural development-led industrialization (ADLI) with the Growth and Transformation Plan (GTP) I and II (Ethiopian Agricultural Transformation Agency [ATA], 2017). As a result, by 2025, the economy is expected to have mostly transitioned from agriculture to industry and services (Ethiopian Agricultural Transformation Agency [ATA] 2017). Despite government efforts to shift the economy from agriculture to services and primary industry, the economy's performance is still thought to be behind expectations (Business Innovation Facility [BIF], 2018; National Planning Commission [NPC], 2016).

Barley (*Hordeum vulgare*) is one of the major crops widely grown in different countries of the world. After rice, wheat, and maize, it is the fourth most produced crop worldwide and in Africa (Food and Agriculture Organization [FAO], 2021). Ethiopia is one of the top ten barley producers in the world and it also ranks first in Africa followed by Algeria (Food and Agriculture Organization, [FAO] 2018). Among cereals, barley ranked fifth next to *Teff*, maize, wheat, and sorghum in 2019/20 (Central Statistical Agency [CSA], 2021). There are two types of barley namely food barley for consumption and malt barley for the brewery. In this sector, more than 3.51 million smallholder farmers produced about 20.51 million quintals on 951,993.15 ha with a productivity of 21.6 qt/ha in 2017 (Central Statistical Agency [CSA], 2018). However, the productivity of barley is lower than its potential and global standards (Central Statistical Agency [CSA], 2018; Food and Agriculture Organization [FAO], 2018).

The production of malt barley has become one of Ethiopia's fastest-growing industries because of the establishment of multinational brewery plants supported by expanding beer consumption and a favorable investment policy. According to (International Center for Agricultural Research in the Dry Areas [ICARDA], 2019), the demand is outpacing malt barley production due to its low productivity (Rashid, et al., 2015) coupled with increasing demand for beer due to increasing per-capita incomes (\$124.5 in 2000 and \$855.76 in 2019) (World Bank [WB], 2021), population growth, and urbanization (Ethiopian Agricultural Transformation Agency [ATA] 2017) as well as the construction of new malt factories (Global Agriculture Information Network [GAIN], 2021). For instance, the average malt barley productivity in 2016/17 was 18.3 qt/ha for the Amhara region and 20.4 qt/ha for the country as a whole (Central Statistical Agency [CSA], 2017). Several factors caused low productivity of malt barley including production inefficiency (Food and Agriculture

Organization [FAO], 2018; Shiferaw et al., 2022), a lack of improved technology (improved varieties and fertilizers), limited market access, and a lack of technical expertise (Bishaw & Molla, 2020; Ferede et al., 2020; Mpeta et al., 2018; Tadesse & Derso, 2019), among others. Theoretically, increasing efficiency and/or diffusing technology can increase production and productivity. In this regard, CF is seen as a strategy for overcoming technical/technological constraints (Swinnen & Kuijpers, 2019), accessing and easing technology adoption (Ragasa et al., 2018), linking farmers to marketing agents (Wiggins & Keats, 2013), minimizing transaction costs (Bellemare, 2012) and creating open access to finance (Carletto et al., 2011). In other words, CF has the advantage of increasing agricultural productivity by enhancing farmers' production efficiency through technical help and supplying improved technology through financing and price support. Contract farming (CF) is an institutional arrangement in which a company contracts the production of agricultural products to farmers and guarantees a reliable supply of high-quality agricultural raw materials (Bellemare & Novak, 2017).

In Ethiopia, CF has been employed in the last 10 years as a solution for several agricultural commodities (Bezabeh et al., 2020; Business Innovation Facility [BIF], 2018; Biggeri et al., 2018; Flores & Holtland, 2017; Yeshitila et al., 2020). Malt barley CF is one, which was introduced in 2013 by multinational malt and brewery firms in response to this need (Addisu, 2018; Business Innovation Facility [BIF], 2018; National Bank of Ethiopia [NBE], 2017; Rashid, Abate, et al., 2015). Malt barley CF is mainly implemented in Oromia (Arsi and West Arsi) and the Amhara Region with brewery factories to ensure local malt supply (Addisu, 2018; Business Innovation Facility [BIF], 2018). This is because malt barley production is concentrated in the Oromia and Amhara Regions, which contribute 53% and 30% of national production, respectively (Central Statistical Agency [CSA], 2020). The Oromia, Amhara, Tigray, and Southern Regions account for 99.5% of the country's land and malt barley output among the current 11 regions (Central Statistical Agency [CSA] 2020). CF is employed by malt factories to regularly purchase malt at stable prices, and offer technologies (improved varieties and fertilizer) and technical assistance to contract farmers in exchange for a reliable supply of high-quality malt in the North Gondar Zone, and elsewhere in the nation. However, the demand for raw malt barley is unmet. As a result, in 2015 and 2018, the national supply of malt barley met only 35% (14452 tons) and 44% (52000 tons) of the domestic demand of the breweries; respectively (Addisu, 2018; Business Innovation Facility [BIF], 2018; National Planning Commission [NPC], 2017), with remaining malt barley imported from abroad. The cost of malted barley imports in 2015 and 2018 was 51.97 million USD and 283.68 million USD, respectively (Food and Agriculture Organization, [FAO] 2021). Moreover, the import cost of malt barley is expected to reach 420 million USD in 2025 (Rashid, et al., 2015). This demonstrates the significance of CF for Ethiopia's capacity to raise malt barley yield and production to conserve hard currency, improve farmer welfare, and reduce transaction costs for the malt and beer industries.

In North Gondar Zone, the study area, the Dashen beer factory introduced CF malt in 2014 with local sourcing of raw malt barley (Food and Agriculture Organization [FAO] 2018). Since then, the Gondar Malt Factory's (GMF) demand for the grain has remained insufficient despite 5170 farmers being actively involved in the cultivation of malt barley, of which 2234 (43.2%) were CF participants in 2021/22 (Beauro of Agriculture [BoA], 2020). According to the BoA (Beauro of Agriculture) [BoA], 2020), the number of producers, including CF participants and non-participants, the volume of malt barley supplied, and the area covered, all demonstrate a falling tendency in the Amhara Region (2016/17 to 2020/21) (Table A1, Figures A1 and A2). The yield and area allocated in the North Gondar Zone are both trending downward (Figure A3). However, the Gondar malt factory's demand for malt barley from the Oromia Region is increasing (Table A1, Figure A1). This implies that empirical evidence is imperative to know the sources of low participation in CF and its impacts on asset accumulation.

Unlike previous studies, this study examined the impacts of CF on household asset accumulation, a more robust long-term indicator of welfare. Assets are more important long-term wealth

metrics than income or consumption because poverty is reflected in the lack of assets in most rural settings (Brockington, 2019; Mutonyi, 2019). Assets are less vulnerable to short-term fluctuations than annual household income (Brockington, 2019). Income is more unstable and lumpier because it is based on seasonal harvests. In most rural areas, the lack of banking facilities or other savings vehicles forces households to invest in assets and other local investment proposals. Assets can also be utilized as buffers and risk-management instruments to reduce income shocks and maintain consumption (Carter & Lybbert, 2012; Verpoorten, 2009). Thus, measuring the impact of malt barley CF on asset accumulation will aid in targeting the type of intervention essential to enable sustained CF strengthening and expansion, thereby enhancing these farmers' ability to build assets. Several studies have been conducted on the impact of CF on farmers' welfare, principally income in Ethiopia and elsewhere, with less focus placed on asset building. While employing transaction cost economics (TCE) as a theoretical framework and endogenous switching regression (ESR) as an analytical technique, the impact of CF on malt barley farmers' assets in Ethiopia in general and the research area, in particular, is almost non-existent. As a result, the influence of CF on the asset accumulation of malt barley farmers in northwestern Ethiopia was evaluated.

2. Literature review

2.1. Theoretical review

The theoretical foundations of CF are based on numerous schools of thought. Political economy and new institutional theory are mainly used to analyze CF. The political economics viewpoint interprets CF from the standpoint of unequal power relations, conflict, and labor-related issues (Little & Watts, 1994, 1994; Wilson, 1986, 1986). This suggests that CF may cause farmers to experience problems like loss of autonomy, increased production risk, and indebtedness. Comparatively, to political economics, new institutional economics lays more stress on the role of CF in addressing market failures (Barrett, 2008; Minten et al., 2009). The most well-known theoretical paradigm is transaction cost economics (TCE), which evolved from the pioneering works of (Coase, 1937) and (Williamson, 1989). It is the main theoretical foundation for CF and a component of New Institutional Economics (NIE). The premise of NIE and TCE is that all interactions between economic actors have transaction costs. According to TCE, economic agents have rationally bounded behavior and a propensity for opportunism.

While opportunistic behavior is defined as seeking personal gain without regard for the other party, bounded rationality is defined as the parties' inability to explain and solve complicated problems in a simple, economical manner. Giving out biased or erroneous information voluntarily or making unreliable promises are further examples of opportunistic behavior (Slangen et al., 2008). Such circumstances permit market transactions that involve risks and hazards, and their mitigation would demand transaction charges. The asset specificity, uncertainty, and exchange frequency characteristics of transactions have an impact on the level of transaction costs (Bijman, 2008; Minot, 2011).

Asset specificity is caused by an investment that the farmer or buyer makes that is unique to a given transaction and has little to no value for a different application (Hobbs, 1996). The motivation to enter into a CF to safeguard such assets rather than using the spot market increases with the degree of asset specificity. Factors that are challenging and costly to predict are said to be uncertain. The main source of uncertainty is incomplete and asymmetrical information. Making successful transactions is difficult due to the lack of knowledge regarding the market circumstances for farmers and the quality of the product for buyers (Bijman, 2008). Finally, if transaction frequency is low, transaction costs will be high, and vice versa.

The firm favors vertical integration when transaction costs on the spot market are too high. The "hybrid" that exists between the extremes of spot markets and vertical integration is CF. The firm will then choose the organization that minimizes transaction costs. In this context, CF can reduce

the negative effects of transaction costs due to an imperfect market by granting malt barley farmers access to agricultural technologies (improved varieties and fertilizers), access to finance, a guaranteed price for the output, and technical support (extension services: advice, training, field demonstration). The TCE method of CF analysis is still the most popular technique, despite being criticized. Therefore, TCE is employed in this study as a theoretical framework to evaluate the impact of CF on the asset accumulation of malt barley farmers.

2.2. Empirical review

There have been numerous studies performed on the impacts of CF on farmers' welfare in Ethiopia and elsewhere. The majority of research demonstrates that CF has a favorable impact on welfare indicators such as income (Bellemare & Novak, 2017; Bezabeh et al., 2020; Bidzakin et al., 2018; Ganewo et al., 2022; Nguyen, 2020; Tefera & Bijman, 2021), food security (Bellemare & Novak, 2017; Ganewo et al., 2022), productivity (Tefera & Bijman, 2021; Wendimu et al., 2016), production efficiency (Bidzakin et al., 2020; Chakraborty, 2009; Nguyen et al., 2018; Yeshitila et al., 2020), and asset (Michelson, 2013).

Ganewo et al. (2022) used PSM to evaluate the impact of CF on the income and food security of malt barley farmers in the Arsi Zone of Ethiopia. They show the positive effect of CF on income and food security. Similarly, Tefera and Bijman (2021) researched the impact of CF on the welfare of malt barley farmers in the Arsi Zone of Ethiopia. CF has a positive effect on malt barley income and other crops' income according to the PSM model result. Similarly, Bezabeh et al. (2020) reported that the PSM model result indicated that CF has a positive impact on the income of smallholder malt barley farmers in the Arsi and West Arsi Zones of the Oromia region in Ethiopia. Bidzakin et al. (2018) researched the impact of CF on rice performance in Ghana. According to them, the ESR result shows that CF has a positive effect on yield and gross income. Furthermore, Abera et al. (2018) have investigated the impact of CF among malt barley producers in the Lemu Bilbilo District, Oromia region of Ethiopia. Thus, OLS regression and PSM techniques show that CF has a positive impact on malt barley net income and spillover into the productivity of other crops measured in net income. In a similar vein, the PSM finding demonstrates that CF has a positive effect on the income of Ethiopian vegetable farmers (Mulatu et al., 2017). Similarly, Ton et al. (2017) in their in-depth Meta-analysis reported that 62% of the sampled studies confirmed that CF improves smallholders' income. This reveals that the benefits of CF on the income of households outweigh its costs in developing countries. In the same way, Seba (2016) has done research on the impact of CF on chickpea growers' smallholders in Ethiopia using PSM. He found that CF enhances the cash revenue and net cash income of chickpea growers compared to non-contract users. Likewise, Girma and Gardebroek (2015) used PSM and instrumental variable regression to investigate the impact of CF on the household income of smallholder farmers producing organic honey in the Sheka Zone of South West Ethiopia. According to the PSM results, CF increases the income of organic honey farmers. A study on CF and food security in Madagascar using PSM and OLS found that CF is frequently associated with an increase in the income of participating households and that participating in CF shortens the duration of a household's hungry season, especially for children and girls (Bellemare & Novak, 2017). According to the OLS findings, the duration of hunger is negatively connected to CF, education, household income, and assets. According to Wang et al. (2014) in their systematic review show that 92% and 75% of studies estimate positive effects of CF on yield and income, respectively. Michelson (2013) used DID to quantify the welfare effects of CF on farmers' assets in Nicaragua. She claims that being a participant in CF increases households' ability to build assets by 16%.

On the contrary, a few researches have verified that CF is viewed as a tool for agricultural businesses to exploit farmers' resources, hence limiting household gain from CF (Abdulai & Al-Hassan, 2016; Mpeta et al., 2018; Olounlade et al., 2020; Ragasa et al., 2018; Wendimu et al., 2016). For instance, Wendimu et al. (2016) offer an analysis of a compulsory (public) CF scheme in Ethiopia for sugarcane out growers. Using PSM, the authors find a meaningful reduction in income and asset stocks of participants in this "forced" contracting arrangement (public CF) due to the low

sugar cane price of out-growers who contributed to irrigated land to the out-grower scheme. Similarly, Olounlade et al. (2020) investigated the impact of CF participation on smallholder farmers' income and food security in rice crop production in Northern rural Benin by combining propensity score matching (PSM) and the local average treatment effects parameter (LATE) to correct both observed and unobserved biases. Rice CF reduces food security and rice producers' income.

To summarize, the literature on the development and impact of CF in Ethiopia and elsewhere is inconsistent. Only a few income-dominated CF impact studies on malt barley have been done because CF is still in its infancy in Ethiopia (Abera et al., 2018; Bezabeh et al., 2020; Ganewo et al., 2022; Tefera & Bijman, 2021). Nonetheless, all of these research efforts are concentrated in a single location, the Oromia region's Arsi and West Arsi Zones. Although asset accumulation is one of the outcomes of CF, most previous research has been disregarded, except (Wendimu et al., 2016), who indicate CF reduced sugarcane out-grower assets. That is, past studies neglected whether the income earned from malt barley is accumulated as an asset or consumed. The impact of CF on malt barley farmers' assets in Ethiopia in general and the study area, in particular, is almost non-existent. Unlike previous studies, we examined the effects of CF on household asset accumulation, which captures long-term advantages and is less vulnerable to short-term fluctuations than annual household income. Thus, measuring the impact of malt barley CF on asset accumulation will aid in targeting the type of intervention essential to enable sustained CF strengthening and expansion, thereby enhancing these farmers' ability to build assets.

Moreover, ESR takes into consideration endogeneity issues, whereas PSM is commonly employed to analyze most impact studies, except for (Bidzakin et al., 2018). As a result, unlike previous research, this analysis seeks to account for both observed and unobserved heterogeneity in CF participation decisions and asset accumulation. As a result, ESR was employed to control selection bias induced by observable and unobservable factors. Thus, to quantify the impact of CF on malt barley farmers in northwestern Ethiopia, this study used TCE as a theoretical framework and ESR as an analytical framework.

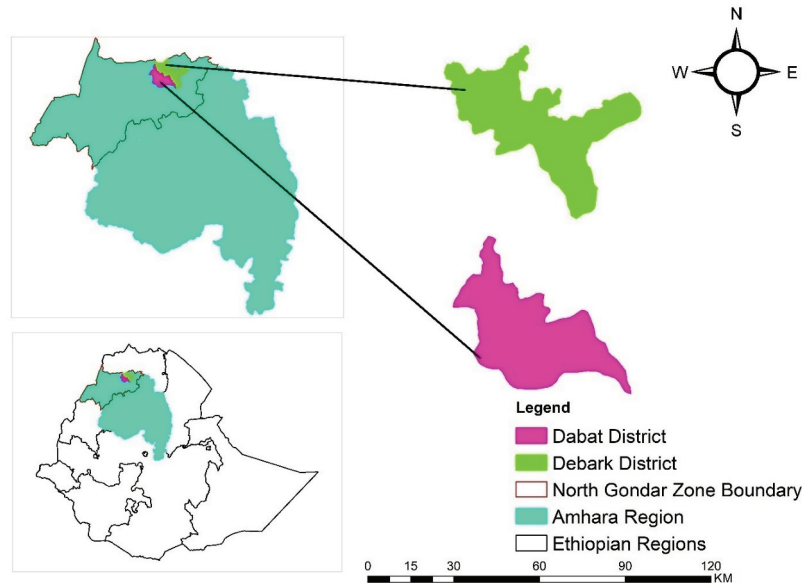
3. Methodology

3.1. Description of the study area

The study area, North Gondar Zone is found in Amhara National Regional State, located in the northwestern part of Ethiopia. Debark is the main town of the Zone, which is located 817 km and 90 Km from the capital Addis Ababa and Gondar Town, respectively. It has 6 rural Districts (Telemt, Adearaky, Dabat, Debark, Beyeda, and Janamora) and 2 urban administrations (Dabat and Debark) covering an area of 38,685.79 square kilometers. It has a total population of 914,266, of whom 452,922 are men and 461,344 women (north Gondar Zone [NGZ], 2020). It is bordered on the south by East Belesa, on the west by Tegede, Tach Armachiho, and Wogera Districts, on the north by the Tigray region, and on the east by Wag Hemra Zone. North Gondar Zone is located between 12.3° to 13.38° north latitudes and 35.5° east longitudes and the altitude ranges from 550 to 4620 meters above sea level (masl) in western lowland and north Semen Mountain (Ras Dashan), respectively. The average annual rainfall varies from 880 mm to 1772 mm, which is characterized by a unimodal type of distribution (National Meteorological Agency [NMA], 2011). The mixed farming system; livestock rearing and crop production are the mainstream in the study area. The livestock population was 888,938.30 TLU (tropical livestock unit). The main crops are the cereals such as *Teff*, maize, wheat, millet, barley, and sorghum (north Gondar Zone [NGZ], 2020).

The highland parts of the Zone have the potential for both food and malt barley production. Malt barley is cultivated in Beyeda, Janamora, Debark, and Dabat Districts. Malt barley contract farming (CF) was introduced in 2014 by the Dashen brewery factory with the objective of local sourcing of malt barley. It is practiced in 9 Kebeles and 12 Kebeles of Dabat and Debark Districts, respectively (Gondar Malt Factory [GMF], 2021). The total number of malt barley producers was 5170; of which

Figure 1. Map of the study area (North Gondar Administrative Zone).



2234 (43.2%) were CF participants. According to the Zone Department of Agriculture report, malt barley is the third most important crop among cereals. This demonstrates that one of the primary cereal crops in the Zone is malt barley. As a result, it is one of the main sources of income, primarily used for asset accumulation. The tradition of saving extra cash in the form of assets, both livestock and non-livestock (radio, mobile, agricultural equipment, consumer goods), has long been practiced by farmers. More than 85% of the farmers in the study area had a tradition of saving surplus cash as assets. Figure 1 in the above indicates the study area; which is the North Gondar Zone of Debark and Dabat Districts.

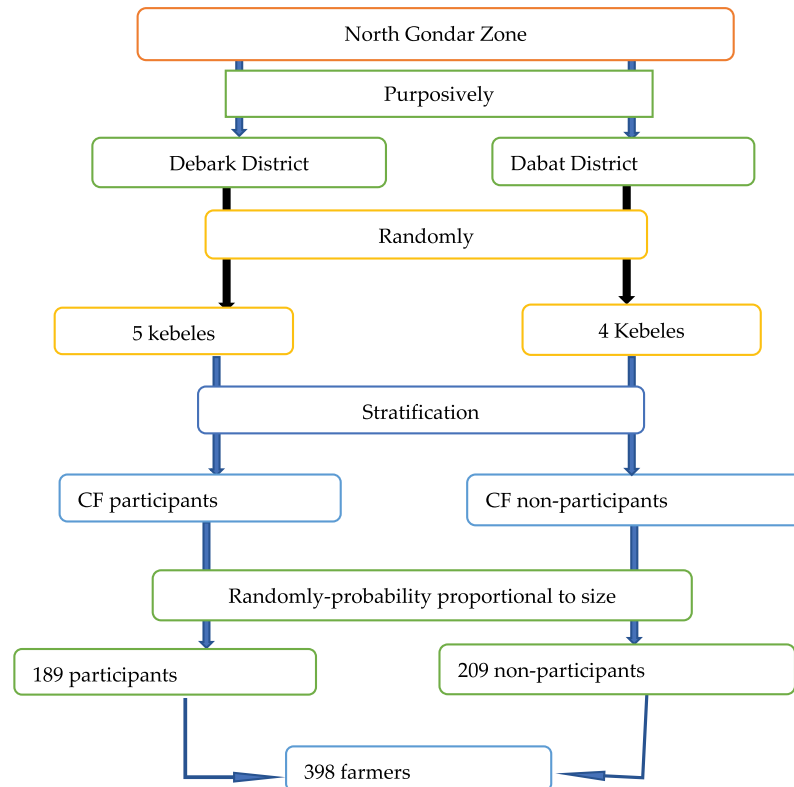
3.2. Sample size and sampling procedures

A multistage sampling procedure was implemented to draw the targeted sample of malt barley farmers who are CF participants and non-participants. Figure 2 depicts the top-down method used to select the sample respondents, with the North Gondar Zone (the largest administrative unit) at the top and the Kebele (the smallest administrative unit) at the bottom. In the first stage, Debark and Dabat Districts were selected purposively among 4 malt-barley-growing Districts, since both malt barley CF participants and non-participants are found in these Districts. In the second stage, 4 Kebeles from Dabat District, namely, Abtera, Dabat Zuria, Woken Zuraia, and Chena; and 5 Kebeles from Debark District, namely, Arginjona, Miligebesa, Miqara, Yekirar, and Gomiya were selected by random sampling. Thirdly, the farmers were stratified into malt barley CF participants and non-participants by taking CF engagement as the criterion. Then, to make the sample size of each stratum comparable and have enough matching groups for the treatment group (CF participants), 189 malt barley CF participants and 209 non-participants were selected randomly based on probability proportional to their size from the lists of farmers from the respective Kebeles and Districts.

3.3. Data types, sources, and method of data collection

Pretested and revised semi-structured interview schedule was used to collect primary data on the types and value of productive assets, the prices of malt barley inputs and output, demographic, socioeconomic, resource endowments, and environmental factors from a sample of CF participants and non-participant malt barley farmers. The interview schedule was prepared in English and it was translated into the local language, Amharic to ease the communication between the enumerator and farmers. Government and non-government

Figure 2. Sampling procedures.



reports, as well as online data sources like FAOSTAT, NBE, and CSA, were used to compile secondary data like background information (for instance: malt barley yield and area coverage, livestock, and human population).

3.4. Data analysis method

3.4.1. Descriptive statistics

The study used descriptive statistics (mean, standard deviation, standard error, frequency, and percentage) and inferential statistics (chi-square test and t-test). The chi-square test and t-test were used to determine statistical differences and the association between CF participants and non-participants on malt barley's price, yield, income, and cost, the value of assets, and demographic, socioeconomic, institutional, and environmental factors. The former and the later tests were used for discrete and continuous variables; respectively.

3.4.2. Econometric model

3.4.2.1. Theoretical framework. According to transaction cost economic theory, the benefits of CF in addressing market imperfections caused by farmers' behavior (bound rationality and inclination for opportunism) and the nature of the commodity (asset specificity, uncertainty, and transaction frequency) must be measured. Hence, following (Ben-Akiva & Lerman, 1985; Louviere et al., 2000), and (Khonje et al., 2015), the theoretical framework for participation decisions in CF of the farmers is the random utility model where farmers choose a strategy that provides the highest utility among the given alternatives. This utility is not directly observed, rather it is observed through the farmers' choice. Suppose U_{i1}^* represents the latent variable of the expected utility that the i^{th} households drives by participating in CF compared with that of non-participating, U_{i0}^* . By comparing the costs and benefits of participating in CF, the household participates in CF only when the net benefits are greater than the costs: $I_i^* = U_{i1}^* - U_{i0}^* > 0$. The net benefit I_i^* , therefore, is a latent

variable determined by explanatory variables: demographic, socioeconomic, institutional, and environmental factors, and the random term.

3.4.2.2. Analytical framework. There are various econometric models for estimating the impact of CF on farmers' asset accumulation. The most widely used moles and techniques are Heckman's two-stage, instrumental variable (IV), difference-in-difference (DID), PSM, and ESR can be used to measure the impact of contract farming on asset accumulation of malt barley farmers. The Heckman selection strategy can be used to control selection biases in the cross-sectional observation data set, but it was unable to control the biases caused by observable factors (Rao & Qaim, 2011). On the other hand, the instrumental variable (IV) captures only unobserved heterogeneity, but the assumption is that the parallel shift of outcome variables can be considered a treatment effect (Ahmed et al., 2017; Sosina Bezu et al., 2014). IV presupposes that at least one Z-variable, or instrument, explaining treatment status exists (Abadie, 2003; Heckman et al., 2005; Imbens, 2004; Imbens & Angrist, 1994). The DiD is suitable for before-after impact studies or a panel data set. This suggests that cross-sectional data are not suitable for DID. PSM can consider observable factors, but it cannot take into consideration unobservable components that affect the decision to take part in the CF and the outcome variable (Caliendo & Kopeinig, 2008). ESR is used to address both observable and unobservable factors (Bidzakin et al., 2020; Jaleta et al., 2018; Lokshin & Sajaia, 2004; Mishra et al., 2018). Therefore, the ESR was used in the current study to explore the influence of observable and unobservable factors that affect malt barley farmers' decisions to participate in CF as well as their asset accumulation.

3.4.2.3. Specification of endogenous switching regression. The switching regression was modeled in two stages (Alene & Manyong, 2007; Asfaw et al., 2012; DiFalco et al., 2011). The first stage is the selection equation (the probit) for participation in malt barley CF, which is a binary variable. Let Y_i^* denotes the value of assets accumulated by i^{th} malt barley farmers, which depends on both exogenous and endogenous variables, including CF participation decision. Thus, Y_i^* can be presented with the selection equation (I_i^*) as follow based on the random utility theory:

$$Y_i^* = X_i\beta + \gamma I_i + \varepsilon_i; I_i^* = \alpha_0 + \alpha Z + v, \text{ where } I = \begin{cases} 1 & \text{if } I_i^* > 0 \\ 0 & \text{if } I_i^* \leq 0 \end{cases} \quad (1)$$

Where I is a binary variable representing the participation in malt barley CF and it is one if the household participated in CF and otherwise zero, α_0 the constant term, α is $m \times 1$ vector of the model parameter to be predicted, Z is $n \times m$ a vector of explanatory variables that affect the decision to participate in CF, latent variable (I_i^*) represents the expected benefits of participating comparing not participating in CF and v is $n \times 1$ vector of normally distributed mean zero random error terms (stochastic) term.

According to Wooldridge (2010), the probit model to calculate the likelihood of observing a farmer participating in CF:

$$\Pr(I_i = 1|x) = F() = \int_{-\infty}^{x\beta} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{Z^2}{2}\right) dZ \quad (2)$$

where \Pr is the probability of I_i being the binary choice variable (1 for participants and 0 for non-participants in CF), F is the cumulative distribution function for ε_i , and $Z = X\beta$.

The log-likelihood function of the probit model is specified in Equation (3):

$$\ln(\beta, I, X) = \sum_{i=1}^n [I_i \ln F(X_i'\beta) + (1 - I_i) \ln(1 - F(X_i'\beta))] \quad (3)$$

However, according to Jaleta et al. (2018), if the selection equation (first stage) is endogenous in the outcome equation (second stage), results would be biased and inefficient. Therefore, it is vital to use instrumental variable methods to identify the second stage equation from the first stage equation. The instrumental variable should affect the participation in CF but not the outcome variable such as asset. This implies that the validity of the ESR requires exclusion restriction that is correlated with participation in CF while it does not play a role in asset accumulation (Adego et al., 2019; Bidzakin et al., 2020; DiFalco et al., 2011; Mishra et al., 2018). While acknowledging the selection of instrumental variables is empirically challenging, information sources are used as selection instruments (selection variables). Hence; among the information sources, field day participation was used as an instrumental variable. The researchers argue that farmers' participation in malt barley field day on-farm and demonstration sites was critically important in determining CF participation. As a matter of fact; farmers participated in the field day of the on-farm demonstration before and after the implementation of malt barley CF. This is the fact that agricultural research centers with brewery factories have demonstrated malt barley on the model farmers and shown the results to the farmers through field days. Furthermore, after the dissemination of malt barley technology packages with CF, field day was found to be a more powerful extension approach to convince farmers according to the NGZ Department of Agriculture. On the field day, farmers had a chance to compare the CF participants' and non-participants' malt barley performance. Moreover, farmers had the chance to learn from model farmers' experiences and general discussions. Hence, this variable is more likely to correlate with participation in CF but not with assets or not correlated with the unobserved variables. Besides, the validity of ESR instruments was empirically checked. The first test was to run a probit model of participation in malt barley CF through instruments and other variables. The instrument has been jointly validated as a strong predictor of malt barley CF participation. The second is the falsification test that checks whether the instrument played an important role in asset accumulation. As reported by DiFalco et al. (2011) and Adego et al. (2019), this test indirectly checks if the instruments correlated with the unobservable. The test confirms that the instrument was not a jointly statistically significant driver of the value of asset accumulation for CF participants and non-participants (Appendix Table 2).

The second step of the ESR is the outcome equation (value of the asset) that split the endogenous model into two equations with the selection equation (1) specified by following the works of (Bidzakin et al., 2020; Kassie et al., 2015; Lokshin & Sajaia, 2004; Mishra et al., 2018):

$$y_1 = X_{1i}\beta_{1i} + \mu_{1i} \text{ if } CF_i = 1 (\text{for CF participants}) \quad (4a)$$

$$y_0 = X_{0i}\beta_{0i} + \mu_{0i} \text{ if } CF_i = 0 (\text{for CF non-participants}) \quad (4b)$$

Where y_1 and y_0 represent the value of asset accumulation for CF participants and non-participants, respectively; β_0 and β_1 are vectors of parameters to be estimated. X_{ij} is a vector of explanatory variables; which determine the asset accumulation. In the switching regression model, the selection bias would manifest itself in the error terms v and μ . As far as the unobserved variables are not captured by the explanatory variables, the error terms of the outcome variables (asset accumulation) and selection equation are correlated, $\text{corr}(v, \mu) \neq 0$. Finally, the error terms v , μ_1 and μ_0 are assumed to have trivariate jointly normally distributed with zero mean and covariance matrix Ω :

$$\begin{aligned} \text{COV}(\mu_0, \mu_1, V) &= N(0, \Omega) \text{ with } \Omega = \begin{bmatrix} \delta_{\mu 1}^2 & \delta_{\mu 1 \mu 0} & \delta_{\mu 1 v} \\ \delta_{\mu 0 \mu 1} & \delta_{\mu 0}^2 & \delta_{\mu 0 v} \\ \delta_{v \mu 1} & \delta_{v \mu 0} & \delta_v^2 \end{bmatrix} = \begin{bmatrix} \delta_{\mu 1}^2 & \cdot & \cdot \\ \cdot & \delta_{\mu 0}^2 & \cdot \\ \delta_{v \mu 1} & \delta_{v \mu 0} & \delta_v^2 \end{bmatrix} \\ &= \begin{bmatrix} 1 & \cdot & \cdot \\ \cdot & 1 & \cdot \\ \delta_{v \mu 1} & \delta_{v \mu 0} & 1 \end{bmatrix} \end{aligned} \quad (5)$$

Where δ_v^2 is the variance of the error term within the selection equation (1); which can be assumed to be equal to 1 since the coefficients are estimable only up to a scale factor of 1, $\delta_{\mu 1}^2$ and $\delta_{\mu 0}^2$ are the variances of the error terms in the outcome equation (4a) and (4b), respectively; $\delta_{v\mu 1}$ is the covariance of v and μ_1 , while $\delta_{v\mu 0}$ is the covariance of v and μ_0 (Maddala, 1986; Rao & Qaim, 2011). Besides, the covariance μ_1 and μ_0 is equal to zero because y_0 and y_1 are not observed simultaneously in a cross-sectional sample. Equations (1)–(5) should be estimated in a way that accounts for the correlation between the error terms.

An important implication of the error structure is that because the error term of the selection equation (1) v is correlated with the error terms of outcome functions (μ_1 and μ_0) such as asset accumulation (4a) and (4b), the expected values of error terms μ_1 and μ_0 conditional on malt barley CF participation (sample selection) equations are non-zero:

$$E(\mu_1 | I = 1, X_1) = E\left(\mu_1 | v > -\alpha Z = \delta_{v\mu 1} \frac{\phi(\alpha Z)}{\Phi(\alpha Z)}\right) = \delta_{v\mu 1} \lambda_1 = \gamma_1 \quad (6)$$

$$E(\mu_0 | I = 0, X_0) = E\left(\mu_0 | v \leq -\alpha Z = \delta_{v\mu 0} \frac{-\phi(\alpha Z)}{1 - \Phi(\alpha Z)}\right) = \delta_{v\mu 0} \lambda_0 = \gamma_0 \quad (7)$$

Where ϕ is the standard normal probability distribution and Φ is the standard normal cumulative distribution while $\lambda_1 = \frac{\phi(\alpha Z)}{\Phi(\alpha Z)}$ and $\lambda_0 = \frac{-\phi(\alpha Z)}{1 - \Phi(\alpha Z)}$ are the Inverse Mills Ratios (IMR) predicted from the selection equation (predicted at αZ for malt barley CF participants and non-participants; respectively) (Greene, 2008). The λ_1 and λ_0 are incorporated into Equations 4a and 4b to account for selection bias.

The significance of the estimated covariances of $\delta_{v\mu 1}$ and $\delta_{v\mu 0}$ reflect that the decision to participate in CF and the value of assets are correlated, which rejects the null hypothesis of sample selectivity bias (Maddala & Nelson, 1975). This highlights the importance of the ESR model. An efficient method to estimate the ESR model is by full information maximum likelihood (FIML) estimation. This is superior to the two-step estimators, which are inefficient for deriving standard errors (Lokshin & Sajaia, 2004). The FIML method simultaneously estimates the probit criterion or the selection equation and the outcome equations to yield consistent standard errors. Given the assumption of trivariate normal distribution for the error terms, the log-likelihood function for the system of equations (1) and (4a and 4b) is given as:

$$\ln L = \sum_{i=1}^N \left\{ I_i \left[\ln \varphi \left(\frac{\delta_{\mu 1i}}{\delta_{\mu 1}} \right) - \ln \delta_{\mu 1} + \ln \Phi(\theta_{\mu 1i}) \right] + (1 - I_i) \left[\ln \varphi \left(\frac{\delta_{\mu 0i}}{\delta_{\mu 0}} \right) - \ln \delta_{\mu 0} + \ln(1 - \Phi)(\theta_{\mu 0i}) \right] \right\} \quad (8)$$

Where $\varphi(\cdot)$ is a cumulative normal distribution function, $\Phi(\cdot)$ indicates a normal density distribution function and θ_{ji} is defined as:

$$\text{Where } \theta_{ji} = \frac{(Z_i \alpha + \rho_j \mu_{ji} / \delta_j)}{\sqrt{1 - \rho_j^2}}, j = 1, 2, \theta_{ji} \text{ denoting the correlation coefficient between the error.}$$

Where, $\rho_1 = \frac{\delta_{u_1 v}^2}{\delta_{u_1} \delta_v}$ is the correlation between u_1 and v ; and $\rho_0 = \frac{\delta_{u_0 v}^2}{\delta_{u_0} \delta_v}$ is the correlation between u_0 and v . To ensure that ρ_1 and ρ_0 are bounded between -1 and 1 and that the estimated δ_1 and δ_0 are always positive, the FIML directly estimates $\ln \delta_1$, $\ln \delta_0$ and $\text{atanh } \rho_j$ (Donkor & Owusu, 2019) is further computed as:

$$\text{atanh } \rho_j = \frac{1}{2} \ln \left(\frac{1 + \rho_j}{1 - \rho_j} \right), j = 0, 1 \quad (9)$$

The FIML estimate of the parameters of the ESR model was obtained using the movestay command in STATA 17 (Lokshin & Sajaia, 2004).

3.4.2.4. Conditional expectations, treatment, and heterogeneity effect. The aforementioned ESR model can be used to compare the expected asset accumulation of malt barley CF participants (a) concerning households that did not participate (b), and to investigate the expected asset accumulation in the counterfactual hypothetical cases (c) that the participated did not participate, and (d) that the non-participants' households participated. The conditional expectations for the outcome variable (asset accumulation) in the four cases are defined as follows (Maddala, 1983):

$$E(y_1|I = 1) = \beta_1 X_1 + \delta_{\nu\mu 1} \lambda_1 \quad (\text{Participants participating in CF}) \quad (a)$$

$$E(y_0|I = 0) = \beta_0 X_0 + \delta_{\nu\mu 0} \lambda_0 \quad (\text{Non – participants without participating in CF}) \quad (b)$$

$$E(y_0|I = 1) = \beta_0 X_1 + \delta_{\nu\mu 0} \lambda_1 \quad (\text{Participants had they decided not to participate in CF}) \quad (c)$$

$$E(y_1|I = 0) = \beta_1 X_0 + \delta_{\nu\mu 1} \lambda_0 \quad (\text{Non – participants had they decided to participate in CF}) \quad (d)$$

Table 1. Conditional expectations, treatment, and heterogeneity effects

Sub-sample	CF participation Decision Stage		Treatment Effects
	Participants	not participants	
Contract farmers	(a) $E(y_1 I = 1)$	(c) $E(y_0 I = 1)$	ATT
Non-contract farmers	(d) $E(y_1 I = 0)$	(b) $E(y_0 I = 0)$	ATU
Heterogeneity effects	BH ₁	BH ₀	ATH

Source: own summarization, 2023

Table 2. Explanatory variables and their expected sign used in the ESR model

Variables	Participation in CF	Asset Accumulation
Sex (1,0)	+	+
Age (years)	±	±
Household size (MDE)	±	±
Education (years of schooling)	+	+
Total land holding (ha)	+	+
Off-farm income (1,0)	±	±
Social activities participation (1,0)	±	±
Cooperative membership (1,0)	+	+
Frequency of extension contact (number)	+	+
Training (1,0)	+	+
Farming Experience (year)	+	+
Field day participation (1,0)	+	
Mobile phone (1, 0)	+	
Distance to market (wt*)	-	-
Distance to FTC (wt*)	-	-
Credit access (1,0)	+	+
Row planting (1,0)		+
Cluster farming (1,0)		+

The actual expectations observed in the sample were represented by cases (a) and (b) along the diagonal, whereas the counterfactual expected outcomes were represented by cases (c) and (d) shown in Table 1.

Following Asfaw et al. (2012), Jaleta et al. (2018), Mishra et al. (2018), and Bidzakin et al. (2020), the average treatment effect on the treated (ATT) is the difference between (a) and (c):

$$ATT = E(y_1|I = 1) - E(y_0|I = 1) = (\beta_1 - \beta_0)X_1 + (\delta_{\nu\mu 1} - \delta_{\nu\mu 0})\lambda_1 \quad (10)$$

Which represents the impact of participation in malt barley CF on the asset accumulation of households that actually participated in CF. Similarly, the average treatment effect on the untreated (ATU) can be calculated for the farm households that actually did not participate in malt barley CF is the difference between (d) and (b):

$$ATU = E(y_1|I = 0) - E(y_0|I = 0) = (\beta_1 - \beta_0)X_0 + (\delta_{\nu\mu 1} - \delta_{\nu\mu 0})\lambda_0 \quad (11)$$

The study differentiates the treatment effects from the heterogeneity effects. For instance, the malt barley CF participants may have a better status in terms of the value of asset accumulation than the non-participants although they participated in CF because of unobservable factors such as their skills that could potentially affect the status of the household's asset accumulation. This "base heterogeneity (BH) effect" is the difference between (a) and (d) for the group of malt barley CF participants (Asfaw et al., 2012; DiFalco et al., 2011):

$$BH_1 = E(y_1|I = 1) - E(y_1|I = 0) = (X_1 - X_0)\beta_1 + (\lambda_1 - \lambda_0)\delta_{\nu\mu 1} \quad (12)$$

Similarly, for the group of households that decided not to participate in CF, "the effect of base heterogeneity" is the difference between (c) and (b)

$$BH_0 = E(y_0|I = 1) - E(y_0|I = 0) = (X_1 - X_0)\beta_0 + (\lambda_1 - \lambda_0)\delta_{\nu\mu 0} \quad (13)$$

Finally, the study investigated the "transitional heterogeneity effect" (ATH) and whether the impact of participating in CF is larger or smaller for the households that actually participated or for the household that actually did not participate in the counterfactual case that they did participate in CF, that is the difference between equations 10 and 11 (i.e., ATT and ATU): $ATH = ATT - ATU$. The overall fitness of the ESR model was checked from the likelihood ratio test statistics displayed together with the model results (Table 5).

3.5. Description of dependent and independent variables

3.5.1. Dependent variable

CF participation: the participation status of the sample household in malt barley contract farming in 2021/22 was considered the dependent variable. It is a dummy that assumed one if the farm household head participated in CF in the 2021/22 production period, and otherwise zero.

Outcome refers to the smallholder farmers' asset accumulation as a continuous variable measured in ETB and refers to the value of the asset (physical asset) obtained from malt barley income by smallholders in 2021/22. Physical assets include productive assets (farm implements), livestock, household goods (utensils), and consumer durables (radio and mobile) purchased with the malt barley income gained in the study period. Hence, total asset or asset accumulation is the sum of the value of livestock and non-livestock assets (farm implements, utensils, radio, and mobile) in Ethiopian Birr.

3.5.2. Independent variables

The independent variables used to determine the participation decisions model and estimate the value of assets with the ESR model of this particular study are indicated in Table 2.

Sex: refers to the sex of the household head, if the household head is male, then it is one and zero otherwise. Sex is expected to have a positive influence on the participation of CF positively since a male-headed household has better access to information, control resources, and access to credit than a female-headed household (Wendimu et al., 2016). Hence, sex was expected to be positively related to participation in malt barley CF, and thereby asset accumulation.

The age of the household head: is a continuous variable in years; which is a proxy for experiences. It is learning by doing and improving the decision-making power of the household head. This means that older farm households have greater access to productive resources such as land and labor for use in the production process. As age increases, farmers also accumulate more experience and thus, be more participants in CF. According to reports, age is positively related to participation in CF (Bellemare & Novak, 2017; Bezabeh et al., 2020) However; the farmer at a certain level of age may get physically weaker and ineffective in agronomic practices and lack access to information that has a negative influence on participation in CF. Studies have shown that age has an inverse impact on participation in CF (Maertens & Vande Velde, 2017; Olounlade et al., 2020). Hence, age was expected to have an indeterminate effect on malt barley CF participation, and hence asset accumulation.

Household size: is a continuous variable measured in the count of who is living within the household. It is directly related to CF participation (Olounlade et al., 2020) since CF is expected to be labor-intensive rather than capital-intensive. It is hypothesized that if labor contributions dominate consumption, the large family-sized household is expected to have better participation in malt barley CF. Therefore, household size was expected to have an indeterminate influence on malt barley CF participation, thus asset accumulation

Level of Education: refers to the level of education of the household head, which was measured by years of schooling. Education facilitates the management capacity, and ability of farmers to make informed decisions. It enhances the ability of the household head to gather, analyze and use relevant information, which is expected to have a direct relationship with the participation in malt barley CF. Studies indicated that the level of education is positively related to CF (Abera et al., 2018). In this study, the level of education was expected to have a positive effect on the likelihood of participation in malt barley CF, thus asset accumulation.

Total land holding of the household: -is a continuous variable measured in hectares (ha) under the control of the household head. In the current scenario, it has a positive correlation with participation in malt barley CF (Ganewo et al., 2022). Hence, it was hypothesized that land size was expected to have a direct relationship with CF, and thereby asset accumulation.

Off-farm is a dummy variable that takes a value of one if the household participated in the off-farm activities and zero otherwise. It refers to the involvement of the household members in off-farm activities; which is a proxy variable for off-farm income that may have negative and positive effects on the participation in malt barley CF. That is to say, a household head who is engaged in off-farm activities may not manage his/her malt barley farm timely due to labor competition Abera et al. (2018), while as Olounlade et al. (2020) reported off-farm income can be used to purchase inputs such as improved inputs (seed, fertilizer, chemicals) and labor for farm management activities. It is assumed that this variable was expected to have indeterminate effects on participation in malt barley CF, and thereby asset accumulation.

Frequency of extension contact: refers to the number of contacts between the household head and extension experts per malt barley production season. The extension improves the knowledge, attitude

towards technology, and skills of household heads through consultation, demonstration, training, and field visits of model farmers. It was expected to have a direct relationship with the participation in malt barley CF because extension experts advise about the benefits of malt barley CF on market security and other supports (Abera et al., 2018; Ganewo et al., 2022). Hence, the more extension contacts the household head had likely participated in malt barley CF, thus asset accumulation.

Participation in training is a dummy variable, if the household head participated in training; it would be one and zero otherwise. Training access can promote the knowledge and decision-making skills of the household head. Training and participation in malt barley CF were found to be directly related (Dube, 2019). So, it was expected that having access to training would have a positive influence on the household head's participation in the malt barley CF, and thereby asset accumulation.

Experience in malt barley production and marketing: the number of years the household head has been involved in the production of malt barley. According to Ganewo et al. (2022), more experienced farmers participated in CF than less experienced ones. Hence, it was expected that malt barley production experience positively determines participation in malt barley CF, thus asset accumulation.

Mobile ownership is a dummy variable that took one if the household head had a mobile phone and zero otherwise. It refers to having a mobile phone to improve the ability of the household head to obtain information. Owning a mobile phone increases the likelihood of farmers participating in malt barley CF by improving information access. It was also found that mobile phone ownership has a direct effect on CF participation (Abera et al., 2018). Hence, having a mobile phone allows the household heads to participate in malt barley CF.

Credit access: it was a dummy variable that takes one for those who received credit from formal lending institutions in 2020/21 and zero otherwise. It gives the input purchasing power to the household heads. Credit access is directly related to CF participation (Abera et al., 2018; Bezabeh et al., 2020). Hence, credit access was hypothesized to encourage household heads to participate in malt barley CF and thereby asset accumulation.

Distance to market: is a continuous variable measured in walking minutes. It is a proxy variable for market access for malt barley producers. Market access encourages household heads to purchase and sell inputs and outputs; respectively (Abera et al., 2018; Bezabeh et al., 2020; Ganewo et al., 2022). In this study, distance from the market was hypothesized to have an inverse relationship with participation in malt barley CF, thus asset accumulation.

Distance to FTC: is a continuous variable measured in walking minutes. The household heads nearest to the farmers' training center (FTC) have the opportunity to observe the demonstration at the FTC, and, pieces of training, information, and advocacy services are easier to obtain than those who are far from FTC. It is inversely related to participation in CF (Abera et al., 2018; Bezabeh et al., 2020; Ganewo et al., 2022). It was expected to have a negative influence on malt barley CF participation decision of the household head; and thereby asset accumulation.

Participation in a social organization refers to the leadership position in a formal (*Gote*, village, and *kebele*) or informal organization (*edir*, *equb*, and *mahiber*) in the community. It is a dummy variable that takes the value of 1 if the household head participated at least in one of the various social statuses and zero otherwise. It was expected to have an indeterminate effect on participation in CF. For instance, this participation might have a positive effect in the sense that the household head may have information access, experience sharing, and labor as well as other resources sharing to participate in CF (Rondhi et al., 2020). Contrarily, taking part in social activities may compete with the family's resources. Hence, the influence of participation in social affairs of the household head on CF participation was indeterminate, thus asset accumulation.

Field day participation: is a dummy variable that takes one if the household head participated in the field day and zero otherwise. The households who had field day participation experiences were expected to participate in malt barley CF because seeing is believing. It is of course among the extension approaches to disseminating technologies through sharing the best experiences from their model peers and on-farm and on-station demonstration sites. According to Yami et al. (2013), and Mathewos et al. (2021) field day participation has a direct relationship with technology adoption. Hence, participation in the field day was expected to motivate household heads to participate in malt barley CF.

Cooperative membership is a dummy variable that takes one if the household is a member of the cooperative and zero otherwise. It can reduce transaction costs by negotiating contracts with a large number of small farmers dispersed across several locations. They guarantee the timely, adequate, and high-quality delivery of goods to contractors and the distribution of inputs to farmers. Cooperatives are expected to offer malt barley producers viable information about production technologies, deliver improved inputs, and arrange ways of easy access to credit services to encourage farmers (Bezabeh et al., 2020). Hence, cooperative members are more likely to participate in malt barley CF, thus asset accumulation.

Cluster farming: it was a dummy variable, if the household participated in cluster farming; it would be one, otherwise, it would be zero. It was expected to increase the production and productivity of crop production since it helps to enhance commercial opportunities for smallholder farmers, by expanding the quantity and quality of interrelated agricultural inputs (chemical fertilizer, improved seeds, and extension and advisory services), and facilitating market linkages on the output side of smallholder farming “business” (Louhichi et al., 2019). Hence, it was expected to have a direct relation with asset accumulation.

Row planting is a dummy variable that takes one if the household planted malt barley in a row and zero otherwise. Row planting is important in many ways. The yield is increased while the amount of seed input and fertilizer needed per hectare is decreased. So, it can be concluded it increases income through increasing yield and cost of production. According to Belete (2020), Eshetu et al. (2022), and Ayele Anaye and Tarekegn Erkalo (2020) row planting improves the production efficiency of wheat and *Teff* production. Hence, it was hypothesized that row planting is directly related to malt barley production and income, thus asset accumulation.

4. Result and discussion

4.1. Characterization of sample farmers

The equality means tests of continuous variables are shown in Table 3 by contract participation. Furthermore, the standard deviation, minimum and maximum values of these variables are presented in Table A3.

Age of the household head: the average age of CF participants was 45.88 years, compared to 43.68 years for non-participants. At the 5% probability level, these differences were statistically significant. In other words; CF participants were older than non-participants.

Malt barley farming experiences: the average malt barley experiences of CF participants and non-participants were 5.42 and 4.59 years, respectively. These differences were statistically significant at a 1% probability level. This implies the participants had more experience in malt barley farming as compared to the non-participants.

Household size: the average household size of CF participants was about 7 persons while it was 6.49 persons for non-participants. The household size of participants was dominant and statistically significant compared to the non-participants at a 1% probability level. The household size of both participants and non-participants was more than the national (6.23) and the regional average household size (4.53) (CSA, 2021).

Table 3. Equality means tests for contract participants

Variables	Pooled	Participants	Non-participant		Mean difference	p-value
	Mean	Mean	Mean	Mean		
Age of the household head	44.73	45.88	43.68	43.68	2.2	0.022 ^b
Malt barley experience(year)	4.99	5.42	4.59	4.59	0.83	0.002 ^a
Household size (count)	6.78	7.09	6.49	6.49	0.6	0.008 ^a
Own land size(ha)	1.05	1.13	0.98	0.98	0.15	0.041 ^b
Livestock holding (TLU)	4.15	4.23	4.09	4.09	0.14	0.597
Distance-market (minutes)	71.62	74.08	69.40	69.40	4.68	0.319
Distance-FTC (minutes)	35.81	34.5	37.00	37.00	-2.50	0.396
Annual extension contacts (count)	6.86	7.96	6.85	6.85	1.11	0.001 ^a
Education (year)	2.09	2.23	1.93	1.93	0.32	0.250
Malt barley yield (kg/ha)	1710.86	1796.27	1633.62	1633.62	162.66	0.0001 ^a
Malt barley produce price (ETB/kg)	37.77	38.26	37.32	37.32	0.94	0.020 ^b
Malt barley revenue (ETB/ha)	64876.66	68772.51	61353.61	61353.61	7418.90	0.000 ^a
Cost for malt barley (ETB/ha)	23264.52	25041.53	21657.56	21657.56	3383.98	0.000 ^a
Malt barley Gross income (ETB/ha)	41612.14	43730.98	39696.06	39696.06	4034.92	0.011 ^b
Livestock asset (TLU)	1.4	1.62	1.3	1.3	0.32	0.070 ^c
Livestock asset (ETB)	20745.49	25545.34	17062.33	17062.33	8480.10	0.002 ^a
Asset (ETB)	24783.17	29363.86	21066.96	21066.96	8296.9	0.005 ^a

Notes: ^a, ^b, and ^c are significant at 1, 5, and 10% probability levels, respectively.

Source: Own Computation, 2023.

Landholding: the average landholding of CF participants and non-participants was 1.13 and 0.98 ha, respectively. The average difference in the land holding of CF participants and non-participants was statistically significant at 5%. This implies that participants had more landholding compared to non-participants. The average land holding of both participants and non-participants was more than the national (0.84 ha per household) and less than the regional average land holding (1.15 ha per household) (CSA, 2021).

Frequency of extension contact: on average, CF participants had with extension personnel, 7.96 whereas non-participants had 6.85 times annually. This implies that CF participants had a greater number of extensions contact than non-participants and were statistically significant at a 1% probability level.

Malt barley yield (kg/ha): the average malt barley output produced by the sample farmers was 1710.86 annually. While the average malt barley yields for CF participants and non-participants were around 1796.27 and 1633.63, respectively. The t-test result shows that participants produce more malt barley compared to non-participants and the difference is statistically significant at a 1% probability level. This result falls below the national (20.4qt/ha), regional (18.3qt/ha), and zonal (18.39qt/ha) malt barley productivity levels for the year 2021 (CSA, 2021).

Total cost for malt barley (Birr/ha): shows that the average cost of malt barley production for the pooled samples was 23,264.52 and the corresponding figure for participants and non-participants were 25,041.53 and 21,657.56, respectively. The t-test for equality of means for the non-participants and participants is statistically significant at a 1% probability level.

The sources of income of malt barley farmers in the study area, which are the sources of asset accumulation, mainly are from the sales of malt barley, sales of other crops, sales of livestock, and off-farm activities. However, the sales of malt barley constitute the major source of income for all groups of sampled malt barley producer households in the study area. The average gross income (the value of the total malt barley yield at the current market price) of malt barley for sampled households in 2021/22 was ETB 64,876.66 (1197.21\$) in the study area.

Livestock in TLU and value (Birr) asset was also the indicator of the long-term asset-building outcome of the commercialization of malt barley farmers' participation in CF. CF participants had more livestock assets in TLU and value as compared to non-participants and were statistically significant at 10% and 1%, respectively. In the study area, the farmers mostly preferred to accumulate assets in the form of livestock (mostly small ruminants such as sheep). That is why the value of the total assets and the value of livestock assets is not as much wider.

Asset accumulation: A long-term consequence of the commercialization of malt barley is the creation of assets that further increase farmers' income. It is the sum of the value of livestock and non-livestock assets in Ethiopian Birr. The average household asset value for the samples was 24,783.17 Birr, with average values of 29,363.86 Birr for CF participants and 21,066.96 Birr for non-participants. At a 1% level of significance, the test for equality between the two groups' means of asset accumulation seemed statistically significant. This demonstrates that participant households' assets that are worth more than non-participant households.

The average malt barley price, income, and gross income were found to be 37.77, 64876.66, and 41,612.14 Birr per ha, respectively for the samples. In comparison to their counterparts, the participants earned higher malt barley prices, revenue, and gross income during the survey period. This implies that participants outperformed their counterparts in terms of malt barley income. Additionally, at 5% and 1% probability levels, there was a statistically significant difference between participants and non-participants in terms of malt barley price, revenue, and gross income.

In a nutshell, it was discovered that participants had slightly more land, family size, and extension contact frequency than their counterparts. In addition, participants benefited from increased yields, prices, revenues, and gross income while incurring higher overall costs compared to non-participants. All of them were anticipated to improve farmer well-being and serve as sources of asset accumulation.

The equality association tests of discrete variables are also shown in Table 4 by CF participation.

Cooperative membership can reduce transaction costs by negotiating contracts with a large number of small farmers dispersed across several locations. They guarantee the timely, adequate, and high-quality delivery of goods to contractors and the distribution of inputs to farmers. In contrast to the 77.8% and 63.6% of CF participants and non-participants, respectively, 70% of sample households are cooperative members. This suggests that the majority of CF participants are cooperative members. At a 1% probability level, there was a statistically significant association between cooperative membership and CF participation.

Credit access: at a 1% probability level, there was a statistically significant association between credit access and CF participation. The sample households who received credit was 64.3%, compared to 75.7 and 54.1% for CF participants and non-participants. This suggests that the majority of CF participants had access to credit.

Participation in training: the production of malt barley requires a high level of managerial expertise, from pre-harvest land preparation to post-harvest handling. Thus, training farmers is crucial. Among the sample households, 75.6% had received training, compared to 86.2% of CF participants. There is a statistically significant association between training and CF participation at a 1% probability level.

Participation in field days was significantly associated with CF participation at a 1% probability level. While 92.1% and 52.2% of CF participants and non-participants, respectively, engaged in the field day, only 71% of the sample houses did. In contrast to their counterparts, the majority of the CF participants had field day participation experiences. Row planting had a 1% probability level statistically significant relationship with CF participation. It was practiced by 49% of the samples, as opposed to 76.2% and 24.4% for participants and non-participants, respectively. Comparing the CF participants to their peers, it appears that a majority of them engaged in row planting for the production of malt barley.

Cluster farming: for a variety of commodities, including malt barley, cluster farming initiatives are being used in Ethiopia to boost output and productivity (Louhichi et al., 2019). It is a pre-request to take part in malt barley CF. Because of this, 93.7% of CF participants cultivate malt barley in cluster farming systems, as opposed to 49.8% of non-participants and 71% of the samples. It had a 1% significant statistical association with CF participation.

These generally show that most CF participants had greater access to credit than their counterparts, participated in training and field days, engaged in cluster farming and row planting, and belonged to cooperatives. This is necessary to increase malt barley output and yield, which will ultimately boost farmers' standard of living.

4.2. Impacts of contract farming participation on asset accumulation

The Full Information Maximum Likelihood (FIML) estimator of the ESR model was employed to examine the impact of malt barley CF participation on asset accumulation (Ahmed & Mesfin, 2017). Therefore, Endogenous Switching Regression (ESR) was used to evaluate the asset accumulation impacts of CF participation. The validity of the instrumental variable, overall model fitness, and the existence of endogeneity was checked by tests (Tables A2 and 5). Once these tests were accomplished, reporting the determinants of asset accumulation and ATT of asset accumulation was followed.

Table 4. Association tests for contract participants

Variables	Response	Participants		Non- participants		Pooled		$\chi^2(p)$
		Freq.	(%)	Freq.	(%)	Freq.	(%)	
Credit	Yes	143	75.7	113	54	256	64.3	20.17 (0.000) ^a
	No	46	24.3	96	36	142	35.7	
Sex	Male	185	97.9	202	96.7	387	97.2	0.561 (0.454)
	Female	4	2.1	7	3.3	11	2.8	
Cooperative membership	Yes	147	77.8	133	63.6	280	70	9.52 (0.002) ^a
	No	42	22.2	76	36.4	118	30	
Cluster farming	Yes	177	93.7	104	49.8	281	71	92.11 (0.000) ^a
	No	12	6.3	105	50.2	117	29	
Row planting practice	Yes	144	76.2	51	24.4	195	49	106.52 (0.000) ^a
	No	45	23.8	158	75.6	203	51	
Participation in Field Day	Yes	174	92.1	109	52.2	283	71	55.26 (0.000) ^a
	No	15	7.9	100	47.8	115	29	
Mobile ownership	Yes	107	56.6	110	52.6	217	54.5	0.63 (0.426)
	No	82	43.4	99	47.4	181	45.5	
Participation in social organization	Yes	57	30.2	54	25.8	111	28	1.91 (0.167)
	No	132	69.8	155	74.2	287	72	
Training participation	Yes	163	86.2	138	66	301	75.6	22.0 (0.000) ^a
	No	26	13.8	71	34	97	24.4	
Off-farm participation	Yes	103	54.5	111	53.1	214	53.8	0.0768 (0.782)
	No	86	45.5	98	46.9	184	46.2	

Notes: ^a, ^b, and ^c significant at 1, 5, and 10% probability levels, respectively.
Source: Own Computation, 2023.

4.2.1. Tests of hypothesis

The validity tests of the instrumental variable such as field day participation were empirically checked. The first test was to run a probit model of participation in malt barley CF through this instrument and other variables. This instrument has been jointly validated as a strong predictor of malt barley CF participation (Table A2). The second is the falsification test that checks whether the field day participation affected asset accumulation. As reported by DiFalco et al. (2011) and Adego et al. (2019), this test indirectly checks if this instrument correlated with the unobservable. The test confirms that the field day participation was not a jointly statistically significant driver of the value of asset accumulation for CF participants and non-participants (Table A2). The next test is the overall fitness of the ESR model for the value of asset accumulation, which was confirmed by the Wald chi-square test significant at 1% probability levels. This suggests there is an endogeneity issue, hence the adoption of the ESR model was determined to be appropriate. The existence of heteroskedasticity in the model for both outcome variables was controlled by the use of robust standard errors (White, 1982). Robust specifies that the Huber/White/sandwich estimator of variance was used in place of the conventional maximum likelihood estimator (MLE) variance estimator. Lastly, sigma, the rhos, and the Wald test of independent equations were significant indicating there is a correlation between the error terms of the selection equation (i.e. participation in CF) and outcome equations (i.e. asset accumulation by participants and non-participants). The null hypothesis of no sample selection bias in CF participation can therefore be rejected at a 5% level of significance. Hence, these tests confirmed that ESR is appropriate for the data sets of asset accumulation impacts of participation in CF.

The correlation coefficients (ρ_1 and ρ_0) between participation in CF and its outcome variable were positive and statistically significant for asset accumulation at a 5% level of significance. This indicates that self-selection occurred among the CF participants and non-participants. The positive sign indicates a negative selection bias, suggesting that farmers with a below-average value of assets have a higher probability of participating in CF. Moreover, CF participants would have above-average asset value whether they participate or not but would be better off if they participated. Relatively, non-participants would have below-average asset value but would be better off if they chose not to participate (Fuglie & Bosch, 1995). The positive correlation coefficients between outcome variables and CF participation status also implied that there were both observable and unobservable factors that affected the participation and outcome such as asset accumulation. The variations among the coefficients of CF participants' and non-participants' outcome variables showed the existence of heterogeneity in the sample. That is to say, the difference in the coefficients of the asset equation between CF participants and non-participants shows the existence of heterogeneity influences on the value of asset accumulation. Furthermore, the Wald test of independence of the CF participation and assets equations was found to be significant at a 5% level of probability; which implies that CF was positively correlated with asset accumulations.

4.2.2. Factors influencing asset accumulation

Table 5 presented the Full Information Maximum Likelihood (FILM) estimates of the ESR model results that show the influences of the demographic, socioeconomic, and institutional factors on malt barley-based asset accumulation and malt barley CF participation. The second column presents the estimated coefficients of selection on participation in CF whereas the fourth and sixth column presents the asset accumulation for participants and non-participants in CF.

The model's findings revealed that participation in field days, credit availability, and household head education were all positively and statistically significantly linked with CF participation. The household head's education level and field day participation did not, however, have an impact on the outcome factors. On the one hand, the asset accumulation of CF participants was positively and significantly influenced by membership in cooperatives, off-farm participation, and land size, and negatively affected by age. The finding implies that the CF under study is the most effective in improving asset accumulation among CF participants with relatively larger landholdings and younger, members in cooperatives and engaged in off-farm. On the other hand, asset

Table 5. Full information maximum likelihood estimates of the switching regression model

Variables	CF participation		Asset			
	Selection (n = 398)		Participants (n = 189)		Non-participants (n = 209)	
	Coefficient	R.S.E	Coefficient	R.S.E	Coefficient	R.S.E
Constant	-1.11	1.38	8.28 ^b	1.26	-7.14 ^a	0.96
Sex	-0.64	0.47	-0.18	0.53	-0.02	0.29
Age	-0.01	0.01	-0.02 ^b	0.01	-0.05 ^b	0.02
Credit	4.00 ^a	0.38	0.23	0.21	0.32 ^a	0.14
Social organization	0.38	0.27	0.12	0.32	0.32	0.25
Household size	0.04	0.05	0.04	0.03	0.09 ^a	0.03
Land size	-0.02	0.19	0.27 ^c	0.11	0.09	0.11
Cooperative	-0.32	0.32	0.51 ^a	0.18	0.65 ^a	0.21
Extension	-0.04	0.04	0.01	0.03	-0.005	0.02
Training participation	0.03	0.34	-0.28	0.19	0.12	0.23
Distance from market	-0.003	0.003	-0.002	0.002	0.003	0.002
Distance from FTC	-0.003	0.004	0.01	0.02	-0.003	0.003
Off-farm	-0.30	0.34	0.48 ^a	0.16	0.63 ^a	0.16
Education status	0.59 ^b	0.29	-0.04	0.15	0.15	0.13
Malt barley Experience	0.003	0.07	-0.004	0.039	-0.05	0.03
Mobile	-0.39	0.25				
Field day participation	0.62 ^b	0.29				
Row planting			0.281	0.18		
Cluster farming			0.15	0.28		
Farming experience					0.05 ^a	0.014
/lnsigma (lnσ _{ij})			-0.15 ^a	0.05	-0.22 ^a	0.05
/r			0.35 ^c	0.18	0.42 ^c	0.22
Sigma (σ _{ij})			0.86 ^a	0.04	0.802 ^a	0.04
Rho (ρ ₁ and ρ ₀)			0.39 ^b	0.19	0.33 ^b	0.16

Wald χ^2 (15) = 204.01^a, Prob > χ^2 = 0.000; Log pseudolikelihood = -443.75

Wald test of independent equations: χ^2 (2) = 7.03^b; Prob > χ^2 = 0.02

Notes: ^a, ^b, and ^c are significant at 1, 5, and 10% probability levels, respectively Source: Own Computation Based on Model Output, 2023

accumulation by non-participants was positively and significantly determined by farming experience, household size, membership in cooperatives, off-farm participation, and access to formal credit while negatively determined by age. The household head's membership in cooperatives was the most important factor of asset accumulation, followed by off-farm engagement of household members, farming experiences and age of the household head, household size, and access to credit.

According to the findings, the age of the household head, cooperative participation, and off-farm engagement of household members were the most important drivers of asset accumulation for both participants and non-participants. Other variables have differing effects on asset accumulation by participants and non-participants. Household size, credit access, and farming experiences, for example, only influenced non-participants, whereas land size influenced participants. These disparities reflect the fact that there is heterogeneity between participants and non-participants (Adegbo et al., 2019; DiFalco et al., 2011; Khanal et al., 2018; Khanal et al., 2018).

The age of the household head was found to have a greater influence on asset accumulation among non-participants than among participants. A one-year rise in the age of the participating and non-participating household heads resulted in a 2% (0.02) and 5% (0.05) decrease in the value of assets, respectively. This means that the likelihood of accumulating assets decreases as the age of the household increases. Non-participants' assets were, nevertheless, favorably associated with their farming experience. Asset accumulation increases by 5% (0.05) due to a one-year increase in non-participants' experiences. This implies that age should not be regarded as a proxy for experiences.

Being a member of the cooperative had a more significant effect on the asset accumulation of both non-participants and participants. This is because the cooperative decrease farmers' transaction costs by providing improved inputs and an established price for their malt barley output. Being a cooperative member, the value of assets accumulated by the participants and the non-participants increases by 51% (0.51) and 65% (0.65), respectively. Similar to this, the household members of participants and non-participants who engage in off-farm activities boost asset accumulation by 48% (0.48) and 63% (0.63), respectively. This is because off-farm activities create additional cash that may be used to purchase inputs for malt barley and other crops, resulting in increased productivity and asset accumulation. Furthermore, off-farm income covered other household expenses, allowing additional revenue from malt barley to be invested for asset accumulation.

The size of the land has a significant impact on the participants' asset accumulation. A one-hectare increase in land size for participants results in a 27% (0.27) rise in asset accumulation; however, non-participants' asset accumulation is not affected by land size. In the context of the research area, there is no potential for increasing land size to boost productivity and thus asset accumulation; rather, land productivity can be improved through intensification. Household size and credit access had a significant effect on non-participants' asset accumulation. A single person added to the non-participants' household results in a 9% (0.09) rise in assets, and having access to credit results in a 32% (0.32) increase in assets. Active family labor benefits the rural community since they can engage in non-farm and off-farm activities to earn additional revenue in addition to farm work. As a result, household expenses can be partially covered by income from non-farm sources, opening the door for the chance to build assets through extra malt barley revenue. Additionally, in the study area, family labor contribution is the most substantial. That is, big family sizes can complete farming tasks, namely malt barley, on schedule. As a result, improve malt barley productivity and production, resulting in asset accumulation.

4.2.3. ESR estimates of asset accumulation impact of contract farming

Table 6 provides estimates for the average treatment effects on the treated (ATT), average treatment effects on the untreated (ATU), and the heterogeneity effect (HE), which demonstrated the influence of CF on asset accumulation. The ESR estimates of ATT and ATU consider selection bias resulting from the possibility that CF participation and non-participation may be systematically different, in contrast to the mean differences presented in the descriptive analysis (Table 3 which may confound the impact of CF participation on asset accumulation).

The results from the ESR-based treatment effects show that malt barley CF has a positive and significant impact on asset accumulation. Given this model's results, a direct difference between the predicted mean outcomes of CF participants and non-participants might lead to a flawed conclusion. However, the predicted value of asset accumulation for CF participants was compared with the same had they not been a participant in CF (i.e. had they been CF non-participants). Similarly, the value of asset accumulation of the non-participants was compared with an outcome variable of whether had they been malt barley CF participants. As a result, the average treatment effect on treated (ATT) demonstrated that participation in CF increased asset value by 9652.7ETB on average and was statistically significant at a1%. Similarly, the average treatment effect on untreated (ATU) demonstrated that non-participants' asset worth would have increased by 7417.3ETB and was statistically significant at a1% if they had participated in CF. In a nutshell, the participants would have lost the value of the asset of 9652.7ETB if they had not participated in CF, whereas the non-participants would have accumulated the value of the asset of 7417.3ETB if they had participated in CF. The result implied that non-participants would have increased the value of their assets by about 35.2% ($7417.3 \times 100/21077.9$) had they participated in CF; while the CF participants would have lost about 32.9% ($9652.7 \times 100/29381.2$) of the value of their asset had they been non-participants in CF. Hence, CF participation had increased the asset accumulation by the value of 9652.7ETB (32.9%) for CF participants. The effect of CF participation will have a considerable impact on current non-participants if they participate in CF. They can increase their asset by a value of 7417.3ETB (35.2%) on average; which is higher than (2.3%) the value of assets accumulated by participants. Overall, CF increases the value of assets of malt barley farmers in Northwestern Ethiopia.

The base heterogeneity also compares the impact of CF participation on participants' and non-participants' asset accumulation. Base heterogeneity can be divided into two categories: participants' base heterogeneity and non-participants' base heterogeneity. The base heterogeneity for participants (BH₁) is the difference between the value of asset accumulation of participants minus the value of asset accumulation of non-participants if they would have participated. Likewise, the base heterogeneity for non-participants (BH₀) is the difference between the value of asset accumulation of non-participants if they would have participated minus the value of asset accumulation of non-participants. The base heterogeneity (BH₁) for asset value was positive, indicating that if present non-participants had participated, their assets worth would have been 886ETB lower than farm households that participated, but this difference was statistically insignificant. That is, if the non-participants joined CF, their assets would diminish by 886ETB in value. In a similar vein, the negative base heterogeneity (BH₀) indicates that present participants would have a lower asset value (-1349.4ETB) than actual non-participants even if they had not participated. This means that if current participants did not participate in CF, the value of their assets would decline by 1349.4ETB, and it was also statistically significant at the 1% level. The average transitional heterogeneity was 2235.4ETB

Table 6. Impacts of CF on asset accumulation using the ESR model

Treatment effects	Decision stage		ATE (treatment effect)	t-value
	To participate	Not to participate		
CF (ATT)	(a)29381.2	(c)19728.5	9652.70	6.20 ^a
NCF(ATU)	(d)28495.2	(b)21077.9	7417.3	3.63 ^a
Heterogeneity effects	BH ₁ = 886(t = 1.25)	BH ₀ = -1349.4 (t = 5.56 ^a)	TH = 2235.4	5.3 ^a

^ais significant at 1% probability level. ATT=Average treatment effect on treated; ATU=Average treatment effect on untreated, ATE=Average treatment effect, BH=base heterogeneity, TH=transitional heterogeneity
Source: Own Computation, 2023.

and statistically significant at a 1% probability level. Generally; the transitional heterogeneity effect was found to be positive for asset accumulation. This implies that the impact of malt barley CF on asset accumulation is significantly greater for farmers who participated compared to those that did not participate in CF. Moreover, the $p_1 > p_0$ (i.e. $0.39 > 0.33$) indicates that CF participant obtains higher asset than they would if they did not participate in CF (Lokshin & Sajaia, 2004). A positive effect on asset accumulation was expected since malt barley CF is expected to improve productivity through price, credit (provision of fertilizer and improved seeds), and technical support. Consequently; increasing production and productivity with price support will lead to an increase in malt barley income so as accumulate assets using extra income. The results agree with other studies that report a positive link between CF and assets (Michelson, 2013) while contradictory with (Wendimu et al., 2016). Though the impacts of CF on asset is few and inconclusive in the literature, the finding of this study supports the transaction cost economic theory. The transaction cost economic theory predicts the positive contribution of CF on household welfare through its services: provision of agricultural technology, output price support, information, and technical support.

5. Conclusion and recommendation

Contract farming (CF) is one of the strategies implemented to commercialize malt barley in Ethiopia since 2013, with the intention of malt barley import substitution. CF enhances the productivity of smallholder farmers by introducing improved farming practices through the provision of inputs, credit, extension services, and other support services. The expected outcome is meeting the domestic demand for malt barley, improving the welfare of smallholder farmers, and saving Ethiopia's foreign exchange. Despite this contribution, the impacts of CF on asset accumulation were previously overlooked. Hence; the study was designed to compute the influence of the participation of malt barley farmers in CF on asset accumulation in Northwestern Ethiopia. A semi-structured interview schedule was used to collect data from 398 (189 CF participants and 209 non-participants) malt barley farmers randomly selected from 9 kebeles in 2 districts selected in 2021/22 by multistage sampling procedures. The data were analyzed using endogenous switching regression.

The inferential statistics highlighted marked differences and associations between malt barley CF participants and non-participants. The results of the ESR model revealed the presence of selection bias stemming from both observable and unobservable factors that influenced CF participation and asset accumulation. The Full Information Maximum Likelihood (FILM) estimates of the ESR model show that there are common variables that determine the asset accumulation of CF participants and non-participants. The finding implies that the CF under study is most effective in improving asset accumulation among CF participants with relatively larger landholdings who are younger, cooperative members, and engaged in off-farm activities. Asset accumulation by non-participants was positively and significantly determined by farming experience, household size, membership in cooperatives, off-farm participation, and access to formal credit, while it was negatively determined by age. CF participation is determined by education level, field day participation, and credit access.

According to the findings, the age of the household head, cooperatives, and off-farm are the most important drivers of the asset for both participants and non-participants, however, they have varying degrees of influence. Furthermore, the land had a substantial effect on participants' assets exclusively, but credit access, household size, and farming experiences influenced non-participants' assets. As a result, both participants' and non-participants' assets were influenced by common variables of varying magnitude and distinct variables. This disparity demonstrates the existence of heterogeneity between CF participants and non-participants. For malt barley farmers, the average treatment effect on treated and untreated barley was 9652.7ETB and 7417.3ETB, respectively, and was significant at 1%. The base heterogeneities for CF participation and non-participation were 886ETB and -1349.4ETB, respectively. The average transitional heterogeneity was 2235.4ETB. The positive transitional heterogeneity effect on asset accumulation implies that

the malt barley CF on asset accumulation is significantly greater for participants compared to non-participants. Generally, CF has a positive association with the asset accumulation of malt barley farmers; this result supports transaction cost economic theory.

Therefore, CF plays a crucial role in malt barley yield through different supports, which is a primary source of income used by smallholder farmers to accumulate assets in the study area. Hence, concerned bodies should develop and/or revise the implantation strategies to promote and scale up malt barley CF so that improving the asset accumulation capacity of farmers will result in raising their living standards in potential malt barley production areas in general and the study area in particular by accounting for the context of the area. Furthermore, the government and other stakeholders should develop the adult education system by operationalizing the existing FTC and enhancing the extension system and credit-sourcing institutions to increase the participation of non-participants in the CF of malt barley and other crops.

Although the welfare impact of CF encompasses yield, income, profit, income poverty, food and nutrition security, and production efficiency (technical, allocative, and economic efficiency), this study only focused on the asset accumulation impact of malt barley CF. Additionally, it only includes cross-sectional data for two Districts and is neither regionally nor temporally inclusive of the impact of CF. Likewise, it exclusively considers malt barley's CF performance while neglecting those of other commodities. To determine whether CF has detrimental or favorable external consequences, it should also be considered how it affects non-participants and other sectors (other crops, and the environment at large). In light of this, future research should pay due attention to the impacts of CF on a variety of commodities on multiple welfare indicators (outcome variables) over time and/or regions, besides spillover effects on non-participants and other sectors (other crops, and the environment).

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Authors' contribution

All authors contribute to the design of the study, data collecting, analysis, and critical review, and they all offer feedback on the paper's content and organization. The final manuscript has been reviewed and approved by all authors.

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Note

1. Kebele is the lowest administrative unit in Ethiopia.

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Appendix

Table A1. Amhara region's malt barley supply, demand, area coverage, and beneficiaries

Malt barley production and Supply in Amhara region 2011/12 to 2020/21 Crop season

Year	Land allocated (ha)	MB collected by GMF(Qt)	Beneficiary Farmers		
			Contract	Non-contract	Total
2011/2	5272.00	15400.00			
2012/3	3345.00	22091.00			
2013/4	4928.00	28732.93			
2014/5	4445.00	57259.67			
2015/6	11794.00	83068.62			
2016/7	14119.00	89650.71	5202.00	28580.00	33782.00
2017/8	15056.50	57421.81	6293.00	30976.00	37269.00
2018/9	12581.00	35825.00	4917.00	30695.00	35612.00
2019/20	9793.75	27319.46	2644.00	28498.00	31142.00
2020/21	7929.75	32203.86	2070.00	22955.00	25025.00

The Supplies of malt barley (Qt) to Gondar Malt Factory

Year	Amhara	Oromia	Imported	Or+Im	Total
2012/3	37491.00		95212.21	95212.21	132703.21
2013/4	28732.93		189212.39	189212.39	217945.32
2014/5	57259.67		164321.77	164321.77	221581.44
2015/6	83068.62		136000.00	136000.00	219068.62
2016/7	89650.71	44258.41	92486.32	136744.73	226395.44
2017/8	57421.81	51237.21	120840.98	172078.19	229500.00
2018/9	35825.00	76218.99	102313.40	178532.39	214357.39
2019/20	27319.46	131111.37	82456.12	213567.49	240886.95
2020/21	32203.86	81215.98	25217.41	206433.39	238637.25

The Annual malt barley (MB) Demand of Gondar Malt Factory (GMF) is approximately 230,000Qt; source: GMF report; 2022.

Table A2. Test on the validity of the selected instruments for asset accumulation

variables	Participation in CF (1/0): Probit		Asset accumulation: OLS	
	coff(SE)	ME(dx/dy)	CF(coff(SE))	NCF(coff(SE))
Constant	−4.15 (1.24) ^a		8.34(1.3) ^a	6.99(1.09) ^a
Sex (male=1)	−0.566(0.467)	−0.224	−0.43(0.52)	−0.07(0.39)
Age (year)	−0.007(0.009)	−0.003	−0.016(0.01)	−0.05(0.02)
MB experience (year)	0.053(0.034)	0.021	−0.008(0.035)	−0.09(0.03) ^a
Household size (count)	0.072(0.032) ^b	0.03	0.029(0.036)	0.10(0.03) ^a
Land size (ha)	−0.072(0.13)	−0.03	0.24(0.11)	0.07(0.12)
Extension contact (count)	0.08 (0.04) ^b	0.03	−0.012(0.034)	−0.01(0.02)
Distance from the market (minutes)	0.001(0.001)	0.0003	−0.002(0.002)	0.004(0.002)
Distance from the FTC (minutes)	−0.004(0.003)	−0.002	0.008(0.003) ^a	−0.004(0.003)
Mobile ownership (Yes=1)	−0.29(0.25)	−0.061	0.25(0.16)	0.06(0.16)
Social participation (Yes=1)	0.103(0.277)	0.041	0.14(0.37)	0.33(0.28)
Cooperative membership (Yes=1)	0.351(0.186) ^c	0.14	0.53(.22) ^b	0.57(0.22) ^a
Off-farm participation (Yes=1)	−0.111(0.167)	−0.044	0.51(0.17) ^a	0.68(0.17) ^a
Education status (year)	0.235(0.148)	0.10	−0.15(0.17)	0.12(0.15)
Training access (Yes=1)	0.519 (0.195) ^a	0.21	−0.36(0.23)	0.15(0.21)
Credit access (Yes=1)	0.652(0.152) ^a	0.26	0.12(0.19)	0.28(0.14) ^b
Field day participation (Yes=1)	1.14 (0.19) ^a	0.451	0.35(0.28)	0.151(0.16)
Farming experience				0.044(0.032) ^a
Row planting (Yes=1)			0.315(0.20)	
Cluster farming (Yes=1)			0.053(0.33)	
Wald chi ² (16)	88.51 ^a		F(18, 170) = 1.34	F(17, 191) =1.38
Prob > chi ²	0.0000		Pro>0.1713	Pro>0.0.1447
Sample size	398		189	209
Pseudo R ²	0.2029		R ² =0.1239	R ² = 0.134
Log pseudolikelihood	−219.49		adj-R ² =0.0311	adj-R ² =0.0366

^{a,b}and ^c are significant at 1, 5, and 10% probability levels, respectively. Values in the parentheses refer to the Robust standard errors.

Source: own computation, 2023

Table A3. Descriptive statistics for malt barley farmers

Variables	Pooled samples			CF Participants			CF non-participants		
	SD	Min	Max	SD	Min	Max	SD	Min	Max
Age	9.59	20	70	9.24	25	68	9.79	20	70
Malt barley experience	2.64	1	13	2.64	1	13	2.59	1	10
Household size	2.27	1	13	2.3	1	13	2.21	1	10
Own land size(ha)	0.72	0.25	4	0.76	0.5	4	0.68	0.25	3.5
Livestock (TLU)	2.63	0	14.92	2.50	0	14.92	2.75	0	14.73
Distance-market (minutes)	46.73	18	300	50.56	18	300	42.99	48	210
Distance-FTC (minutes)	29.4	12	300	27.78	12	180	30.81	30	300
Annual extension contacts	3.47	2	10	2.92	4	10	3.84	2	8
Education (year)	2.82	0	12	2.98	0	12	2.67	0	10
Malt barley yield (kg/ha)	425.53	708.33	3650.01	422.76	708.333	3650.01	414.33	800.00	3330.02
Malt barley produce price (ETB/kg)	4.29	35	39	0.44	38	39	5.87	35	38
Malt barley revenue (ETB/ha)	17934.61	24126.35	138700.5	16365.66	26916.65	138700.5	18589.64	24126.35	129870.6
Cost for malt barley (ETB/ha)	3988.88	16095.56	52965.07	3885.62	19207.89	52965.07	3355.36	16095.56	32899.98
Malt barley Gross income (ETB/ha)	17547.64	14500.25	118137.3	16499.96	3755.102	118137.3	18272.19	14500.25	102848.7
Livestock asset (TLU)	2.17	0	5.2	2.17	0	5.2	2.59	0	3.34
Livestock asset (ETB)	590.13	0	65200.00	499.67	0	65200.00	736.85	0	57522.00
Asset (ETB)	990.44	0	95600	990.44	0	95600	505.51	0	81236.00

*Values in the parentheses refer to the SD =standard deviation; Source: own computation, 2023

Figure A1. Malt Barley (MB) Supply to Gondar Malt Factory (GMF) in Amhara Region.

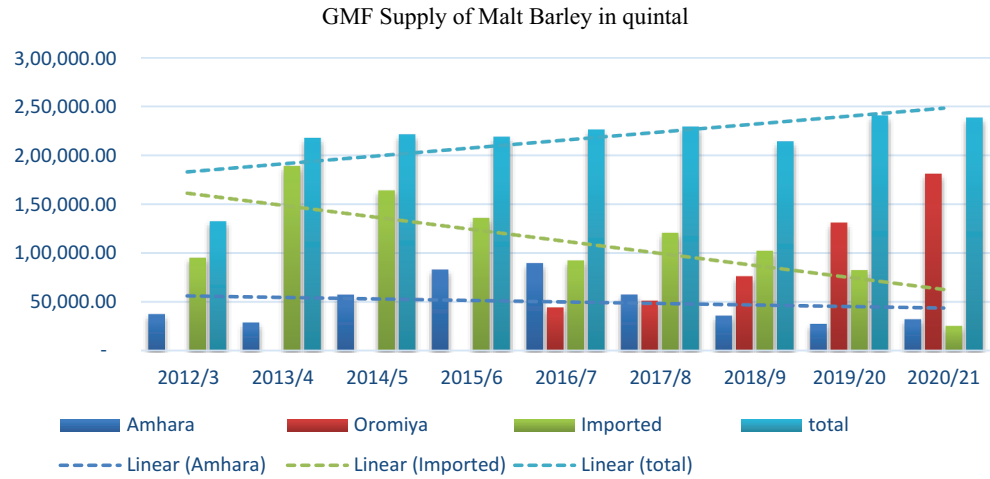


Figure A2. Malt Barley (MB) Beneficiaries in Amhara Region.

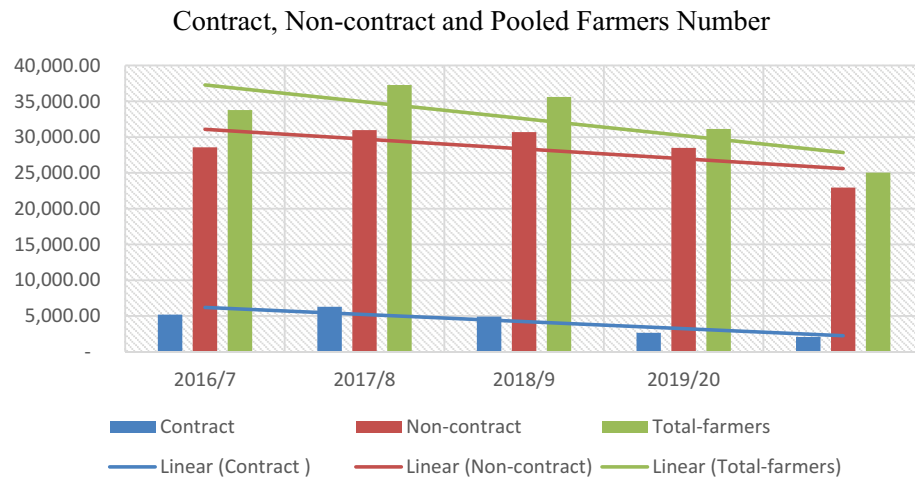


Figure A3. North Gondar Zone malt barley productivity and Area coverage trends for the last four years.

