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Are smallholder farmers benefiting from malt barley contract farming engagement in Ethiopia?

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Abstract

Background: It is believed that in Ethiopia barley has been cultivated before 3000BC. Among the cereals, it is ranked in fifth place and the most important crop next to teff, sorghum, and wheat in the country. Different works of literature highlight that engagement in contract farming is one of the innovations promoted to tackle technology constraints of the smallholder farmers, as a possible solution to raising productivity and linking smallholders in the emerging modern marketing chains. Associated with the rapid rate of urbanization in the country, there is a high demand for malt barley which is resulting high expansion of beer factories. Consequently, in the study area, many farmers got into a contract agreement with Assela malt barley factories. Recent studies conducted on malt barley in Ethiopia gave much emphasis to the value chain aspect of malt barley. Therefore, the main motive behind this study was to fill the empirical literature gap in the field by giving much emphasis on the impact assessment of malt barley contract arrangement on income and food items dietary diversity of the respondent households.

Methodology: To attain the study objectives, both primary and secondary data were collected and used. Randomly selected 312 households comprising 127 households engaged in malt barley contract farming arrangements and 185 non-contract households were the source of primary data for this study. Secondary data were collected from a review of different works of literature. Both descriptive and econometric models were used to analyze the primary data using Stata software version 14. The propensity score matching model was applied to examine the impact of malt barley contract farming engagement on the income and dietary diversity of the respondents.

Result: It was found that family size, credit use, livestock holding, malt barley production experience, frequency of extension contact, and land allotted for malt barley production positively determine the probability of participation in malt barley contract farming arrangement. Contrary to this, distance to the malt barley collection centers negatively determine the probability of participation in malt barley contract farming. The ATT estimation of the PSM indicated that participation in malt barley contract farming has a positive impact on the income and dietary diversity of the respondent households.

Conclusion: Participation in contract farming had a positive and significant impact on the annual income and dietary diversity of the smallholder households. The sensitivity analysis result showed that the impact results estimated by this study are insensitive to unobserved selection bias and the result obtained shows the true impact of contract

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farming on the income of the households. Therefore, concerned bodies working on malt barley production aspects as a development intervention should work to encourage non-contract farmers to engage in this activity.

Keywords: Income, Impact, Malt barley, Contract farming, Dietary diversity

Background

Barley is one of the major crops widely grown in different countries of the world. It ranks fourth in the world in terms of production after wheat, maize, and rice [1]. It is believed that Barley in Ethiopia has been cultivated before 3000BC [2]. In Ethiopia, among the cereals, barley is ranked in the fifth place most important crop next to teff, sorghum, and wheat [3]. Ethiopia is listed in one of the top 10 major barley-producing countries in the world and it is the second largest producer of barley in Africa next to Morocco [2]

In Ethiopia, more than 4 million smallholders produce barley and derive their livelihood from its value chain [4]. Nationally, two types of barley are grown: food barley for home consumption and malt barley for brewing [5]. It is a common source of food in the highlands of the country [6]. It is prepared in different forms of indigenous food and homemade beverages. In recent years the demand for malting barley has increased in the country. This is because of the development of new domestic breweries, which requires large quantities of malting barley [7]. The total area covered by barley in Ethiopia is 811,782.08 hectares and total annual production of about 1,767,518.447 tons with a productivity of 2.177 $t\,ha^{-1}$ in the 2018/2019 main cropping season [8]. In 2020/2021, barley production is estimated to be 2.35 million metric tons. It has been projected that barley production in 2021/2022 to be 2.36 million metric tons [5].

The malt and beer industries in Ethiopia have been growing with increasing in beer demand associated with the rise of urbanization, population growth increased income [9], and construction of new malt factories [5]. Ethiopia's beer market has been steadily growing for the past decade. In 2014, annual beer production stood at 5.6 m hectoliters, rising to around 7 m hectoliters in 2018 and this figure could reach 25 m hectoliters by 2023 [10].

Several works of literatures show that contract farming arrangement has their benefit for the smallholder farmers, particularly in developing countries. Contract farming has the potential to connect farmers to markets, thereby increasing agricultural productivity. It has the great ability to bridge the gap formed when governments liberalized without warranting access to basic farming requirements including technologies, credit, and inputs along with other essential services [11].

Engagement in contract farming is one of the innovations promoted to tackle technology constraints of the smallholder farmers that they cannot afford [12]. It has been presented as a possible solution to raising productivity and linking smallholders in the emerging modern marketing chains [13]. Further, it is a means to link farmers with potential market sources and reduce transaction costs [14] and create a favorable environment for access to finance [15]. Recent studies [16–23] conducted on malt barley in Ethiopia gave much emphasis on the value chain aspect of malt barley. Due to the rapid rate of urbanization, there is a high demand for malt barley and a high expansion of malt barley factories. Therefore, this study was conducted to fill the empirical literature gap by giving emphasis on the impact analysis of malt barley contract farming engagement on the income and dietary diversity of the farmers.

Literature review

Contract farming may be defined as agricultural production carried out according to a prior agreement in which the farmer commits to producing a given product in a given manner and the buyer commits to purchasing it. Often, the buyer provides the farmer with technical assistance, seeds, fertilizer, and other inputs on credit and offers a guaranteed price for the output [24–26]. It is most likely to be economically justified when the buyer is a large processor, exporter, or retail chain; when the commodity has a high value–bulk ratio, is perishable, and/or is not widely grown; and where the destination market is willing to pay a premium for attributes that are not easy to obtain through spot markets. In practice, this means that contract farming will be most suitable for fruits and vegetables for quality-sensitive markets; commercial dairy and poultry production; and cash crops such as tea, tobacco, sugarcane, and cotton [27]. Contract farming has become a prominent agricultural issue in most developing nations. Forces of change, such as globalization, industrialization of the agricultural sector, and market reforms have paved the way to contract farming in many emerging countries and more so in Africa. It is gradually changing the face of small-scale agriculture in Africa and has become a new potential to put enthusiasm in developing global agriculture [11].

In Ethiopia barley is widely grown by smallholders as a staple food and as a source of cash income. It is concentrated in the Oromia and Amhara regions, which contribute 53% and 30% of national production, respectively [28]. A host of studies in the literature on contract farming observe its positive effect on the income and productivity of participating farmers [14, 29, 30]. Contract farming has also been shown to have a positive association with household food security [31], household asset accumulation [32], and employment of skilled labor on farms [29]. Ashraf et al. [33], relates contract farming with credit and observes that the contracting firm's offer of credit alongside the output contract significantly increases farmers' participation in contract farming for the exports market.

Ethiopia has experienced one of the fastest increases in beer consumption with consumption rates steadily rising from 15 to 20% every year since 2011 [32]. Currently, malt barley contractual farming is widely practiced in Ethiopia due to the emerging investment of multiple beer factories [34]. Diageo and Heineken breweries, Boortmalt, Asella, and Saint George brewery are engaged in the contract production of malt barley in the Arsi areas [35]. In the same manner, The Asella malting company is under operation in the study area since 2017 through contract farming. Dawit [21] in their study on contract farming, cooperatives, and challenges of side selling: malt barley value-chain development in Ethiopia, confirmed that Assela Malt Factory and Dashen Malt factory, breweries (Diageo and Heineken), and public service providers are engaged in malt barley contract farming.

The main reasons for smallholders to enter farming contracts are higher and more stable incomes, access to markets, access to more affordable credits and inputs, access to new technologies, extension, training and information, and reduction of production and marketing risks. With respect to the advantages for buyers to work with smallholders, small farms are frequently the most efficient agricultural producers, and have advantages over large farms in terms of labor-related transaction costs, in particular supervision and motivation [36]. Malt barley farmers have a high potential market opportunity that is expected to grow with the increased investment in breweries to meet the rising demand for beer that has resulted from urbanization and burgeoning hospitality industry. An adequate supply of locally produced malt barley, of appropriate quality, to meet the demand is crucial for sustainable agro-industrial development of this sector. Ethiopia's malt barley productivity had been unimpressive at 2.1 metric tons per hectare, compared with 2.93 metric tons in South Africa, 3.26 in Kenya, and more than 6 metric tons in France, Germany, and the Netherlands [26].

Several literatures [37–39] have illustrated three types of widely used contracts: market specification contract, production-management contract, and Resource-providing contract. They are described as follows.

Market-specification contracts

As the phrase says, they indicate quality, price, and timing with the least or non-provision of inputs. Producers are in have the responsibility for most of the decisions to be made in production. As a consequence, they endure most of the risk. Nonetheless, it produces meaningful rewards for both contracting parties by permitting market data flows between them. Alternatively, these contracts feed the producer demand-side information related to consumers' taste, crop variety, quality, quantity, timing, and price. On the other hand, the buyer will be able to approach material related to supply conditions. Such contracts are mostly used in casual or unofficial models of Contract farming. This is a pre-harvest arrangement between the farmer and the company indicating the time and location of sale, as well as the quality of the product. Market specification reduces information and coordination costs, which are particularly important for perishable, export markets, or new markets.

Production-management contracts

In this contract, the buyer provides technical guidelines on the production process. Contract stipulations vary, based on the local context, the type of product, and the problem faced. Still, to augment the benefit of any type of contract it is important to give eloquence to the implications of revenues, costs, and risks for both parties involved, to prepare clear and detailed contracts with enforcement mechanisms, and last but not least, to develop a conjoint commitment of both parties.

Resource-providing agreement

This contract usually specifies that buyers will offer inputs and extension services at different stages of production to producers on loan. The inputs and extension services will have to be paid for when the crop is sold. The contract might give a certain level of decision-making power to each party at different stages and the risks are also allocated appropriately. For farmers, this type of contract eases the risk of coordination because inputs, credit, and extension services are provided. In turn, the buyer profits from lower selling prices and reliable supplies of the required quality.

Concept of diet diversity and its measurements

Dietary diversity is a qualitative measure of food consumption reflecting the households' access to a variety of foods. Dietary diversity also reflects a snapshot of the economic ability of a household to consume a balanced diet [40, 41]. It is widely applied as an indicator of household diet quality and refers to the number of different food groups consumed by a household during the last 24 h preceding the survey time [42–44]. FAO [45] recommends calculating Household Diet Diversity Score (HHDS) based on 12 food groups. They include cereals, white tubers and roots, vegetables, fruits, meat, eggs, fish and other seafood, legumes, nuts and seeds, milk and milk products, oils and fats, sweets, spices, condiments, and beverages. This indicates score generated from these food groups ranges from 0 to 12 [46]. This further can depict that the more food groups included in the daily diet the greater the likelihood of meeting nutrient requirements because all nutrients cannot be found within a single food item [47]. In developing countries, dietary diversity is a challenge for rural communities. Their diets are based on starchy staples with inadequate animal products, fresh fruits, and vegetables.

In countries where resources are limited, lack of access to an adequate and diversified diet has been identified as one of the severe problems among poor populations resulting in various forms of nutritional problems. In a study conducted in northern Ethiopia, Finote Selam town low, medium, and high household dietary diversity scores were found to be 11.8, 67.2, and 21%, respectively [47]. Another similar study conducted in southern Ethiopia in enset growing region diet diversity was found at 64% [40]. In areas where household food security is poor, meeting minimum standards of dietary quality is another challenge in many developing country settings and it has often not been given enough emphasis [45]. Now, developing countries are burdened with the 'triple burden of malnutrition' encompasses the three dimensions of undernutrition (wasting, stunting and underweight), micronutrient deficiencies, and overnutrition. Food security policies should focus not only on calorie intake but also on consumption of a diversified diet. Consumption of a diversified diet promotes the intake of different nutrients and thus prevents many diseases. A reduction in dietary diversity will lead to an increase in the proportion of malnourished people [48]. In this study following the suggestion of FAO [45], the aforementioned 12 food groups were considered to calculate the HHDS during the 24 h before the survey period.

Research methodology

Description of the study area

This study was carried out in Melga district, Sidama National Regional State. Melga district is located 27 km from Hawassa, the capital city of the Sidama region. It is bordered in the North by Wondo Genet district, in the South by Gorche and Shebedino district, in the West by Oromia region, and in the east by Tulla sub-city. According to the central statistics agency [49] report, the district has a total population of 114,030 having 50.6% male and 49.4% female. Coffee and Khat are the major cash crops that are produced and much of men and women farmers time is spent on the production of these crops. Cereal crops are grown in the highland part consisting of wheat, barley, and beans, vegetables are also grown seasonally and continuously through irrigation at some distance from the rivers.

Sampling technique

Multi-stage sampling procedures were used. In the first stage, Malaga district was selected purposively due to its high production of malt barley and farmers' engagements in contact agreement with Asella brewery. In the second stage, among sixteen kebeles that produce malt barley, four kebele were selected purposively. These selected four kebeles are engaged in contract farming with Asella brewery. In total, there are 581 contract farmers in these four kebeles. On the other hand, at the same kebeles, 842 farmers produce malt barley but sell it at an open market in Sidama and Oromia regions for suppliers to beer factories. Accordingly, the sample size was determined by Yamane [50] formula at a 5% level of error. We applied this formula to determine sample size because it is the most appropriate formula when the study population size is known [51]. Consequently, it has been widely used by many recent studies [52–54] in determining the sample size for their studies:

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

$n = \frac{1423}{1+1423(0.05)^2} = 312$,where n is the sample size, and N is the population (total number of malt barley) producers.

Using the sample size based on proportion to the population size approach, the total sample selected for this study was 312 comprising 127 households engaged in malt barley contract arrangements and 185 farmers not engaged in malt barley contact arrangements.

Data source and methods of collection

Both primary and secondary data were collected for the study. The primary data were collected from malt barley producers (respondents engaged in contract and non-contract farming arrangements) using a questionnaire focusing on the study variables under consideration. The questionnaire was prepared in a way that measures the objectives of the study. Following the preparation of the questionnaire, five enumerators who have experience in primary data collection got training on the questionnaire for 3 consecutive days. Before actual data collection, pre-test of the tool was conducted and amendments were made following suggestions made by the enumerators. Actual data collection was undertaken by those enumerators under the supervision of authors to solve any problems that arise during the process of data collection. The secondary data used were from a review of different documents which include research works, books, office reports, and journal articles written by different scholars.

Methods of data analysis

Following the objectives of the study, different data analysis tools were used. The Impact analysis was carried out by using the propensity score matching model. Furthermore, Chi-square and *t*-test were also employed to test the difference between farmers engaged in contract farming and not engaged in contract farming across categorical and continuous variables.

Specification of propensity score matching (PSM) model

Impact assessment requires a group affected by the certain intervention (users), and a control group (non-users) to compare the outcomes. Then, the differences between the two groups will provide an important component of the total impact of the intervention under consideration [55]. For this study, the intervention was participation in malt barley contract farming. However, the problem is to identify groups that look alike [56]. To deal with this problem, the PSM technique was used, which, has gained popularity in recent years for its potential to remove a substantial amount of bias from non-experimental data [57, 58]. The main reason for employing this technique is that firstly, it helps to adjust for initial differences between a cross-section of the participant and non-participant groups by matching each participant unit to a non-participant unit based on characteristics. Secondly, it summarizes all the differences in a single dimension, the propensity score, which is then used to compute treatment effects [59]. To minimize bias, the goal of propensity score analysis is to balance treatment and comparison subjects on as many pretreatment covariates as possible [60]. Valid inferences about causal effects from observational studies can only be drawn by controlling for all confounders, that is, pretreatment variables that are related to both treatment allocation and the outcome because the treated subjects generally differ systematically from the control subjects [61].

There are several methods that could be applied in impact studies like ordinary least squares (OLS), Heckman two-step method, the instrumental variable (IV) approach and propensity score matching (PSM) methods. According to Mendola [62] both OLS and IV procedures impose linear functional form, and finding instruments are very difficult in impact analysis procedure. In addition to this, unlike an observed control variable, an instrumental variable is assumed not to have any direct effect on the outcome. Instead, the instrumental variable is thought to influence only the selection into the treatment condition which results in over estimation or underestimation of impact under consideration. Contrary to this, PSM is a combination of two powerful approaches: matching and propensity score. The basic idea of matching is to match treated subjects with controls so that, within matched pairs, covariates values are the same or similar, hence treatment effects can be estimated by comparisons within matched pairs. It reduces the influence of these covariates, and consequently the variability and potential bias in matching based estimators if some of the covariates are confounders (i.e., those affecting both the outcome and treatment allocation). Therefore, PSM creates a quasi-randomization environment so that a direct comparison between matched treated and control subjects can be carried out without the need of further adjustment. Mendola [62] identified that when outcome variables are independent of assignment to the treatment group, the matching method can yield an unbiased estimate of the treatment impact. Considering these advantages of the PSM over the other methods, in our study, we adopted PSM to examine the impact of malt barley contract farming engagement.

According to Caliendo and Kopeinig [63], the implementation of PSM involves six steps. These are: PSM estimation; choosing a matching algorithm, checking for overlap (common support); matching quality test, impact estimation, and sensitivity analysis.

Estimating the propensity score

When estimating the propensity score, two choices have to be made. The first one concerns the model to be used for the propensity score estimation and the second one the variables to be included in this model. Regarding the model choice, several studies aimed at assessing impact analysis applies a probit/logit model to determine propensity score [64]. According to Fadare [65], employing the probit or logit model leads to similar results when estimating the propensity score of an individual adopter or non-adopter. However, due to its simplicity, this study applied the logit model to estimate the propensity score of the sampled households. The model takes a value of 1 for irrigation users and 0 for non-users. According to Gujarati [66], in estimating the logit model, the dependent variable is participation which takes a value of 1 if the household participated in the intervention program and 0 otherwise. The logit model is mathematically formulated as follows:

$$p_i = \frac{e^{zi}}{1 + e^{zi}}, \quad (1)$$

where p, is the probability of participation in the malt barley contract farming

$$z_i = \beta_0 + \sum \beta_i x_i + u_i, \quad (2)$$

where i= 1, 2, 3… n; β_0 = intercept;

β_i =regression coefficients to be estimated; u_i = a disturbance term, and x_i =variables.

The probability that a household belongs to the non-participant group is:

$$1 - p = \frac{1}{1 + e^{zi}}. \quad (3)$$

Then the odds ratio can be written as:

$$\frac{P_i}{1 - p} = \frac{1 + e^{z}}{1 + e^{-zi}} = e^{zi}. \quad (4)$$

The left-hand side of Eq. (4) $\frac{P_i}{1-p}$ is simply the odds ratio in favor of participating in malt barley contract farming. It is the ratio of the probability that the household would participate in the malt barley contract farming to the probability that it would not participate in the malt barley contract farming. Lastly, by taking the natural log of Eq. (4) the log of odds ratio can be written as:

$$L_\mathrm{i} = \ln\left(\frac{p_i}{1 - p_i}\right) = \ln\left(e^{\beta_0 + \sum_j^n = 1^{\beta_j X_{ij}}}\right) = Z_i, \quad (5)$$

$$z_i = \beta_0 + \sum_j^n = 1^{\beta_j x_{ji} + \varepsilon_i}, \quad (6)$$

where L_i is the log of the odds ratio in favor of participation in the malt barley contract farming, which is not only linear in X_{ji}, but also linear in the parameters.

Regarding the selection of variables, according to Bergstra [67], the highest precision is achieved by adding all variables related to the outcome of the study, whereas variables that are only related to the exposure, but not to the outcome, decrease precision and should not be included. Following these suggestions, variables that simultaneously affect farmers' decision to engage in contract farming and outcome variables were included in this study (Table 1). In addition to this, to control the problem of bias associated with unobservable characteristics of the respondents we applied sensitivity analysis as a final step of the PSM model.

Choosing matching algorisms

There are four most widely applicable matching algorisms. They include the nearest neighbor, caliper matching, radius, and kernel matching algorisms. As explained earlier the purpose of the PSM is to match contract farming households with non-contract households to reduce bias in estimating impact. To do this selection of matching algorisms among these four algorisms is very important and results in relatively good matching quality. According to Dehejia and Wahba [68], the choice of matching algorisms that results in large matched sample size with low pseudo-R^2 and the large number of insignificant variables after matching should be considered as the best matching algorism in the impact assessment procedure.

The common support region determination

A common support region is a region where the propensity score of both groups overlaps. It is a region that ranges from the minimum propensity score of

Table 1 Description of variables used in the logit model

Definition and measurement of the variable	Variable type	Expected sign
Age of the household head in years	Continuous	−
Malt barley area of cultivable land in hectares	Continuous	+
Sex of the household head (1 if male,0 female)	Dummy	+ for 1
Malt barley production experience	Continuous	+
Membership in cooperative/groups (1 if member,0 otherwise)	Dummy	+
Total number of the household members in a number	Continuous	+
Livestock holding measured in TLU	Continuous	+
Education in number of schooling years	Continuous	+
Credit use (1 for received and 0 otherwise)	Dummy	+
Distance to the barley collection center in kilometers	Continuous	−
Frequency of extension contact	Discrete	+

households engaged in contract farming to the maximum propensity score of households who are not engaged in contract farming.

Matching quality

According to Caliendo and Kopeinig [69], matching quality has to be checked if the matching procedure is able to balance the distribution of the relevant variables in both the intervention participant and non-participant. Standard bias, *t*-test, joint significance, pseudo-R^2, and stratification test are the mechanism that different literatures suggested to test this situation. The basic idea of all approaches is to compare the situation before and after matching and check if there are any differences after conditioning on the propensity score. Based on this, matching is considered as a good match when there is no statistically significant difference in the mean of covariates of both groups, significant mean bias reduction, and low pseudo-R^2.

Impact estimation

Following matching quality tests, impact estimation needs to be conducted using the average treatment effect on the treated. It is the mean outcome difference between intervention participants and non-participants matched by PSM. It is unbiased under three conditions. The first condition requires that after matching by propensity scores, the selection of participants and non-participants can be considered random. Intuitively, it means that the selection bias is caused by observables, not unobservable (that affect both treatment selection and treatment outcome). The second condition requires that at the propensity scores used in matching, both participant and non-participant selections are possible. The condition fails at a given score if only treated firms are observable at that score. This condition is referred to as the "common support condition" intuitively, outside the common support, condition one cannot reasonably find a match for the treated firm. The third condition is balancing, that is, the distributions of covariates are approximately similar for the treated and control groups after PSM [70].

We follow Rosenbaum and Rubin's [71] propensity score matching (PSM) and focus our analysis on the average treatment effect on treated (ATT). This is because ATT can be considered the main parameter [72]. Hence, the ATT for the individual can be defined as the difference between the expected outcome variable; (income based on our study with and without contract farming).

Finally, ATT will be defined as follows:

$$\tau\text{ATT} = E(\tau|D = 1) = E[Y(1)|D = 1] - E[Y(0)|D = 1],$$

where ATT represents the Average Treatment effect on the treated group. The symbol " $\mid$ " stands for conditional on $E(Y)$ denotes the expectation with respect to the distribution of propensity score in the entire population and D denotes intervention participation indicator which is equal to one (1) if a farmer participated in the intervention and zero (0) if otherwise. The estimation of ATT clearly depends on the characteristics of the two groups: treated and control for $\{(\text{Y1} \mid D=1)$ and $(\text{Y0} \mid D=0)\}$, respectively, as explained above.

Sensitivity test

This is the final step in the application of PSM. Matching has become a popular method to estimate average treatment effects. It is based on the conditional independence or unconfoundeness assumption which states that all variables simultaneously influencing the participation decision and outcome variables should be considered. However, this assumption is non-testable since the data are uninformative about the distribution of the untreated outcome for treated groups and vice versa [73]. The estimation of treatment effects with matching estimators is based on the selection of observables assumption. As a result, a hidden bias might arise if there are unobserved variables that affect the assignment into treatment and the outcome variable simultaneously. This results in biased estimates of the average treatment effect on the Treated [71]. Since matching estimators are not robust against hidden biases, it is important to test the robustness of results to departures from the identifying assumption. However, it is impossible to estimate the magnitude of selection bias with non-experimental data. Therefore, this problem can be addressed by sensitivity analysis [63]. To check the sensitivity of the estimated ATT (average treatment effect) with respect to deviation from the conditional independence assumption, it is suggested that the use of the Rosenbaum bounding approach is appropriate [71].

Variable definition and hypothesis

Age of the household head

Age is one of the demographic factors considered by different studies in identifying determinants of participation in different crop-based contract farming. It is a continuous variable measured in years. Different researchers found that younger farmers tend to be more willing to adopt different agricultural practices than their older counterparts. With the increase in age, farmers tend to abandon contract farming for less demanding cropping systems with a low transactional cost associated with them. Furthermore, older farmers tend to be risk-averse and may avoid contract farming in an attempt to avoid the risk associated with the initiative [74, 75]. Accordingly, it was hypothesized that age would have a negative relationship with participation in malt barley contract farming.

Sex of the household head

It can be defined as maleness or femaleness of the household head having a dummy nature measured as 1 for male-headed households and 0 otherwise. Different recent literature argues that [76] male-headed households do have better opportunities of discussing with collectors, sign a contract, collect sales money, make negotiations, etc. This is because they have little control over resources [77, 78]. Male-headed households do often have better practical experiences in the external affairs of the household compared to others. Contrary to this, female-headed households are usually occupied with core domestic activities and have little time for activities outside home management which might lead them to low participation in contract farming arrangements [76]. From this, it was hypothesized that being male would have a positive relationship with participation in malt barley contract farming.

Family size

Can be defined as a total number of the household members living together in the same household. Farmers with large household sizes tend to have the opportunity to grow large areas of the crop with adequate financing from contractors. This is because households with large family sizes found it cheaper to use family labor for crop growing than their counterparts with small family sizes [79–82]. Consequently, it was hypothesized that family size would positively determine participation in malt barley contract farming.

Distance to the barley collection center

It is defined as a distance between malt barley farm plots to the center measured in kilometers where farmers collect malt barley to supply for the beer factory. Contracting companies found it easier to buy produce bulked at specified bulking points/mini-stores, rather than from individual farm gates which may attract more additional transactional costs [79]. Farmers that are located far away from the contracting firm collection center have a low level of participation in contract farming [83]. From this, it was expected that distance to the barley collection center would negatively determine participation in malt barley contract farming.

Frequency of extension contact

Agricultural extension is the process of transferring different knowledge and skill to farmers and helping them to implement that knowledge and skills to improve their farming [84]. Agricultural extension agents are experts who are responsible to provide these supports to farmers either in individual or group-based extension approaches. Here the frequency of extension contact is defined as the number of monthly contact respondents made with agricultural extension experts to get extension advice for their agricultural activities. Several findings support that farmers who received an agricultural extension are more likely to participate in contract farming than others [85–87]. This is because farmers who have frequent contact with extension agents may get a clear understanding of the benefits of contract farming. Therefore, it was hypothesized that contact with an extension agent positively determines participation in malt barley contract farming.

Livestock holding

In the context of this study, this variable can be defined as the total number of livestock owned by the respondents measured in the Tropical Livestock Unit (TLU). Livestock ownership allows farmers to use manure from the animals for their farms. Livestock can also serve as a store of wealth, provide draught power and organic fertilizer for crop production, and as a means of transport [88, 89]. This will encourage them to participate in contract farming. As a result, it was hypothesized that livestock holding positively determines participation in malt barley contract farming.

Credit use

It is a dummy variable that takes a value of 1 for those who received credit from formal lending institutions during the last 3 production seasons at a point of survey time and 0 otherwise. Improved technology adoption may require credit to procure complementary inputs to maximize their benefits. Farmers can invest in new technologies either from past accumulated capital or through borrowing from capital sources. Farmers without cash and no access to credit will find it very difficult to attain and adopt new technologies like malt barley contractual farming. According to Bidzakin [90], agricultural finance is a major constraint that limits market access, participation, and commercialization of the smallholder farmers. Farmers who had access to credit had a greater probability of going into contract farming [87, 91]. Consequently, a positive relationship between credit use and participation in malt barley contract farming would be expected.

Malt barley production experience

It can be defined as the number of years since respondents have started producing malt barley. The more years a farmer took in producing crops, the better he/she got exposed to terms of contract farming; and the better the chances of being able to participate in contract farming

[79]. This is because the more experience farmers have with crop production under consideration, the more they are aware of the advantages of participating in a contract; therefore the more they would join contract farming [91–93]. Therefore, it was expected that malt barley production experience positively determine participation in malt barley contract farming.

Land allocated for malt barley production

It can be defined as the total amount of land farmers are producing malt barley measured in hectares. The area of land affects the risk of farming faced by farmers. An increase in the land area will increase farming production, which then increases the value of a significant loss if the price at harvest is low. This risk can be anticipated by participating in contract farming, where farmers will get certainty about the sale of their products [74, 94]. The size of the farm denotes higher investments, thus farmers shall like to reduce their risk coverage by participating in the contract [90]. Hence, a positive relationship was expected between the total area of land allocated for malt barley production and participation in contract farming.

Membership in cooperative

Different studies show that membership in cooperatives strengthens social capital and farmer confidence [74, 95, 96]. Members of cooperatives have better farm resources, and better access to extension services compared to non-member farmers [95]. This advantage of the cooperative encourage farmers to engage in contract farming activities. Therefore, it was hypothesized that being a member of a cooperative positively determines participation in malt barley contract farming.

Educational status

Education is one of the major factors that widen the understanding of farmers to adopt farming technologies and application of different farming practices disseminated by the extension agents. A more educated Farmer is more likely to participate in contract production than a farmer who is not educated because they may have a better understanding of the concept and also better negotiation ability than their illiterate counterparts [80, 90, 91]. From this, it was expected that education positively determines participation in malt barley contract farming.

Results and discussion

Characteristics of the respondents

The result in Table 2 reveals that out of the total 312 respondent households, 23.1% and 76.9% were female and male-headed households, respectively. The result also showed that 22.1% and 77.9% of malt barley contract households are female and male-headed households, respectively; whereas, 23.8% and 72.2% of malt barley non-contract households are female-headed and male-headed households, respectively. The Chi-square test result found that there was no statistically significant difference in sex of household heads between malt barley contract and non-contract farmers. The result of the study revealed that only 31.1% of sampled households are credit users while the vast majority of 68.9% were not the user of credit. The result in Table 2 indicates that the majority of respondent households didn't use credit services. The result of the study also indicates that 37.8% and 26.5% of contract participants and non- participant households used the credit services, respectively. On the other hand, 62.2% and 73.5% of contract users and non-user households didn't use credit services, respectively. The Chi-square test shows that there was a significant difference between malt barley contract participants and non- participants in the use of credit services at a 5% level of significance.

The results in Table 2 reveal that the mean age of contract and non-contract households in the study area was 40.13 and 43.1 years with a standard deviation of 0.83 and 0.58, respectively. The result of the t-test shows that there was a statistically significant mean age difference between barley contract and non-contract households. Being a member of a barley producers cooperative is considered a condition to engage in contracts. But still, large portions of the contract are not organized in a formal cooperative. Organizing themselves helps farmers to increase their bargaining power with the malting company. As depicted in Table 2, 44.1% and 32.9% of contract and non-contract farmers are a member of cooperatives. The chi^2 value confirmed that there is a statistically significant difference between contract and non-contract farmers.

Education is a key social factor that determines the individual's decisions toward the use of improved practices. The mean year of education for the sample household was 3.62 with a standard deviation of 0.22. The result revealed that there was a significant difference in years of education between contract and non-contract household heads at a 10% significance level (Table 2). According to the study result, the average family size of the contract and non-contract households was 5.85 and 5.05, respectively. The mean comparison between the two groups revealed that there was a statistically significant difference between the two groups at less than a 1% significant level.

Livestock is the most important productive asset and important source of income, traction, and food. The mean difference between contract and non-contract household's livestock holding in tropical livestock units was found to be 0.61. The mean livestock holding for

Table 2 Summary statistics of contract and non-contract farmers

Variables	Contract farmers		Non-contract farmers		Total		*t*-value/Chi^2
	Mean (Freq.)	St.dev (Perc)	Mean (Freq.)	St.dev (Perc)	Mean (Freq.)	St.dev (Perc)	
Sex							
Male	99	77.9	141	76.2	240	76.9	0.12
Female	28	22.1	44	23.8	72	23.1	
Age	40.12	0.83	43.10	0.58	41.89	0.49	3.01[c]
Education	3.98	0.18	3.38	0.35	3.62	0.22	1.32[a]
Family size	5.85	0.12	5.05	0.17	5.38	0.11	3.38[c]
Livestock	1.61	0. 11	1.00	0.03	1.25	0.05	5.83[c]
Land holding	2.30	0.08	1.77	0.06	1.98	0.05	4.95[c]
Land malt barley	1.62	0.05	1.09	0.06	1.31	0.04	5.52[c]
Extensions	1.87	0.11	1.74	0.10	1.79	0.07	0.80
Experience	6.89	0.11	6.24	0.08	6.51	0.07	4.62[c]
Credit use							
Yes	48	37.8	49	26.5	215	31.1	
No	79	62.2	136	73.5	97	68.9	4.49[b]
Cooperative membership							
Yes	56	44.1	61	32.9	117	37.5	3.97[b]
No	71	55.9	124	67.1	195	62.5	
Distance	3.91	0.25	5.53	0.2	4.87	0.16	4.92[c]

[a] $p<0.1$
[b] $p<0.05$
[c] $p<0.01$

contract and non-contract households was 1.61 and 1.0, respectively. The mean difference between contract and non-contract households was a statistically significant difference at less than a 1% significant level. From malt barley production, the extension services are provided from two sources. The study result indicated that the mean contact with DAs was 1.87 and 1.74 for contract and non-contract households, respectively. The t-test values show that there is no statistically significant difference between the two groups in terms of extension services. This could be because almost all the households have ready information regarding malt barley production.

The Land is an important asset for agricultural and other related activities. It determines the level of participation in contract farming. The mean of overall respondents were 1.98 hectares. The landholding of contract and non-contract farmers was 2.30 and 1.77 hectares, respectively. The t-test values confirm that there is a statistically significant mean land holding difference between contract and non-contract farmers at a 1% level of significance. The mean land allocated for malt barley production by the overall sample households was 1.31 hectares. On average, contract households allotted 1.62 for malt production, whereas non-contract farmers allotted 1.09 hectares. There is a statically significant mean difference in land allocated for malt barley production between contract and non-contract farmers in the study area.

The survey results further indicate that the mean malt barley production experience of overall sample farmers was 6.51 years. The mean farming experience of contract and non-contract farmers were 6.89 and 6.24 years, respectively. The t-test value confirms that contract farmers have a better malt production experience as compared with non-contract farmers at a 1% level of significance (Table 2). It was also depicted that there was also a significant difference between the two groups in terms of distance to the barley collection center at a 1% significance level.

Econometric model analysis results

This part describes the PSM model approaches that were followed to identify the impact of malt barley contract farming arrangements on the income and dietary diversity of the smallholders. All standard steps of the model were followed including estimation of propensity scores, defining common support region, choosing matching algorism, testing matching quality, calculating average treatment effect on treated, and lastly sensitivity analysis. The result obtained under each step is presented and discussed as follows.

Estimation of propensity scores

For the purpose of this research, the logistic regression model was used to estimate the propensity score of contract and non-contract households. The logistic regression model is applied when the choice variable is dichotomous. For this study, the dependent variable was the participation of the household in contract farming which takes a value of 1 if the household engaged in contract and 0 otherwise.

As indicated in Table 3, the output of the logistic regression model shows that the pseudo-R^2 value is 0.2475 which was fairly low. This low pseudo-R^2 value revealed that the distribution of the contract farming has been fairly random and contract user households do not have many distinct characteristics over non-user households hence obtaining a good match between contract and non-contract households becomes easier [97]. Moreover, according to Caliendo and Kopeining [69], after matching there should be no systemic differences in the distributions of covariates between both groups and therefore, the pseudo-R^2 should be fairly low.

The logistic regression result in Table 3 revealed that different variables determine a household's probability of participation in malt barely contract farming arrangement at a different statistically significant level. Eleven variables were hypothesized that determine household participation in malt barley contract farming. Among these variables, seven of them were found to be significant in determining households' probability of participation in contract farming. Accordingly, family size, credit use, livestock ownership, malt barley production experience, frequency of extension contact, and land allotted to barley production were variables that were found to positively determine participation in malt barley contract farming, whereas the distance to malt barely collection center negatively determine participation in malt barley contract farming.

Family size

family size can be considered a source of labor. Based on this finding, family size has a positive and significant influence on the engagement of households in contract farming at a 5% level of significance. The odds ratio of family size indicates that a unit increase in family size increases the probability of participation in contract farming by a factor of 1.15. This result is in line with the findings of Bezabeh et al. [98].

Credit use

credit use creates advantages for farmers to purchase inputs. Moreover, the malt barley productions are labor intensive for weed management and demand labor. Therefore, credit obtained either from formal or informal sources could be used for daily labor. The odds value showed that as compared to those farmers who do not receive credit, credit users have 2.56 units better probability of participating in contract farming. Credit use significantly influences at a 1% level of significance. Based on the findings, it is better to boost access to credit services for malt barley producers to improve their status in

Table 3 Household's probability of participation in malt barley contract farming

Contract	Coef	Odds ratio	Robust Std. Err	*Z*	*p*-value
Constant	− 3.480	0.030	0.034	− 3.17	0.002
Age of household head	− 0.020	0.980	0.018	− 1.18	0.239
Family size	0.1405[a]	1.150	0.083	2.07	0.038
Sex of household head	0.039	1.040	0.331	0.12	0.904
Credit use	0.942[b]	2.566	0.760	3.21	0.001
Livestock in TLU	0.477[a]	1.612	0.321	2.21	0.027
Malt barley production experience	0.259[a]	1.295	0.153	2.28	0.023
Educational status	0.023	1.024	0.038	0.76	0.445
Membership in cooperatives	0.199	1.220	0.356	0.69	0.493
Frequency of extension contact	0.308[b]	1.360	0.154	3.50	0.000
Distance to collection center	− 0.105[a]	0.900	0.057	− 2.08	0.038
Land allocated for malt barley	0.481[b]	1.619	0.270	2.97	0.003
Number of observations	312				
LR Chi^2 (11)	61.75		Pseudo-R^2 = 0.2475		
Prob > Chi^2	0.0000[b]		Log likelihood = − 158.65		

[a] $p < 0.05$;

[b] $p < 0.01$

contract farming. A study by Khan et al. [29] shows that contract farming significantly improved small farmers' loan repayment ability. Another study by Mercy et al. [99] indicated that there is a positive association between credit access and participation in contract farming. The positive relationship between malt barley contract farming and credit is also reported by Tefera [35] and a study by Abdulai [100]; Mwambi et al. [101] on avocado contract farming reveals positive relation between contract farming and credit use.

Livestock ownership

livestock ownership is considered as most important asset for households. This could be due to the fact that as the households have better livestock, they may sell to purchase inputs and also use it to cultivate the land. The odds ratio of livestock ownership in livestock indicates that a unit increase in TLU, increases the probability of participation in contract farming by the factor of 1.61. Addisu Bezabeh, et al. [98] also reported the same finding.

Malt barley production experience

production experience helps to compare alternative production and marketing options. The odds ratio of malt barely production experience indicates that a unit increase in experience, increases the probability of participation in contract farming by the factors of 1.29. Sendhil et al. [102] reported a positive effect of the farm experience on the farmer's participation in contact farming.

Frequency of extension contacts

access to extension services positively and significantly correlated with contract farming. This could be due to the fact that, while the farmers get the extension services, they can increase production, and have better information about the market, prices, and conditions for contract engagement. The odds of extension contact confirm that as a farmer had one more extension contact, the probability of engaging in contract farming increases by 1.36 units. This result is consistent with the findings of the study conducted by Tefera [35] on malt barley contract farming. Other studies [103, 104] also indicate that the extension service and contract farming have positive relationship.

Land allotted for malt barley production

the land is the most important asset that determine the amount of production. As land ownership of land increases, the production of malt barley increases. The odds in favor of contract farming increase by a factor of 1.61 units. Sendhil [102] found that farm size positively affects the engagement of the farmers in contact farming.

Distance to collection centers

Asella malting factors collect malt barley from contract farmers at specified places. At the same time, local collectors purchase from the farm gate. As the households are located far from the collection centers, they prefer to sell at the farm gate. Based on the findings of this study, distance from collection centers negatively influences the participation of households in contract farming. The odds ratio value confirms that the probability of malt barley contract farming decreases by the factor of 0.9 units as the households distance one more kilometer from the collection centers (Table 3). This finding goes on par with a study of the Tefera [35].

Additionally, the p-score graph was used to describe the distribution of contract and non-contract households with respect to the estimated propensity score to know the common support region. Figure 1 depicts that most of the contract framers were found in the middle and right side while non-contract farmers were found in the middle and left. The figure also shows that there is a wide area in which the propensity score of both the contract and non-contract households is similar.

Matching contract participants with non-participants households

In this section, four main tasks were accomplished. First, distributions of sample households in estimated propensity score matching were executed. Secondly, a common support condition was imposed on the propensity score distributions of households and then discard observations whose predicted propensity scores fall outside the range of the common support region. Thirdly, treatment effects on treated households were analyzed. And finally, sensitivity analysis was done in order to check the robustness of the estimation.

The result in Table 4 depicted that the distribution of propensity scores for contract participants varies from

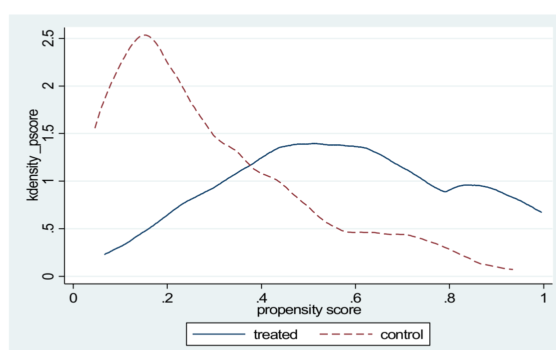

Fig. 1 Kernel density of propensity score distribution before matching

Table 4 Distribution of estimated propensity score of households

Sample	Observation	Mean	SD	Min	Max
All households	312	0.4070	0.2684	0.0457	0.9956
Contract participants	127	0.5834	0.2507	0.0667	0.9956
Contract non-participants	185	0.2859	0.2062	0.0457	0.9350

0.066–0.9956 with a mean value of 0.583. Similarly, the score varies between 0.0457 and 0.935 for non-participants with a mean of 0.2859. The common support lies between 0.066 and 0.935. This implies that households whose propensity score was less than the minimum (0.066) and larger than the maximum (0.935) were not considered for matching purposes. According to this reality, a total of 34 households (18 households from the contract participants group and 16 households from the contract and non-participants group) were discarded from the study in impact evaluation.

Figure 2 shows the propensity score distribution and common support region for propensity score estimation. The upper half shows the propensity score distribution of contract participants and the bottom half of the histogram shows the propensity score distribution of non-participants households. The green colored (treated on support) and pink colored(untreated on support) indicate the observation in the contract participation and non-participation that have suitable for comparison, respectively, while the yellow colored(treated off support) and blue colored(untreated off support) indicates the observation in the contract participation and non-participation that do not suitable for comparison, respectively.

Choice of matching algorisms

Different matching algorisms were tried to match contract participants with non-participant households in the identification of a common support region. These matching methods included; radius matching, nearest neighbor matching, kernel matching, and caliper.

The final choice of matching algorism was guided by different criteria. These were equal mean test (balancing test), pseudo-R^2 value, and size of the matched sample [68]. Accordingly, the preferable matching estimator is which balances all explanatory variables (that is, results in insignificant mean difference between the two groups), with a low pseudo-R^2 value, low mean bias, and a large matched sample. The result showed that based on those criteria, a kernel with a bandwidth of 0.1 was found to be the best estimator for the data with a low pseudo-R^2 value of 0.013 and a larger matched sample size of 278, mean bias of 6.6 as compared to other alternative matching estimator. Therefore, the impact analysis procedure was followed and discussed by using kernelband width 0.1 (Table 5).

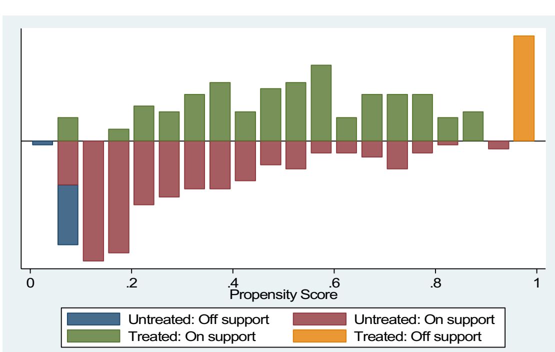

Fig. 2 Propensity score distribution and common support region for propensity score estimation

Table 5 Performance criteria of matching algorisms

Matching algorisms	Performance criteria			
	Balancing test	Pseudo-R^2	Mean bias	Matched sample size
Nearest neighbor				
Nearest Neighbor 1	10	0.021	8.1	278
Nearest Neighbor 2	11	0.020	7.9	278
Nearest Neighbor 3	11	0.020	7.5	278
Nearest Neighbor 4	11	0.019	7.2	278
Nearest Neighbor 5	11	0.013	6.7	278
Caliper				
Caliper 0.01	11	0.020	7.0	230
Caliper 0.1	10	0.021	8.1	278
Caliper 0.25	10	0.021	8.1	278
Caliper 0.5	10	0.021	8.1	278
Radius				
Radius 0.01	4	0.162	30.9	278
Radius 0.1	4	0.162	30.9	278
Radius 0.25	4	0.162	30.9	278
Radius 0.5	4	0.162	30.9	278
Kernel				
Kernel (bw 0.01)	11	0.022	8.1	230
Kernel (bw 0.1)	11	0.013	6.6	278
Kernel (bw 0.25)	11	0.015	7.6	278
Kernel (bw 0.5)	9	0.062	17.0	278

Testing the matching quality

The main objective of estimating propensity scores is to balance the distributions of relevant variables in both groups [69]. Consequently, the selected matching kernel bandwidth 0.1 algorithms have created a covariate balance between contract participants and participants' households, which was important to analyze the impact of the program. As depicted in Table 6, the standard bias difference between identified explanatory variables before matching was in the range of 4.1–81.2% in absolute value. But after matching by using the best algorism, the remaining standard bias differences between explanatory variables lay between 0.3 and 12.8% in absolute value.

The Chi-square test for joint significance kernel bandwidth 0.1 algorism was the low pseudo-R^2 value and the insignificant likelihood ratio test revealed that both groups have the same distribution in all covariates after matching. This result indicates that the matching procedure was able to evaluate the impact of contract participation among the group of households having similar observed characteristics (Table 7).

Table 7 Chi-square test for the joint significance of variables

Sample	Pseudo-R^2	LR Chi^2	$p > chi^2$	Mean bias
Unmatched	0.248	104.54	0.000	49.2
Matched	0.013	4.06	0.984	6.6

Outcomes of malt barley contract farming

Contract farming helps to uplift the households and improves their livelihoods through creating better marketing options. The primary goal of this study is to know whether contract farming has brought a significant change in terms of households' income. In this regard, the impacts of contract participation on outcome variables (household incomes) were tested using the PSM model. The Average treatment effect on treated (ATT) indicated that the household income improved as a result of contract farming. On average, the contract participants' households increased their annual income by 3029.03 which was significant at a 1% significance level (Table 8). From this, it can be concluded that the implementation

Table 6 Propensity score and covariate balancing

Variable		Mean		%Bias	% Bias reduction	*p* value
		Treated	Control			
P-score	Unmatched	0.583	0.28	129.6		0.000
	Matched	0.517	0.51	3.3	97.5	0.789
Age	Unmatched	40.12	43.10	− 34.2		0.003
	Matched	41.76	41.78	− 0.3	99.2	0.983
Sex	Unmatched	0.779	0.76	4.1		0.722
	Matched	0.761	0.77	− 2.1	48.6	0.877
Education	Unmatched	3.98	3.38	16.2		0.186
	Matched	4.06	4.50	− 11.8	27.3	0.586
Family size	Unmatched	5.85	5.05	40.7		0.001
	Matched	5.88	6.13	− 12.8	68.6	0.382
Credit	Unmatched	0.377	0.26	24.3		0.034
	Matched	0.440	0.44	− 1.6	93.4	0.912
Coop member	Unmatched	0.440	0.32	22.9		0.046
	Matched	0.348	0.40	− 11.7	48.9	0.389
Livestock	Unmatched	1.60	1.00	62.0		0.000
	Matched	1.17	1.09	7.5	87.9	0.396
Barley land	Unmatched	1.62	1.09	65.6		0.000
	Matched	1.55	1.62	− 8.6	86.9	0.567
Extension contact	Unmatched	4.46	2.67	81.2		0.000
	Matched	3.53	3.37	7.3	91.1	0.535
Distance to collect	Unmatched	3.91	5.53	− 56.7		0.000
	Matched	4.22	4.24	− 0.7	98.7	0.957
Experience	Unmatched	3.89	3.24	53.1		0.000
	Matched	3.84	3.70	11.8	77.8	0.404

Table 8 Impact of malt barley contract farming on household income and dietary diversity

Variable	Contract participants	Contract non-participants	Difference (ATT)	*t*-test
Household income	11712.04	8683.01	3029.03	5.55[a]
Dietary diversity score	9.11	5.69	3.41	12.9[a]

[a] $p < 0.01$

of contract farming brought significant changes in the income of participants. The statistical t-test value showed that there is a significant difference in income between participants and non-participants at a 1% level of significance. Here, the researcher can conclude that the implementation of contract farming has shown a significant improvement in participants' households to increase their income. The result of this study is consistent with several studies. A study conducted by Miyata and Hu [30] in China found that contract farming raises income even after controlling for observable and unobservable household characteristics. Similarly, in Pakistan Khana [29] found that higher total household income for potato contract farmers. In Senegal, Key [105] found that farmers who are participants in the contract farming program perform very well on both counts: participants and non-participants are indistinguishable by wealth measures and farmers increase their income substantially by participating in the program. Furthermore, Vellema [106], and Tuan [107] reached the same conclusion.

The other outcome considered by this study was the dietary diversity score. It was found that the mean dietary diversity score of the contract participants was 9.11 and it was 5.69 for non-participants. The result of the t-test indicates that there was a significant mean difference between the two groups in their diversity score which indicate that contract farming has brought a positive impact on the dietary diversity of the smallholder farmers. The finding of this study is consistence with other studies. A study conducted by Debela [108] in Ghana shows that contracting improves smallholder nutrition through dietary diversity.

Sensitivity analysis

In this study, sensitivity analysis was used to address the impact of contract farming on different significant outcome variables with respect to the choice of the balancing scores. Sensitivity analysis for insignificant effects is not meaningful and is therefore not considered. The first column of Table 9 shows those outcome variables which bear the statistical difference between contract participants and non-participants households while the rest of the values which correspond to each row of the significant outcome variables are p-critical values (or the upper bound of Wilcoxon significance level − Sig+) at a different critical value of e^{Y}. Based on this, sensitivity analysis was conducted for the outcome variable which is annual income. Table 9 presents the critical level of $e^{Y} = 1$ (first row), over which the causal inference of significant contract farming use outcomes (impact). The first column of the table shows the outcome variable which bears statistical differences between contract farmers and non-contract farmers in impact estimate. The rest of the values which correspond to each row of the significant outcome variable were p-critical values (or the upper bound of Wilcox on significance level − Sig+) at a different critical value of e^{Y} (Rosenbaum, 2002). The results show that inference for the impact of contract farming does not change, even though the participant and non-participant households were allowed to differ in their odds of being treated up $e^{Y} = 3$ for income in terms of unobserved covariates. That means for the outcome variable estimated, at various level of the critical value of e^{Y}, the p- critical values are significant which further indicate that the study has considered important covariates that affected both participation and outcome variables. Thus, it is possible to conclude that impact estimates (ATT) of this study for the outcome variables were insensitive to unobserved selection bias.

Table 9 Result of sensitivity analysis using Rosenbaum bounding approach

Outcomes	$e^{Y} = 1$	$e^{Y} = 2$	$e^{Y} = 3$
Household income	5.9–10	0.00057	0.036
Dietary diversity	0	$9.7e^{-10}$	$7.9e^{-7}$

Conclusion

This study analyzed the impacts of malt barley contract farming engagement on the income and dietary diversity of smallholder farmers in Ethiopia. Both primary and secondary data were to answer the research questions. The primary data were collected from 312 households using a structured questionnaire. Secondary data were collected from the review of related literature. The study implemented the Propensity Score Matching (PSM) model to analyze the impact of malt barley contract farming on the income and dietary diversity of the participant households. In the impact analysis approach, standard steps of the PSM model were followed including identification of the propensity score of the household determined based on the identified covariates, deciding common support, choosing matching algorisms, checking matching quality, and estimating average treatment effect and sensitivity analysis. It was found that, family size, credit use, livestock holding, malt barley production experience, extension contact, and land allotted for malt barley production positively determine malt barley contract farming participation, whereas distance to malt barley collection centers negatively determines the probability of participation in malt barley contract farming arrangements. The result of the PSM model analysis indicates that farmers engaged in malt barley contract farming arrangements are able to earn more than 3029.033 birr and their diversity score enhanced to 3.41 than their counterparts. It was concluded that participation in contract farming had a positive and significant impact on the annual income and dietary diversity of the households. This was assured by the sensitivity analysis result which shows the result of this study is insensitive to unobservable selection bias. Therefore, concerned bodies working on malt barley production aspects shall promote contract farming arrangements for the benefit of the farmers.

This study has some limitations. The result of this study comes from Melga district of the Sidama Region and had a limitation in covering Ethiopia in general. Even though the model used in this study was found to be best in reducing self-selection bias, it was difficult to capture unobservable characteristics of the respondents which again may have implications on the result of the study. To get better insight into the impact of microcredit, future studies should include more samples and carry out further studies incorporating other parts of Ethiopia.

Abbreviations

PSM: Propensity score matching; ATT: Average treatment effect on the treated; FAO: Food and Agricultural Organization; GAIN: Global Agriculture Information Network; CSA: Central Statistical Agency.

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Author contributions

ZG: contributed to research proposal writing, data collection, and supervision. TB: assisted proposal writing and data collection. AA: contributed data analysis and article writing. MM: supervised data collection and feeding and cleaning data. TL: assisted data cleaning and feeding. All authors read and agree on the final article. DK: contributed to data cleaning and draft article review. AA: contributed to data cleaning. All authors read and approved final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

We declare that we do not have competing interests.

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