Beer Multinationals Enhance Agricultural Commercialization in Africa: Empirical Evidence from Ethiopia

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Abstract

Foreign investment can facilitate modernization of domestic food chains in emerging economies through increased use of vertical coordination. The paper sheds lights on how beer multinational investments in African food chains affect smallholder market participation and value chain development. In particular, we examine the impact of contract farming arrangements among malt barley producers in Ethiopia. On the basis of cross-sectional survey data, we employ OLS regression and propensity score matching techniques to analyze the impact of contracting on a number of performance indicators. We find that contracting has positive impact on malt barley production, intensification, commercialization, quality improvement and farm-gate prices, ultimately resulting in increased net income and spillover into the productivity of other crops.

Key words: Beer multinationals; inclusive transformation; food systems; contract farming arrangement; Ethiopia; Africa

1. Introduction

Smallholder agriculture remains important for economic development in sub-Saharan Africa (SSA) and produces about 80% of the food consumed in the region (FAO, 2013b). In recent years, food systems in this region witnessed major changes and rapid structural transformation. The increase in urbanization, rising incomes, industrialization, a burgeoning middle class, and globalization have led to the emergence of modern supply chains, including modern food retail (Maertens and Swinnen, 2012; Minten et al., 2016; Reardon et al., 2009; Verhofstadt and Maertens, 2013). These developments have resulted in changes in the food production process, increasing vertical coordination, and dominance of food processors (Swinnen and Maertens, 2007).

Increased vertical coordination and modernization in food chains present market opportunities for smallholders (Dries et al., 2009; McCullough et al., 2008; Verhofstadt and Maertens, 2013). However, smallholder access to modern chains is limited due to several constraints. Smallholders are unable to comply with the stringent standards (safety, quality and reliability) and technical requirements. They often are constrained by the lack of access to improved technology, low access to resources, low bargaining power, and high transaction costs (Poulton et al., 2010).

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Contract farming has been presented as a possible solution to raising productivity and engaging smallholders in modern chains (FAO, 2013a). For instance, supermarkets and processors use private quality standards and modern procurement systems which favor increased use of vertical coordination through contracting. Many scholars studied the increasing prevalence of contract farming arrangements (CFAs) in the changing food systems (Bellemare, 2015; Bijman, 2008; Minot and Sawyer, 2016; Oya, 2012; Wang et al., 2014b). Most of these studies claim that CFAs promote smallholder linkages to high-value markets and increase farm income. Yet, there is also evidence that suggests that participating in a CFA has a negative association with farm income (Michelson et al., 2012; Narayanan, 2014; Wendimu et al., 2016).

Most studies have focused on supply chains of high-value products (e.g. vegetables), traditional cash crops (e.g. coffee, tea, cocoa) and industrial commodities (e.g. cotton, palm oil, and rubber) destined to international markets (Minot and Sawyer, 2016; Otsuka et al., 2016). The empirical evidence on the impact of CFAs in domestic food chains is sparse, with the exception of Maertens and Vande Velde (2017). In this paper, we seek to fill the knowledge gap on domestic food chains by studying the implications of CFAs for the economic performance of smallholders in the malt barley sector in Ethiopia. Understanding the role of CFAs in the malt barley sector in Ethiopia is particularly relevant because the country aims at expansion of the domestic malt barley production to cut the import bill for malt barley and to increase smallholder commercialization. The paper also discusses how foreign investment in developing countries - in Africa in particular - affects modernization of domestic food chains.

The main objective of this paper is to analyze the impact of CFAs on production, commercialization, and farmer income, within a staple food chain. Specifically, we seek to address: (i) What factors determine farmers' participation in malt barley CFAs? (ii) How do CFAs improve production, crop yield, product quality, and commercialization and prices in malt barley chains? and (iii) How do CFAs improve malt barley producers farm income in the chain? The study is based on cross-sectional survey data and uses parametric (OLS) and non-parametric (propensity score matching) methods to analyze the impact of CFAs.

The rest of the paper is organized as follows. The next section provides a short review of the literature on CFAs in emerging economies. In section 3 we present a brief account of the Ethiopian malt barley chain and describe the process of vertical coordination. Section 4 describes the methodology. Section 5 presents the empirical results. Section 6 discusses and puts the results into perspective. Section 7 concludes.

2. A review of the literature

Various empirical studies investigated the prevalence and effectiveness of CFAs in food chains of developing and emerging economies. We present a short review of these studies using the following perspectives: (a) the prevalence in the use of CFAs, (b) which farmers participate in CFAs; (c) the welfare impacts of CFAs; and (d) the organization of the contract and the role of intermediaries. Applying New Institutional Economics, it is often argued that a CFA can reduce transaction costs and solve market failure problems (Kirsten et al., 2009).

Contract farming can be defined as "agricultural production carried out according to an agreement between farmers and a buyer which places conditions on the production and marketing of the commodity" (Minot, 1986 pp.2). Agreements are made in advance and often on the volume, quality, time of delivery, use of inputs, and the price that will be offered. The recent development in food systems of emerging economies has witnessed a rapid expansion and use of contract farming (Jia and Bijman, 2014). The expansion of high-value products, improvement in food processing, consolidation in retail markets, and increased demand for quality and food safety cause the growth in CFAs (Minot and Sawyer, 2016; Otsuka et al., 2016).

In studying the implications of CFAs, it is crucial to understand which factors determine smallholders' decision to enter in a CFA. Participation in a CFA depends on a number of demographic and socio-economic factors. For instance, demographic factor such as age, gender and education, and economic factors including family labor, farm size, farmer experience and asset ownership are often used in empirical studies. Several studies conclude that the farmer's level of education has a negative effect on the likelihood of participation in a CFA (Maertens and Vande Velde, 2017; Miyata et al., 2009; Simmons et al., 2005; Wainaina et al., 2014), whereas others find a positive effect (Mishra et al., 2016). There are also studies that show that education does not determine CFA participation (Bellemare, 2012; Girma and Gardebroek, 2015). Many studies conclude that the farmer's age has a negative effect on participation in a CFA (Bellemare, 2012; Maertens and Vande Velde, 2017; Simmons et al., 2005), implying that younger farmers are more likely to join a CFA.

Several empirical studies have found that farm size positively determines farmers' participation in CFAs (Bellemare, 2012; Mishra et al., 2016), whereas other studies conclude that farm size is not an important determinant of CFA participation (Maertens and Vande Velde, 2017; Miyata et al., 2009; Wainaina et al., 2014). Thus, the empirical evidence on the effect of farm size is conclusive. Access to public institutions such as extension services (Girma and Gardebroek, 2015) and credit (Ma and Abdulai, 2016; Simmons et al., 2005) determines farmers' likelihood of participation in CFAs. Ownership of a mobile phone has also been found to affect CFA participation (Kumar et al., 2016; Mishra et al., 2016). Finally, distance to market has a positive and significant effect on CFA participation (Kumar et al., 2016; Maertens and Vande Velde, 2017), but Wainaina et al. (2014) found a negative effect.

There are numerous empirical studies on the impact of CFAs (Andersson et al., 2015; Barrett et al., 2012; Bellemare, 2012; Bolwig et al., 2009; Briones, 2015; Girma and Gardebroek, 2015; Mishra et al., 2016; Simmons et al., 2005; Wang et al., 2014a). These studies show that participating in a CFA improves the income of farmers who have chosen to participate. There is also empirical evidence on effects other than income. For example, Maertens et al. (2012) show the implications of CFAs for gender, Dedehouanou et al. (2013) show the impact of CFAs on subjective well-being in Senegal, and Minten et al. (2009) document implications of CFAs for food security and technology adoption in Madagascar. Yet, most of these studies focused on high-value products, industrial crops, traditional cash crops, and seeds production. With the exception of Maertens and Vande Velde (2017), there are no rigorous empirical studies on the impact of CFAs in grain and staple food chains. Maertens and Vande Velde (2017) have studied the impact of CFAs in the Beninese rice sector, and document positive effects of CFAs on intensification of rice production, commercialization of rice, and household income.

A recent discussion in CFA literature is the role of intermediaries such as producer organizations (POs) and NGOs (Briones, 2015; Roy and Thorat, 2008; Royer et al., 2017). POs can reduce transaction costs of contracting with a large number of dispersedly-located small farms. POs can facilitate the supply of inputs to contracted farmers and improve their bargaining power as well. Contracts are often between a processor and a PO; a farmer must first be a member of the PO before she can enter the CFA. In such arrangements, POs ensure the quantity, quality and timely delivery of products. However, some authors have argued that POs become selective when achieving this business objective, and resource-poor farmers may be left out of membership (Bernard and Spielman, 2009; Bijman et al., 2016).

Several empirical studies on export-oriented chains found a positive effect of CFAs on the income and productivity of the contracted farmer. Minot and Sawyer (2016) conclude from their review of the literature that income effects of CFAs ranges between 25 and 75%. However, the literature falls short when it comes to CFAs in domestic grain and staple food chains. Our study seeks to fill this gap by analyzing the economic impact of CFAs in the malt barley sector in Ethiopia.

Our study is particularly relevant with respect to the literature on CFAs in Ethiopia, where the development and impact of CFAs are a mixed story. First, CFAs are in the inception stage in Ethiopia. There are only a few recent studies (Abebe et al., 2013; Girma and Gardebroek, 2015), which show that CFAs improve farmer income in export-oriented chains. Second, there is also recent evidence against CFAs, as Wendimu et al. (2016) show that participation in CFAs significantly reduces farm income and asset stocks of farmers in the Ethiopian sugarcane industry.

We hypothesize that CFAs assure markets for smallholder barley producers and potentially lead to improvement in farm income and productivity. We expect that farmers with contracts earn a higher income than farmers without contracts, because the buyer (brewery) introduces improved technology (e.g. improved seeds), provides key inputs and technical assistance, and facilitates logistics and coordination in the supply chain. In return, buyers demand higher quality and they are willing to pay a higher price.

3. Beer multinationals and CFAs in malt barley industry-Ethiopia

Ethiopia is the largest producer and consumer of barley in the African continent (Rashid et al., 2015). Barley is a smallholder crop and currently more than 4 million smallholders produce barley and derive their livelihood from the barley value chain (CSA, 2015). Nationally, two types of barley are grown: food barley for home consumption and malt barley for brewing. Driven by rising income and increased urbanization, per capita beer consumption in Ethiopia has grown rapidly at an annual rate of 20% (ATA, 2015). This promising beer market has attracted beer multinationals, including Heineken, Diageo, and Bavaria. These breweries invest both in beer brewing and in local sourcing of malt barley. Companies used CFAs to organize their supply chains and source malt barley.

The appearance of foreign breweries in the malt barley chain has increased the annual demand for malt barley, on average at a rate of 20% (ATA, 2015). This has affected the malt barley sector by generating new market opportunities for smallholders, reducing price volatility, ensuring reliable supply chains, and cutting the import bill thus saving foreign currency for the government. Heineken, Diageo, and Assela Malt factory (AMF) are engaged in the sourcing of malt barley from smallholders in the Arsi highlands, Ethiopia (Figure 1).

We have identified two types of malt barley supply chains: the conventional and the modern chain. The co-existence of the conventional and modern chains has led to important changes in barley production and marketing. The conventional chain starts from smallholders selling malt barley to local traders and retailers. Transactions are governed by market prices negotiated at the spot. AMF is the dominant aggregator of malt barley from local traders. The modern chain, however, is driven by breweries and characterized by vertical coordination. In this chain, a strict requirement for quality and quantity is arranged together with price premiums. Written contracts are used to safeguard these agreements. The modern chain is characterized by few intermediaries, supply chain management (control of quality and quantity), and technology transfer.

The foreign companies have organized local sourcing through public-private-partnerships (PPPs) consisting of four partners: brewery, non-government organization (NGO), PO, and government. For contracting with smallholders, foreign breweries have subcontracted NGOs (e.g., Technoserve and Hundee) to select and organize farmers, select POs, facilitate input supply and provide technical assistance. POs play an intermediary role through distributing modern inputs, arranging logistics, and aggregating malt barley. As part of the contractual agreement, breweries provide improved seeds, fertilizers and pesticides on pre-financing basis to smallholders. In return farmers deliver malt barley that fulfils the quality requirements. The companies pay quality-based price premiums.

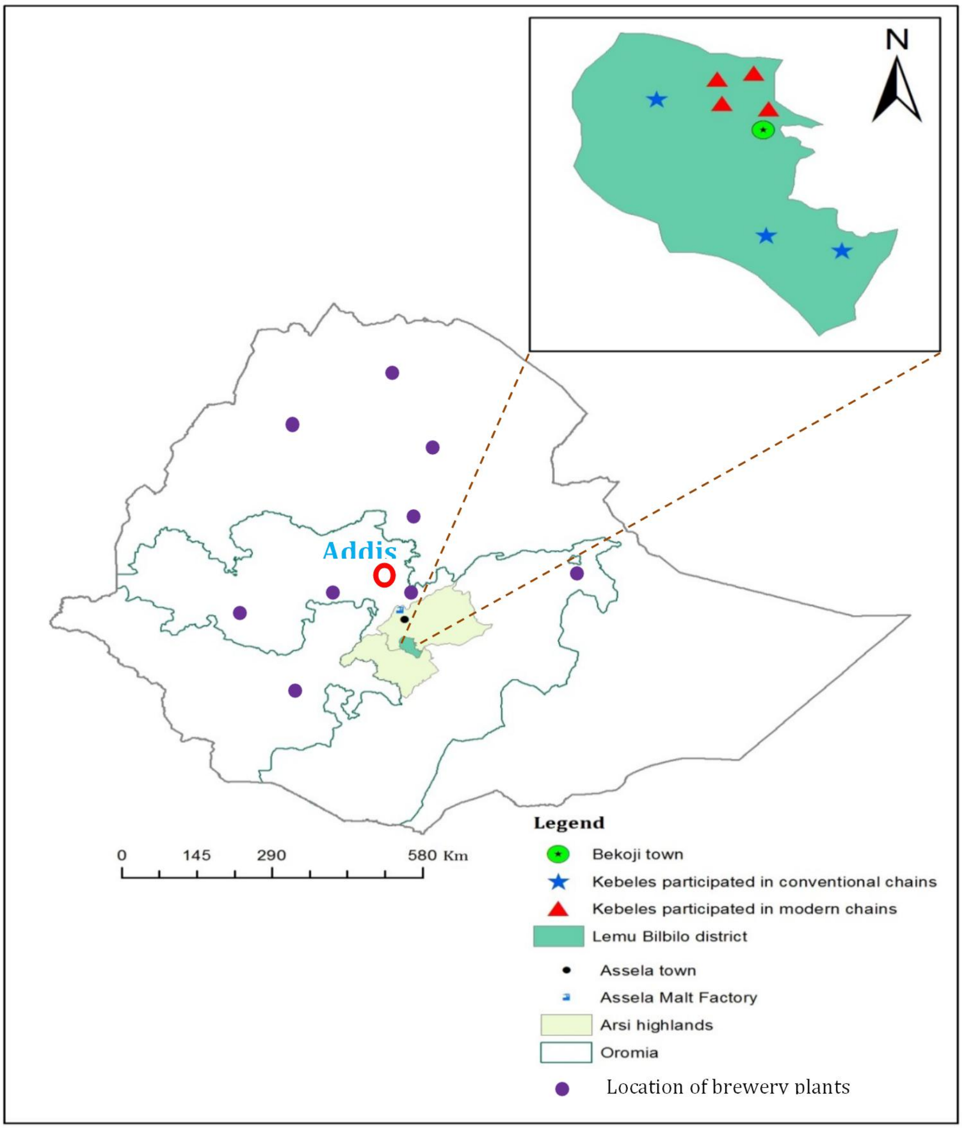

Figure 1. Location of brewery plants in Ethiopia and research area

4. Methodology

4.1 Data collection

Data were collected from the main barley-belt of Ethiopia, the Arsi highlands (Figure 1). The Arsi highlands consist of many districts that are known for production of barley. Among these, the district of our study, Lemu Bilbilo, is in the top three. We purposively selected Lemu Bilbilo district for three reasons: it has a high production of malt barley; it has seen the appearance of foreign breweries in the local sourcing of malt barley; and it already has multiple cases of CFAs between breweries and farmers.

To investigate the economic impacts of CFAs in the malt barley sector, we used original survey data. We conducted the survey on a total of 262 farm households in different villages of Lemu Bilbilo district. The survey was carried out from April to May 2015, but the field study started in January. A multi-stage sampling procedure was used for the selection of a targeted sample. First, four POs with contract arrangements were selected from four different villages in the district (Figure 1). From this group, we randomly selected a total of 110 households. Second, a total of 152 non-contract farmers were randomly selected from three other villages in the district. These farmers could incidentally be PO-members without contract arrangements. Lists of contract and non-contract farmers were obtained from the POs and village chair persons respectively. However, in the final analysis only 258 households were used, as four questionnaires from the non-contract group were incomplete.

A structured questionnaire was prepared and carefully administered to gather household-level primary data. Well-trained enumerators were used to collect the data through face-to-face interview. Data were collected on household demographic characteristics, sources of livelihoods, conditions of food security, off-farm employment, asset ownership, types and quantities of crops produced, sale of crops and output prices, household access to credit, markets and extension services, membership in irrigation associations and POs. Moreover, the data collected included information on types and volume of inputs used in malt barley production, inputs supply arrangements, costs of inputs (hired labor, fertilizers, pesticides and improved seeds), quality improvement practices, quality grading and post-harvest issues, malt barley prices, market outlets, and overall production and marketing challenges in the value chain.

4.2 Econometric approach

To examine the economic impact of participation in breweries CFAs, we start with a comparative analysis of contract and non-contract farmers using a series of t-tests. Then we use different techniques to measure the average impact of CFA participation. First, we apply ordinary least squares (OLS) regression, which is used in related studies (Girma and Gardebroek, 2015; Maertens and Vande Velde, 2017; Wang et al., 2014a). We estimate regression models of the following type:

$$\mathrm{Y}_i = \alpha_i + \beta \mathrm{P}_i + \gamma \mathrm{X}_i + \varepsilon_i \qquad (1)$$

Where Yi measures the outcome of household i, Xi a vector of control variables, Pi is the dummy variable for participation in CFA, and ε is the error term. α, β and γ are parameters to be estimated. We use the following nine outcome indicators and estimate the model separately for each indicator: 1) total malt barley production, measured in quintal or 100kg; 2) malt barley yield, measured in quintal per hectare; 3) malt barley selling price, measured in Ethiopian birr (ETB) per quintal; 4) cost of inputs for malt barley production, measured in ETB per hectare; 5) share of malt barley sold, measured in percentage (i.e., malt barley sold / malt barley produced ratio); 6) gross income from malt barley production, measured in ETB per hectare (calculated as malt barley produced X malt barley price); 7) net income from malt barley production, measured in ETB per hectare (calculated as the difference between gross income and malt barley-related variable costs); 8) product quality; measured in a scale (i.e., farmers stated quality on a 3-point Likert scale; ranging from 1 = low and 3= high); and 9) gross income from other crops, measured in ETB per hectare (calculated as volume other crops produced X selling prices). These are all continuous variables, and hence linear regression and OLS are used (Maertens and Vande Velde (2017).

Our main variable of interest (Pi) is a dichotomous variable for participation in a brewery CFA. Participation in a CFA is likely not randomly distributed among malt barley farmers; hence we include a large set of observable farm and farmer characteristics, Xi. The vector Xi includes various covariates selected on the basis of theory and previous studies (see section 2). We include the following covariates: age and education of the household head, family available labor, number of people in the household, land and livestock ownership, malt barley cultivated area, farming experience, proportion of off-farm income (as proxy for off-farm employment), distance to markets, mobile phone ownership, credit received from microfinance, and extension contact. We provide a detailed description of these variables in Table 1.

Second, we apply propensity score matching (PSM) to control potential selection bias and estimate an average treatment effect of CFA participation (Rosenbaum and Rubin, 1983). PSM reduces the selection bias through employing counterfactuals that control all other factors but treatment. The essential mechanism of PSM is to find comparison groups (non-contracted farmers) that are similar to the treated in all relevant pre-treatment characteristics. First, a logit model is estimated with the binary treatment variable (CFA status of the farmer) as selection variable, conditional on the baseline characteristics of both the treatment (contracted) and the comparison group (non-contracted). From this, propensity scores, i.e., the conditional probability of assignment to a treatment given their baseline characteristics, are predicted. In the logit model, we used the same covariates that are employed in the OLS models. Second, two balanced groups are created based on their estimated propensity scores for final comparison.

Following Caliendo and Kopeinig (2008), let Wi be a binary treatment variable that equals one if a farmer participates in a CFA, and zero otherwise. The potential outcomes of the CFA are represented by (Wi) for each household i. The average treatment effect on the treated (ATT) is expressed as:

$$\tau ATT = E(\tau|W = 1) = E[Y(1)|W = 1] - E(Y(0)|W = 1] \qquad (2)$$

Where E[Y (1) |W = 1] is the expected outcome value for contracted farmers; E[Y (0) |W = 1] is the expected outcome value for contracted farmers if they had not been contracted. E[Y (0) |W = 1] is the counterfactual and not-observed, as we need a proper substitute to estimate ATT. In this case, PSM helps to construct the counterfactual from the non-contracted farmers. In doing so we invoke the conditional independence assumption (CIA) and the common support assumption to control the selection bias problem (Caliendo and Kopeinig, 2008). The non-confoundedness assumption (i.e., CIA) ensures that selection into treatment is only based on observable covariates, which is a strong assumption. We address this assumption using the bounding approach (Rosenbaum, 2002). The common support condition ensures that farmers with similar observable covariates have a positive probability of being both participant and non-participant (Caliendo and Kopeinig, 2008). We check this assumption using balancing properties and a density distribution histogram. If CIA holds and there is overlap between contract and non-contract groups, the PSM estimator for τ_{ATT} is given as:

$$\tau^{PSM}_{ATT} = E_{p(x)|\,W=1}\{E[Y(1)|W = 1,p(x)] - E[Y(0)|W = 0, p(x)]\} \qquad (3)$$

Where p(x) is the predicted propensity score from the logit model. We used different methods to match similar contract and non-contract farmers. We apply nearest neighbor matching (NNM), radius matching (RM), and kernel-based matching (KBM) as the main ATT estimation methods (Becker and Ichino, 2002; Caliendo and Kopeinig, 2008). In the NNM, each treated farmer is matched with a comparable farmer that has the closest propensity score. But in case of KBM, a treated farmer is matched with a weighted average of all controls, using weights that are inversely proportional to the distance between the propensity scores of treated and control groups. This indicates that KBM uses more information. In the RM, information is used only from the nearest neighbor within the caliper distance.

The PSM method is usually built on a strong assumption that observable characteristics determine selection to treatment and control groups (i.e. CIA). Thus, matching estimators are often prone to selection bias. We used the inverse-probability-weighted-regression-adjustment estimator (IPWRA) to further check the robustness of treatment effect estimates.

IPWRA provides efficient estimates by allowing the modelling of both the outcome and the treatment equations (StataCorp, 2017). This allows us to control for selection bias at both the treatment and outcome stages. Thus, the IPWRA estimator has the double-robust property, which means that only one of the two models is correctly specified to consistently estimate the impact (Bang and Robins, 2005; StataCorp, 2017). One could say that regression adjustment (RA) concentrates on outcomes and inverse probability weight (IPW) focuses more on treatment in calculating treatment effects. IPWRA estimators use probability weights to obtain outcome regression parameters and the adjusted outcome regression parameters are used to compute averages of treatment-level predicted outcomes. The IPWRA method is recently used by Kebebe (2017) in the impact evaluation of dairy technology adoption in Ethiopia.

5. Empirical results

5.1 Comparison of contract and non-contract farms

Farm characteristics

In Table 1, we present summary statistics for contract and non-contract farmers. Contract farmers are, on average, more educated than non-contract farmers. Contract and non-contract farmers are also significantly different in access to a mobile phone, access to extension services, access to savings, access to credit, and PO membership. In addition, the mean distance to the market was lower among the contract farmers. All contract farmers are member of a PO; which reflects the fact that organizing themselves in groups is a precondition for engaging in the CFA.

Economics of malt barley production

Smallholders use various inputs to produce malt barley. The main inputs include fertilizers, pesticides and improved seeds. Farmers have access to improved seeds from buyers (i.e., breweries) and other sources. Another input category is labor, whereby farmers mostly use family labor and some additional hired labor during the peak farming season. Table 1 presents the mean comparison of the various outcome indicators. On average, contract farmers produce more malt barley (17qt) than the non-contract farmers (12qt). The average yield is also 15% higher than non-contract farmers. Contract farmers receive a 22% higher average price and commercialize on average 21% point more of their malt barley production than non-contract farmers. In addition, contract farmers have a 20% higher average cost of production per ha than non-contract farmers. Finally, farmers participating in CFAs obtain on average 42% and 41% higher malt barley gross income and net incomes per ha respectively than those who do not participate.

Table 1. Characteristics of contract and non-contract malt barley farmers

Variables	Description	Full sample	Contract	Non-contract	Diff.
Socioeconomic characteristics					
Age	Household head (HH) age in years	44.32	44.55	44.16	0.39
Family size	Number of people in the household	6.35	6.21	6.45	-0.24
Family active labor	Family members 15-65 years age	3.87	3.81	3.91	-0.1
Education	HH education level in years	5.14	5.96	4.54	1.42***
Off-farm income	HH share of off-farm income (%)	4.51	3.18	5.51	-2.32*
Innovativeness	HH innovativeness in farm business[†]	3.30	4.06	2.73	1.33***
Entrepreneurship	HH entrepreneurial skills[a]	3.13	3.77	2.66	1.10***
Mobile ownership	HH mobile phone ownership(0-1)	0.70	0.81	0.62	0.19***
Malt barley cultivation					
Farm size	HH landholding size in hectare	2.75	2.70	2.79	-0.09
Malt barley area	MB cultivated area in hectare	0.74	0.79	0.69	0.10
Experience	MB farming experience in years	20.29	20.69	20.0	0.69
Total livestock	Total livestock ownership in TLU[‡]	11.09	14.45	8.59	5.85
Access to public institutions					
Savings	HH saving in last 12 months(0-1)	0.59	0.74	0.48	0.25***
Extension contact	HH access to public extension service(0-1)	0.53	0.67	0.42	0.24***
Access to credit	HH credit received from Microfinance(0-1)	0.14	0.20	0.09	0.10***
Distance to market	Distance to market(km) (1way walk)	7.93	5.59	9.67	-4.08***
Access to collective institution					
Iddir membership	HH membership to Iddir in year	19.37	19.81	19.04	0.77
PO membership	HH membership to POs(0-1)	0.72	1.00	0.52	0.47***
Debo membership	HH membership to Debo in year	20.09	20.62	19.66	0.96
Outcome indicators					

Total production	HH malt barley production in quintal	14.17	17.10	11.99	5.10***
Yield	Malt barley yield (qt/ha)	20.03	21.67	18.80	2.87***
Price	Malt barley selling price (ETB/qt)	906	1013	829	184***
Share sold	Malt barley sold to produced ratio	0.59	0.71	0.51	0.21***
Cost	Cost of MB production per ha (ETB/ha)	4442	4803	3994	809***
Product quality	HH stated malt barley quality (scale1-3)	2.39	2.80	2.08	0.71***
Goss income	Malt barley gross income per ha (ETB/ha)	18346	22177	15576	6601***
Net income	Malt barley net income per ha (ETB/ha)	13604	15532	10990	4542***
Other crop income	Income from other food crops sale (ETB/ha)	9952	13653	7202	6452***
N		258	110	148	258

Source: Field survey, 2015; *** P < 0.01, ** P < 0.05, * P < 0.10; note: † = Likert scale variables with 5 scales; ‡ = tropical livestock unit to describe livestock numbers of various species as a single unit.

5.2 Factors determining CFA participation

A farmer's decision to participate in a CFA could be conditioned by demographic variables, socio-economic characteristics, and access to assets. We used a logit model to estimate the parameters. Specific variables were selected based on theory and previous empirical research. From the selected covariates six were significant in influencing a farmer's decision to enter a CFA. These are education level, off-farm income, distance to markets, having a mobile telephone, access to public extension service, and receiving microfinance credit (Table 2). All these covariates positively affect the probability of farmers' participation in CFAs except off-farm income and distance to markets.

The results show that education of the household head has a positive and significant effect on participation in a CFA. Education facilitates managerial capacity, farmers' ability to make informed decisions and to comply with quality requirements. Having a mobile phone increases farmers' likelihood to participate in a CFA by enhancing access to information and effective communication. Farmers having received credit from rural microfinance institutes are more likely to participate in a CFA. Results further show that access to government extension service is positively correlated to CFA participation, while off-farm income is negatively correlated. Our results also show that distance to markets negatively influences the likelihood of CFA participation. This is plausible as companies prefer farms near the road or the market center for logistic reasons and reduction of transaction costs in monitoring and provision of technical assistance.

Table 2. Determinants of farmers' decision to participate in CFA

CFA Participation	Coefficient	Std. Error	z	P > |z|
Age	-0.006	0.036	-0.18	0.855
Family size	-0.004	0.116	-0.04	0.968
Family active labor	-0.086	0.182	-0.48	0.634
Education	0.144	0.058	2.48	0.013**
Farm size	0.008	0.110	0.07	0.942
Malt barley area	0.331	0.313	1.06	0.290
Farming experience	0.051	0.033	1.51	0.130
Total livestock	0.006	0.013	0.47	0.638
Share of off-farm income	-0.041	0.019	-2.16	0.031**
Distance to markets	-0.392	0.067	-5.82	0.000***
Mobile ownership	1.287	0.441	2.91	0.004***
Credit received from microfinance	1.283	0.499	2.57	0.010***
Extension contact	1.179	0.347	3.40	0.001***
_cons	-0.589	1.352	-0.44	0.663

Summary statistics
Pseudo R^2 = 0.359 — Percentage of correct prediction = 77.95%
Model χ^2 = 124.65*** — Number of observations = 254
Log likelihood = -110.883

Source: Field survey, 2015; *** P < 0.01, ** P < 0.05, * P < 0.10

Finally, variables representing access to productive assets such as available family labor, farm size, malt barley area and total livestock, did not affect farmers' decisions to participate in CFAs. This implies that small and large farms both participate in contracting. Though not included in the model, membership to a PO is a pre-requisite to breweries' CFAs. Based on the pseudo-R2 (0.359), which is high and significant at 1% level, the covariates clearly explained the participation probability. In addition, the model indicates that 78% of the sample observations are correctly predicted.

5.3 Impact of smallholder participation in CFA

Estimating propensity scores

We estimated the propensity scores for the contract and non-contract farmers using the logit model. The magnitude of the propensity score ranges between 0 and 1; the higher the score, the more likely that the farmer would participate in CFA. The predicted propensity scores for contract farmers range from 0.030 to 0.990 with a mean of 0.660 and from 0.001 to 0.926 for non-contract farmers with a mean of 0.246.

Based on these predicted propensity scores, we test the common support assumption. Using the rules of minima-maxima (Caliendo and Kopeinig, 2008), the common support assumption is satisfied in the region of 0.030 – 0.926. The common support region is also examined using the density distribution for the two groups of treated (contract) and untreated (non-contract) (Figure A1 in Appendix I: line graphs and histogram). The overlap in the distribution of the propensity scores for contract and non-contract farmers is also visually checked: the result suggests that there is a high chance of obtaining good matches.

Estimating impacts of CFA

We then estimated the average treatment effects on the treated (ATT), which is the mean impact that participation in CFA has on malt barley farmers along a number of outcome variables. The result for PSM estimates (NNM, KBM and RM) are presented in Table 3. We also included the summary of results from OLS and the naive t-test. We found positive and significant impact of participation in CFAs on all the selected outcome indicators. We find that results are quite robust, with the same signs and significance levels and comparable point estimates among the different matching algorithms. The results from the OLS regression analysis and PSM are also comparable, indicating the robustness of our results. The full regression results are presented in Table 7 in Appendix I.

(a) Malt barley production

We find that CFAs result in a significantly larger malt barley production (Table 3). Participation in a CFA increases production with about 5 quintals, which is an increase of 36% compared with the average malt barley production in Arsi highlands. This could be associated with improved access to modern inputs and technical assistance.

(b) Malt barley yield, quality and intensification

We find that CFAs lead to using more inputs per ha in malt barley production, which is evidenced by a higher variable cost per ha (Table 3) and higher quantity of fertilizers used (Table 4 in Appendix I). We also find that CFAs lead to larger malt barley yields and higher quality. On average, a CFA increases input costs with about 828 ETB per ha, which is an increase of 19% compared with the average input costs per ha in the research area. Yields are found to increase with 2.54 quintal per ha or 13% in comparison with the average yield in the Arsi highlands. The results also show that CFAs increase the quality of malt barley grown by contract farmers by an average of 31% as compared to the sample average. Higher yield, quality, and variable costs of production would lead to higher malt barley net income.

(c) Malt barley commercialization

Our results reveal that participation in a CFA positively influences smallholders' commercialization in the malt barley sector. We find that participation in a CFA leads to an increase in the share of produced malt barley that is commercialized and a higher farm-gate price. The share of malt barley that is commercialized is significantly higher for those with contract, on average 17% points. The price is significantly higher for those with a contract, on average 197 ETB per quintal. CFAs increase the average price farmers receive for their malt barley with 22% compared with the sample average. The effect on farm-gate prices is most likely associated with improved quality.

Table 3. Average estimated effects of participation in CFAs

Outcome indicators	Naive t-test	OLS	PSM			Critical level of hidden bias (Γ)
			NNM	KBM	RM	
Production	5.1 (1.38)***	2.84 (0.900)***	5.37 (2.42)**	5.09 (2.63)**	5.47 (2.52)**	1.6 – 1.7
Yield	2.86 (0.8) ***	2.30 (0.991)**	2.40 (1.45)*	2.38 (1.38)*	2.76 (1.33)**	1.4 – 1.5
Price	184 (10)***	190 (11.61)***	206 (22.72)***	198 (23)***	207 (22)***	3.0 – 3.1
Share sold	0.21 (0.033)***	0.14 (0.04)***	0.17 (0.072)**	0.16 (0.067)**	0.16 (0.065)**	2.4 – 2.5
Costs	809 (71)***	799 (96)***	839 (101)***	845 (143)***	850 (135)***	3.0 – 3.1
Gross income	6601 (785)***	6265 (995)***	7350 (1358)***	7101 (1342)***	7223 (1306)***	3.0 – 3.1
Net income	4542 (1027)***	3577 (1416)***	3864 (2062)*	5004 (2505)**	4502 (2046)**	2.8 – 2.9
Product quality	0.71 (06)***	0.63 (0.082)***	0.78 (09)***	0.78 (12)***	0.78 (11)***	3.0 – 3.1
Other crops income	6452 (1615)***	5603 (2047)***	6974 (2932)**	7168 (2688)**	6534 (2602)**	1.5 – 1.6

Source: Field survey, 2015; Standard errors in parentheses; *** P < 0.01, ** P < 0.05, * P < 0.10

(d) Income

We find that participation in a CFA has a positive effect on farm family income. We find that a CFA leads to a higher malt barley gross income and net income, on average 6908 and 4298 ETB per ha respectively. These are crucial effects, which implies that participation in a CFA increases malt barley gross income and net income by 38% and 31% respectively in comparison with the sample average. Our results also reveal that CFA participation leads to an increase in other crops' gross income, on average 6546 ETB per ha. This implies that participation in a CFA increases farmer's income from other crop production with 66% compared with the sample average. There may be a significant spillover from CFA benefits into the production of food crops such as food barley and wheat, the major staples in the research area, probably due to modern inputs usage and technical assistance.

Robustness and assessing matching quality

For examining the quality of the matching process we conducted two tests. First, on the observable factors, the credibility of the PSM procedure is evaluated using the covariates balancing test (Table 5a and 5b in Appendix I). Using pseudo-R2 values we assessed the extent of systematic differences in covariates between contract and non-contract farmers after matching. Our result show that the pseudo-R2 reduced from 0.241 before matching to a range of 0.07-0.08 after matching (Table 5b in Appendix I). This fairly low value indicates that after matching there was no systematic difference in the distribution of covariates between the two groups. The chi-square test for Pseudo-R2 is also insignificant after matching. Thus, the matching process is successful regarding balancing distribution of covariates between contract and non-contract farmers.

Second, we assessed the sensitivity of the ATT estimates to unobserved heterogeneity or hidden bias. In the PSM technique, selection to treatment is only based on observed characteristics, and it does not control for hidden bias due to unobserved factors (Caliendo and Kopeinig, 2008). Heterogeneity may arise when contract and non-contract farmers differ on unobserved variables that simultaneously influence assignment to treatment and the outcome variable. We checked this using the bounding approach (Rosenbaum, 2002). This method relies on the sensitivity parameter gamma (log-odds ratio) that determines how strong an unobservable variable must be to influence the selection process so as to bias the results (DiPrete and Gangl, 2004).

Following DiPrete and Gangl (2004) and Girma and Gardebroek (2015), we consider various critical gamma value levels. We reported the results of rbound-tests in Table 3 last column. It indicates that the estimates of ATT are robust to hidden bias due to unobserved factors, even to the extent that would triple (Γ = 3) log odds of differential assignment to treatment. For the outcome indicators production, yield and other crops income, the critical level of gamma at which we would have to question our positive causal inference is between 1.6 and 1.7, 1.4 and 1.5, and 1.5 and 1.6 respectively (Table 3).

Finally, we also assess the robustness of NNM, KBM, and RM results by comparing to the results of a doubly robust inverse-probability-weighted-regression-adjustment (IPWRA) estimator. The results for the IPWRA estimator are presented in Table 6. The IPWRA approach produces almost similar results as the estimates in Table 3.

Table 6. Average treatment effects using Inverse-Probability-Weighted Regression Adjustment

Outcome indicators	Mean outcome		Difference (ATT)	% change
	Contract	Non-contract		
Total production	14.52	12.57	4.29 (1.25)***	34.12
Yield	19.41	18.75	3.34 (0.98)***	17.81
Price	993	822	208 (22.7)***	25.36
Share sold	0.66	0.52	0.18 (0.06)***	34.61
Cost	4702	3920	946 (84)***	24.13
Gross income	19604	15312	7743 (696)***	53.56
Net income	13009	10755	4829 (1317)***	45.01
Product quality	2.5	2.07	0.83 (0.099)***	40.09
Other crops income	11809	7575	4811 (2112)**	63.51

Source: Field survey, 2015; Standard errors in parentheses; *** P < 0.01, ** P < 0.05, * P < 0.10

6. Discussion

The literature on CFAs in emerging economies shows a debate on whether CFAs improve smallholders' income and production efficiency. Several empirical studies document a positive impact of CFAs, focusing on high value chains (Abebe et al., 2013; Andersson et al., 2015; Bolwig et al., 2009; Kariuki and Loy, 2016; Roy and Thorat, 2008; Wang et al., 2014a). There is, however, also evidence that CFAs have negative income effects (Narayanan, 2014; Wendimu et al., 2016). In addition, CFAs are criticized for favoring large-sized farms at the expense of smallholders. It is claimed that CFAs exclude the participation of resource-poor farmers (Otsuka et al., 2016; Weatherspoon and Reardon, 2003).

On the effectiveness of CFAs, the results of our study are in agreement with earlier findings about the positive impact of contract farming on farmers' income. Our findings demonstrates that CFA participation has a positive impact on the following performance indicators: malt barley production, yield, intensification, quality, share sold, farm gate price, malt barley income and other crops income. Contract farmers achieved better performance in all of these indicators. For example, a CFA increases malt barley production with 36%, yield with13%, input costs with 19%, farm-gate prices with 22%, and net income with 31% compared with sample average. Our result is consistent with CFA literature both in high-value chains and domestic food chains (Maertens and Vande Velde, 2017; Mishra et al., 2016; Wang et al., 2014a). This strong positive outcome is attributed to the improved technologies, technical assistance, and coordination introduced in the malt barley supply chain.

Foreign breweries introduced quality-based pricing and the use of a grading system, which resulted in quality improvement. For instance, CFAs increase the farm gate prices that farmers receive with 22% compared with the sample average. Our finding is in line with the result from Maertens and Vande Velde (2017) that rice contract farming in Benin increases farm-gate prices with 11% and from Miyata et al. (2009) that vegetable contract farming for supermarket in China increases farm-gate prices with 8%. Foreign breweries are investing in the supply chain to ensure reliable local supply and consistent malt barley quality, for instance by coordinating supply chain activities in different stages of the chain with the support of NGOs and POs. This has brought dynamism in malt barley production and distribution, and has led to more coordinated chains. By investing in local sourcing of malt barley, breweries can reduce the high cost of import, manage price volatility, and show their corporate social responsibility.

On the determinants of CFA participation, our findings show mixed evidence. Contrary to the results of Wainaina et al. (2014), we have found a positive relationship between household education and the likelihood of participation in CFA. Similar positive effects of education on CFA participation have been reported for ginger farmers in Nepal (Kumar et al., 2016) and avocado farmers in Kenya (Mwambi et al., 2016). Education, as an indicator of human capital, enables households to understand information and take decisions on modern technologies and quality issues. It may also lead to more entrepreneurship and increased aspiration about the future of households' farming business. However, Girma and Gardebroek (2015) and Miyata et al. (2009) have reported that education has no significant effect and a negative effect on CFA participation in Ethiopia and China, respectively.

Our results also reveal that having a mobile phone, access to credit and access to public extension services are positively related with participation of CFAs. With regard to a mobile phone, similar results have been reported by Mishra et al. (2016) and Kumar et al. (2016). Our result is also in line with the findings reported by Ma and Abdulai (2016) and Mwambi et al. (2016), who show a positive relationship between access to credit and CFA participation. However, Wainaina et al. (2014) report that access to credit has no significant effect on participation. In addition, Kariuki and Loy (2016) and Girma and Gardebroek (2015) have been reporting that extension services positively and significantly influence CFA participation. Contrary to this, Wainaina et al. (2014) have reported that access to extension services is negatively related with CFA participation.

The positive association between access to credit and CFA participation could be explained by farmers who are able to access credit, tending to invest in the production of malt barley that meets the buyer's quality requirements, which can then earn them premium prices. Extension service as an important determinant could be explained by households who have better extension contacts, being in a better position to access useful information regarding benefits of modern agricultural technologies and marketing schemes.

Furthermore, we find that distance to markets and off-farm income negatively relate with CFA participation. Similar results have been reported by Miyata et al. (2009) for apple farmers in China, Wainaina et al. (2014) for poultry farmers in Kenya, and Mwambi et al. (2016) for avocado farmers in

Kenya. The pattern observed could be explained by breweries preferring to work with nearby farmers for reasons of logistics, monitoring, provision of technical assistance and farm visits. Thus, a larger distance to the main road (or market) increases the transaction cost of sourcing malt barley from smallholders. Contrary to this, Maertens and Vande Velde (2017) have reported a positive effect of distance to markets on the likelihood of farmers' participation in rice CFAs in Benin.

Our results also show that off-farm income negatively affects the likelihood of participation in CFAs. This may be explained by smallholders specialized in farming (less off-farm activities) are more likely to join in CFAs. However, Azumah et al. (2016) and Wainaina et al. (2014) report that the likelihood of CFA participation increases with off-farm income. They argue that farmers' access to finance from off-farm activities improves their ability to buy basic inputs and this increases their probability of CFA participation.

7. Conclusion

The paper is an original contribution to the few empirical studies analyzing the impact of CFAs within domestic (staple) food chains using robust econometric methods, with correction of selection biases. The paper examined the factors that influence farmers' decision to participate in a CFA, as well as the impact of CFA participation on intensification of production, commercialization and prices, and farmer income in malt barley chains of Ethiopia. The study utilized cross-sectional survey data of malt barley farmers collected from the Arsi highlands of Ethiopia.

Our empirical findings demonstrate the positive impacts of CFAs on all selected outcome indicators. We find that CFAs result in intensification of malt barley production, increased commercialization of malt barley, higher farm-gate prices, increased net malt barley income, and higher income from other crops. Our estimated results are robust, consistent across different matching methods and OLS regression. Our findings imply that CFAs in a value chain context lead to higher smallholder farm income. In addition, promoting CFAs and its interlinkage with POs might be an effective way to increase smallholder commercialization, intensification of barley production, and quality improvement in the value chain. Previous studies on the impact of CFAs mainly focused on high-value and export oriented chains, while studies on domestic and staple food chains are few. Our study, thus, contributes to the agribusiness and development literature through providing empirical evidence on CFAs in domestic food chains.

Consistent with literature our results reveal that contracting in domestic and local food chains can be beneficial for smallholder producers. This seems against the expectation, as expressed Maertens and Vande Velde (2017), that contracting in domestic food chains is not feasible due to contract-enforcement problems that stem from a low value of produce and a large number of buyers in the chain. Three arguments could be forwarded why CFA works in barley value chains: First, low side-selling could be related to a high premium price of 22% that contract farmers received. Second, involvement of a PO may have a positive impact on the sustainability of the CFA. Third, linked to the new development paradigm - from-aid-to-trade – the role of NGOs has changed from providing generic farming support towards subcontracting specific supply chain activities.

The findings have several important implications for policymakers and stakeholders involved in the transformation and development of food systems. The study provides empirical evidence on how multinationals influence upgrading of food chains and commercialization of smallholders in Africa. It also indicates that supporting CFAs in the malt barley chains is an effective way to contribute to reaching the government aim of expansion and intensification of malt barley production and quality upgrading. Public support on capacity building of POs also helps for smallholder linkages to modern chains and the smooth functioning of contract arrangements.

A major constraint for the expansion of contract production is the poor condition of the physical infrastructure such as the lack of all-season roads. The brewery companies only have contracts with POs close to the district towns (within a 6km radius). Thus, the government should invest in building infrastructure so that farmers in remote areas can be included.

Our findings encourage further research on the following issues. First, we have not addressed the impact of malt barley production on food security. Does malt barley production compete with food barley production? Second, it would be worthwhile to carry out a within-country comparison of impact of CFAs in staple food chains and export-oriented chains. In particular, such research should focus on contract attributes in the two distinct chains and the implications for key actors including smallholders.

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Appendix I

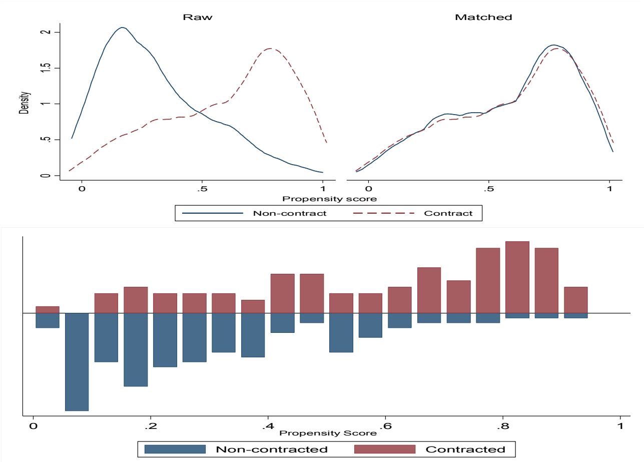

Figure A1. Propensity score distribution and common support (before and after matching)

Table 4. Effect of CFA on intensification

Indicators of intensity	Contract	Non-contract	t-stat	Sig.
Improved seeds (0-1)	1.0	0.39	13.2	***
Quantity of fertilize-DAP(qt)	2.6	1.6	4.24	***
Quantity of fertilizer-NPS(qt)	1.96	1.65	1.09	
Quantity of fertilizer-Urea(qt)	0.48	0.45	0.41	
Cost of seed (ETB/ ha)	1245	799	44.62	***
Cost of fertilizer (ETB/ha)	1307	1280	5.94	***
Cost of weeding (ETB/ha)	620	380	12.75	***
Cost of harvesting(ETB/ha)	709	571	4.04	***
Total variable costs (ETB/ha)	4803	3994	11.33	***

Source: Field survey, 2015; *** significant at 1% level

Table 5a. *t*-tests for equality of means for each variable before and after the match

Variable	Sample	Mean		% bias	% reduction (bias)	t-test p> |t|
		Contract	Non-contract			
Age head	Unmatched	44.39	43.692	6.1		0.667
	Matched	44.39	43.107	11.1	- 83.0	0.473
Family size	Unmatched	6	6.359	-14.3		0.318
	Matched	6	5.747	10.0	29.7	0.463
Working labor	Unmatched	3.59	3.837	-13.7		0.340
	Matched	3.59	3.447	8.0	42.0	0.550
Education head	Unmatched	5.79	4.837	23.9		0.057
	Matched	5.79	6.117	-10.7	60.2	0.446
Farm size	Unmatched	2.64	2.859	-9.5		0.514
	Matched	2.64	2.802	-7.0	26.1	0.607
Malt barley area	Unmatched	0.75	0.735	1.9		0.898
	Matched	0.75	0.648	15.1	- 711.3	0.297
Farming experience	Unmatched	22.99	21.650	11.1		0.432
	Matched	22.99	22.047	7.8	29.7	0.620
Total livestock	Unmatched	9.06	8.849	2.4		0.868
	Matched	9.06	8.674	4.4	- 82.9	0.768
Off-farm income	Unmatched	3.24	5.299	-21.1		0.144
	Matched	3.24	2.719	5.3	74.8	0.670
Distance to market	Unmatched	6.18	8.170	-67.9		0.000
	Matched	6.18	7.145	-33.0	51.4	0.011
Mobile ownership	Unmatched	0.81	0.675	30.2		0.035
	Matched	0.81	0.862	-12.8	57.7	0.323
Access to credit	Unmatched	0.17	0.094	22.6		0.105
	Matched	0.17	0.352	-53.7	- 137.6	0.006
Extension contact	Unmatched	0.61	0.427	37.8		0.008
	Matched	0.61	0.574	7.9	79.2	0.603

Table 5b. Matching quality test: balancing property

	Before matching	After matching (algorithms)		
		NNM*	KBM	RM
Pseudo-R^2	0.241	0.073	0.081	0.080
LR $\chi2$	67.59	17.3	19.1	18.9
P-value	0.000	0.188	0.120	0.127
Mean bias	20.4	14.1	14.5	15.1
Median bias	14.3	11.6	9.0	12.1

Note: * seven nearest is used

Table 7. Full OLS regression results

Variable	Production	Yield	Price	Share sold	Cost	Gross income	Net income	Product quality	Other crops income
Contract	**2.84*****	**2.30****	**190.26*****	**0.14*****	**798.94*****	**6264.59*****	**3577.2*****	**0.63*****	**5602.78*****
	(0.900)	(0.991)	(11.61)	(0.04)	(96.44)	(994.56)	(1416.3)	(0.082)	(2047.15)
Age	-0.131*	-0.15*	0.493	0.003	-7.038	-138.32*	-177.81	0.008	-55.36
	(0.076)	(0.084)	(0.971)	(0.003)	(7.93)	(83.22)	(115.02)	(0.007)	(173.22)
Family size	-0.165	-0.173	3.18	-0.014	25	-160.87	-62.63	-0.006	236.09
	(0.241)	(0.265)	(3.104)	(0.1)	(24.449)	(265.87)	(352.58)	(0.022)	(548.67)
Active labor	0.773**	0.66*	-3.30	-0.006	-10.45	602.50	606.8	0.035	36.12
	(0.361)	(0.397)	(4.60)	(0.016)	(34.80)	(394.18)	(498.61)	(0.033)	(820.79)
Education	0.33***	0.39***	1.46	0.008	13.58	409.43***	532.87***	0.013	239.01
	(0.119)	(0.131)	(1.55)	(0.005)	(11.66)	(132.88)	(174.203)	(0.011)	(271.25)
Farm size	-0.12	0.054	-1.93	0.005	24.566	32.13	35.41	-0.023	982.52*
	(0.228)	(0.251)	(2.91)	(0.01)	(20.72)	(249.12)	(299.69)	(0.021)	(518.70)
Malt barley area	15***	-1.78***	37.76***	-0.137***	184.72***	-1031.37	-1260.84	0.167***	-4616.65***
	(0.637)	(0.702)	(8.12)	(0.028)	(55.46)	(698.59)	(789.8)	(0.058)	(1448.54)
Off-farm income	0.065*	0.065	0.22	-0.001	5.57	62.77	48.28	-0.002	53.11
	(0.037)	(0.042)	(0.48)	(0.001)	(4.09)	(41.37)	(58.96)	(0.003)	(86.24)
Mobile phone ownership	-0.65	-1.09	34.25***	0.07*	-48.44	-315.07	-1887.19	0.081	-1080.53
	(0.915)	(1.00)	(11.68)	(0.04)	(97.12)	(1001)	(1387.97)	(0.084)	(2081.22)
Extension contact	0.688	0.571	12.07	0.005	11.45	673.80	226.35	0.21***	3903.59**
	(0.757)	(0.835)	(9.73)	(0.033)	(74.90)	(833.46)	(1090.74)	(0.07)	(1723.57)
Farming experience	0.106	0.11	-0.006	0.0002	9.19	122.58	124.1	-0.004	-141.78
	(0.072)	(0.08)	(0.931)	(0.003)	(7.36)	(79.75)	(107.74)	(0.006)	(164.84)
Total livestock	-0.003	-0.007	0.027	0.0004	0.083	-6.78	-5.96	0.0003	1.22
	(0.009)	(0.009)	(0.114)	(0.0004)	(0.75)	(9.80)	(10.61)	(0.0008)	(20.46)
Distance to market	-0.12	-0.142	5.03***	-0.01**	-6.55	-14.92	-107.65	0.002	-216.45
	(0.095)	(0.105)	(1.22)	(0.004)	(9.09)	(104.24)	(134.81)	(0.008)	(216.17)
Credit from microfinance	-0.43	-1.25	-9.41	0.033	8.03	-1510.25	-1366.48	-0.03	-1059.89
	(1.05)	(1.159)	(13.57)	(0.047)	(103.92)	(1162.51)	(1523.21)	(0.096)	(2392.1)
Intercept	2.69	22.5***	695.47***	0.58***	3733***	16334***	15022***	1.44	11508.64*
	(2.80)	(3.09)	(35.89)	(0.125)	(301.115)	(3074.92)	(4370.4)	(0.258)	(6378.09)
F-value	57.48	3.48	35.03	7.16	11.73	7.01	3.26	11.26	2.66
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0013
Adjusted R^2	0.7710	0.1205	0.6559	0.2565	0.4550	0.2517	0.1583	0.3621	0.0841

Figures in parentheses are standard errors; *** P < 0.01, ** P < 0.05, * P < 0.10; *Source:* Field survey, 2015