IFRO Working Paper

Sugarcane Outgrowers in Ethiopia: 'Forced' to Remain Poor?

Mengistu Assefa Wendimu
Arne Henningsen
Peter Gibbon

2015 / 06

Sugarcane Outgrowers in Ethiopia: 'Forced' to Remain Poor?

Mengistu Assefa Wendimu, Arne Henningsen and Peter Gibbon

Abstract

Contract farming is often seen as a panacea to many of the challenges faced by agricultural production in developing countries. Given the large heterogeneity of contract farming arrangements, it is debatable whether all kinds of contract farming arrangements offer benefits to participating smallholders. We apply matching methods to analyze the effects of a public sugarcane outgrower scheme in Ethiopia. Participation in the outgrower scheme significantly reduces the income and asset stocks of outgrowers who contributed irrigated land to the outgrower scheme, while the effect was insignificant for outgrowers who contributed rain-fed land. We provide several explanations and discuss policy implications.

Key words: Outgrower scheme, contract farming, sugarcane, propensity score, genetic matching,

Ethiopia

1. INTRODUCTION

Contract farming[1] is often seen as a panacea to many of the challenges faced by agricultural production in developing countries. First, the contractor usually provides yield-increasing inputs, credit, and/or new technologies to contracted small-scale farmers, which could enhance their productivity and improve the food supply in developing countries (World Bank, 2011). Second, contract farming could facilitate small-scale farmers' participation in rapidly evolving local or global value chains that require certification and/or stable and reliable supply of large quantities of homogeneous products (e.g. Barrett et al., 2012). Third, while these value chains could also be supplied by large-scale commercial farms, land acquisitions for large-scale farming usually require the displacement of the current land users, which can be avoided by making the current land users into contract farmers (e.g. Cotula et al., 2009). Finally, due to improved productivity and participation in modern value chains, contract farming could enhance farmers' income and thus reduce rural poverty (World Bank, 2008).

As contract farming arrangements are very heterogeneous and may have diverse effects (Sivramkrishna and Jyotishi, 2008; Oya, 2012), there is a legitimate concern as to whether all kinds of contract farming arrangements offer economic benefits to participating smallholders. For instance, contract farming arrangements can be divided into private (voluntary) contract farming and outgrower schemes, i.e. a variant of contract farming, where the government or a public-private agency is the contracting agent and where participation in such schemes is usually compulsory (Glover, 1990). In the last two decades, studies of contract farming have concentrated on examining the effects of private (voluntary) contract farming on smallholders' income. Outgrower schemes tend to be overlooked in the contemporary contract farming literature, even though they were the primary variant of contract farming until the mid-1990s (Gibbon et al., 2010), and they continue to be the dominant form of contract farming for certain crops and in certain countries (e.g. for sugarcane in Kenya, Malawi, Mozambique, and Ethiopia). As private (voluntary) contract farming arrangements need to provide positive incentives to encourage farmers to participate in the arrangement, it is not surprising that most existing studies find a positive effect of (private voluntary) contract farming on the participating households' income. In contrast, it is questionable whether outgrower schemes with mandatory participation also provide benefits for farmers because the farmers are forced to participate regardless of whether the participation is beneficial for them or not.

In order to tackle this question, we use genetic matching and Propensity Score Matching (PSM) to analyze the effects of mandatory participation in the sugarcane outgrower scheme of the publicly-owned Wonji-Shoa Sugar Factory in central Ethiopia on the participating households. In this study, we focus on sugarcane in Ethiopia because: (i) sugarcane outgrower schemes are rapidly expanding there; (ii) the presence of both long-standing outgrower schemes (established in 1975) and recently established outgrower schemes (in 2008) allows us to make both long-term and short-term assessments of their impacts and; (iii) sugarcane is the dominant crop grown under outgrower

---

[1] Little and Watts (1994, p. 9) define contract farming as a, 'form of vertical coordination between growers and buyer-processors that directly shapes production decisions through contractually specifying market obligations (by volume, value, quality, and, at times, advanced price determination); provides specific inputs; and exercises some control at the point of production.'

schemes with similar contractual arrangements in many African countries (Oya, 2012) so that the results of our study have relevance beyond the Wonji-Shoa outgrower scheme. In contrast to previous studies on the effects of contract farming, we not only examine the effects on household income, but also on asset stocks, which captures long-term effects and is less sensitive to short-term fluctuations than annual household income. Moreover, asset data are often characterized by fewer problems regarding recall bias, seasonality and measurement errors, while the emphasis on productive assets is further warranted by their capacity to change future household incomes and income dynamics (Michelson, 2013).

The remainder of this paper is organized as follows. Section 2 presents an overview of outgrower schemes and contract farming in general and of the Wonji Sugar Factory outgrower schemes in particular. Section 3 describes the study area and the survey design. Section 4 presents the empirical model used. Section 5 presents the empirical results, while Section 6 discusses these results. Section 7 concludes by proposing some policy implications of the empirical findings.

2. CONTRACT FARMING AND OUTGROWER SCHEMES

(a) General overview

Both earlier and recent studies have suggested that contract farming and outgrower schemes are likely to remain an important feature of African agriculture (Glover, 1987; Little, 1994; Bolwig et al., 2009; Bellemare, 2012; Smalley, 2013). While the terms 'contract farming' and 'outgrower schemes' are usually used interchangeably, Glover (1990) draws a distinction between the two, where he classifies contract farming into private-led schemes and outgrower schemes (i.e. schemes involving management or ownership by public enterprises or parastatals).[2] Little (1994) states that the majority of the outgrower schemes that existed in Africa at the time of his review incorporated some component of state ownership or management. Most of the literature on contract farming in Africa until the mid-1990s reflected the experiences of outgrower schemes (Gibbon et al., 2010). Recognizing the diversity within contract farming arrangements, White (1997) points out that the existence of a contract in all types of contract farming arrangement is the only thing that binds them together as an analytical category. In this study, we follow Glover's (1990) classification based on public or private scheme ownership.

Some studies (e.g. Glover, 1987; Sivramkrishna and Jyotishi, 2008) indicate that private and public scheme ownership tends to be associated with contrasting welfare outcomes. In private-led contract farming arrangements, contracts are mostly verbal—or if written, usually for one production season to a year only—and farmers have the right to decide whether to terminate or remain in the contract. In these schemes, a farmer accepts a contract offer from a firm only when his/her expected gain from participation is at least as great as from not doing so (Sivramkrishna and Jyotishi, 2008; Barrett et al., 2012). There is a possibility that farmers may accept contracts that are *ex-ante* welfare reducing because of misinformation or incorrect beliefs (Barrett et al., 2012), but farmers can correct such mistakes in subsequent contract negotiations or decisions. Thus, for farmers to enter

---

[2] Various other criteria for classifying contract farming can be found in Gibbon et al. (2010) and Oya (2012).

into and remain in the private contract farming arrangements, the contract must provide some kind of incentive (whether this is in the form of a price premium, provision of credit, or access to inputs and technology). Furthermore, the existence of an exit option gives farmers better contract negotiating power than the case where farmers do not have an exit option. Indeed, notwithstanding problems of endogeneity related to cases of participant self-selection, the majority of the recent empirical studies of private contract farming show that participation in contract farming significantly increases the income of participating smallholders (e.g. Singh, 2002; Warning and Key, 2002; Bolwig et al., 2009; Maertens and Swinnen, 2009; Miyata et al., 2009; Jones and Gibbon, 2011; Bellemare, 2012; Kleemann et al., 2014).

Outgrower schemes are usually designed and initiated by public enterprises or with state involvement in order to supply commodities to processing facilities located near the production areas. They are often financially supported by donor agencies with the objective of rural development. Contract agreements are typically for longer durations and participation in such schemes is often compulsory (e.g. White, 1997; Buch-Hansen and Marcussen, 1982; Shumba et al., 2011 and the case examined here). In most of these schemes, the title to the land is allocated to the farmer associations (cooperatives), to government enterprises that manage the schemes (Tiffen and Mortimore, 1999), or to public banks who provide initial 'loans' for setting up scheme infrastructure (White, 1997). After entering the outgrower scheme, this arrangement means that outgrowers have no direct power when negotiating the contractual conditions. While to the best of our knowledge, the effects of mandatory participation in outgrower schemes has not yet been analyzed with quantitative studies, most qualitative studies indicate that situations of unequal power relations or the absence of exit options potentially lead to the exploitation of contracted smallholder farmers (Isaacman, 1981; Glover, 1987; Little 1994; Poter and Phillips-Howard, 1997; White, 1997; Eaton and Shepard, 2001; Taruvinga, 2011; Amrouk et al., 2013).

(b) The Wonji Area Sugarcane Outgrower Schemes

The Wonji Sugarcane Outgrower scheme, which is the focus of this study, is the oldest outgrower scheme (contract farming arrangement) in Ethiopia. The first (seven) associations of sugarcane outgrowers in Ethiopia were founded in 1975/76 to supply sugarcane to the Wonji-Shoa Sugar Factory.[3] As the plantation of the Wonji-Shoa Sugar Factory was established in an area where the surrounding agricultural land was already in use by local communities, the factory could not expand the land area for sugarcane production without displacing small-scale farmers after the 1960s. In order to increase the supply of sugarcane, the factory initially proposed to the government and the then Ethiopian Sugar Enterprise to resettle the households who were using the surrounding land, but this plan was not approved because of intense resistance from local communities. Thus, the resettlement plan was changed to an outgrower scheme which was considered to be a win-win solution for both local communities and the factory. To make the scheme amenable to mechanization, the factory decided that all households who had land along the Awash River adjacent to the factory's plantation had to participate or leave their land.

---

[3] The Wonji and Shoa Sugar Factories (in short Wonji-Shoa) are the two oldest sugar factories in Ethiopia, established in 1954 and 1964, respectively. The two factories were located about 7 km apart and were run by the same management. Together, the two factories operated a plantation with 5900 ha of large-scale sugarcane production. Around mid-2014, both factories were replaced by a new factory with a higher cane crushing capacity than the two old factories combined.

Due to its steadily increasing demand for sugarcane, the Wonji-Shoa Sugar Factory has undertaken three further expansion projects to establish new outgrower associations. The first and the second expansion projects were established in 2008 and 2011, respectively. Like the original scheme, these two expansion projects are located in villages in the Adama and Dodota districts within 10 km of the Wonji-Shoa Sugar Factory. Altogether, 3,722 households (between 15,000 and 20,000 people) participate in the outgrower schemes that were established in 1975, 2008 and 2011. In total, these outgrower schemes cultivate about 4,540 ha of sugarcane and supply around 40% of the total cane crushed by the Wonji-Shoa Sugar Factory. In 2013, a third expansion project started planting sugarcane at Welenchiti in the Adama district, about 42 km from the new Wonji-Shoa Sugar Factory at Dodota, on a planned area of 5,000 ha.[4] As the outgrowers in the schemes established in 2011 and 2013 had not received any income from sugarcane at the time of the data collection (mid 2013), this study only focuses on the two outgrower schemes established in 1975 and 2008.

Sugarcane land holdings per household in the schemes established in 1975 and 2008 vary between 0.2 and 6 ha. The outgrowers receive all the inputs required for sugarcane production and a down-payment for their labor from the factory and they are contractually required to sell all produced sugarcane to the factory. After harvesting the sugarcane on a plot, the factory subtracts all input costs and advances for the labor from the sugarcane revenue, and the outgrower association distributes these net revenues among all the owners of the plot.

The factory and the outgrowers have a formal contract that is renegotiated every three years. Because the land titles are held by the associations[5], individual outgrowers have no power to renew or terminate a contract at the end of the three-year contract duration, which basically means that outgrowers are in a contract of unlimited duration to grow sugarcane on their land.

3. STUDY AREA, SURVEY DESIGN AND DESCRIPTIVE STATISTICS

(a)Study area

The data for this study have been collected from agricultural households in the Adama and Bora districts in the Oromia Region, which are adjacent to each other and are located in the Awash River Basin in the Great Rift Valley of Ethiopia with similar geographical and ecological characteristics. Although the Awash River Basin accounts for only 4 to 5% of the total land suitable for irrigation, it is the most intensively utilized river basin where about half of the irrigated land in Ethiopia is currently located (Awulachew et al., 2007). The study districts are located in the upper Awash River Basin which is the source of irrigation water for many of the sampled households in the Adama district, while the sampled households in the Bora district mainly use underground water for

---

[4] For recent developments within the Ethiopian Sugar industry and a detailed description of sugarcane outgrower schemes see Wendimu et al. (2015).

[5] All land in Ethiopia is formally owned by the state and farmers only have (indirect) use rights. The individual outgrowers also have use rights for the land that they contributed to the outgrower association and they have the right to transfer the use rights through inheritance (but not through sale). Since the land titles were allocated to the outgrower associations, the outgrowers do not have the right to decide what to grow on their land, but are forced to grow sugarcane as long as this regulation remains unchanged.

irrigation. The Wonji-Shoa Sugar Factory, its plantation and the outgrower schemes examined in this study are all located in the Adama district.

Sugarcane production is the main source of income for the majority of the sampled households in the Adama district. However, in addition to sugarcane production, most of the sampled households also produce other crops through rain-fed and/or small-scale irrigated agriculture[6]. In the Bora district, from which most of the study's control group was drawn, rain-fed cereal crop production and small-scale irrigated vegetable production are the main sources of income.

Onion and tomato are the dominant crops produced under small-scale irrigation in the study areas. In 2012/2013, about 28% and 33% of the sampled households produced tomato and onion on average land areas of 0.39 ha and 0.41 ha, respectively. The productivity of vegetable crops (tomato and onion) in the study areas (Adama and Bora districts) is among the highest in the country. The average yield per hectare for tomato and onion for our sample is 24.9 tons and 25.9 tons, respectively.[7] More than half of the tomatoes and onions that are marketed in Addis Ababa and exported to neighboring countries such as Djibouti, Somalia and Yemen are produced in the Awash River Basin. Among the cereal crops produced in the study areas, teff is by far the most dominant, both in terms of the number of households involved in production and in terms of crop area. About 47% of the sampled households produce teff on an average area of 0.89 ha. Other crops produced in the area in descending order by area are maize, wheat, and haricot beans. About 11% of the sampled households produce sugarcane without contracts with a sugar factory and supply it to the local market for human consumption. Figure 1 shows the factory plantation, the outgrower schemes, and non-outgrower villages surveyed as part of this study.

(b) Survey design and sampling procedures

In order to investigate the effect of participation in the Wonji-Shoa sugarcane outgrower schemes, we conducted a survey of 364 agricultural households in the Adama and Bora districts between March and August 2013. The sample was broken into two groups, firstly outgrowers from sugarcane outgrower schemes established in 1975 and 2008 in the Adama district (n = 169), and secondly non-outgrowers (the control group) from one village in the Adama district and five villages in the Bora district (n = 195).

Schemes and villages in the Adama and Bora districts were purposely selected because: (i) at the time of data collection, the only sugarcane outgrower schemes in Ethiopia in which outgrowers had received income from sugarcane at least once were in the Adama district and (ii) the villages selected in the Adama and Bora districts are located adjacent to the sugarcane growing areas with similar geographical and ecological characteristics and similar access to irrigation. Tarmac roads pass through both study locations connecting them to the regional and national markets.

---

[6] See Wendimu and Gibbon (2014) for a definition of small-scale irrigated agriculture in the context of the study area.

[7] Beshir and Nikishawa (2012) report yields averaging 20.13 tons and 19.6 tons per hectare for tomatoes and onions, respectively, for their sample of outgrower villages (based on only 35 households). They also reported that the national average yield per hectare for tomatoes and onions in 2011 was 8.21 tons and 9.75 tons per hectare, respectively. The same study reports average net revenues per hectare for tomato and onion production of 58,940 ETB and 23,804 ETB, respectively.
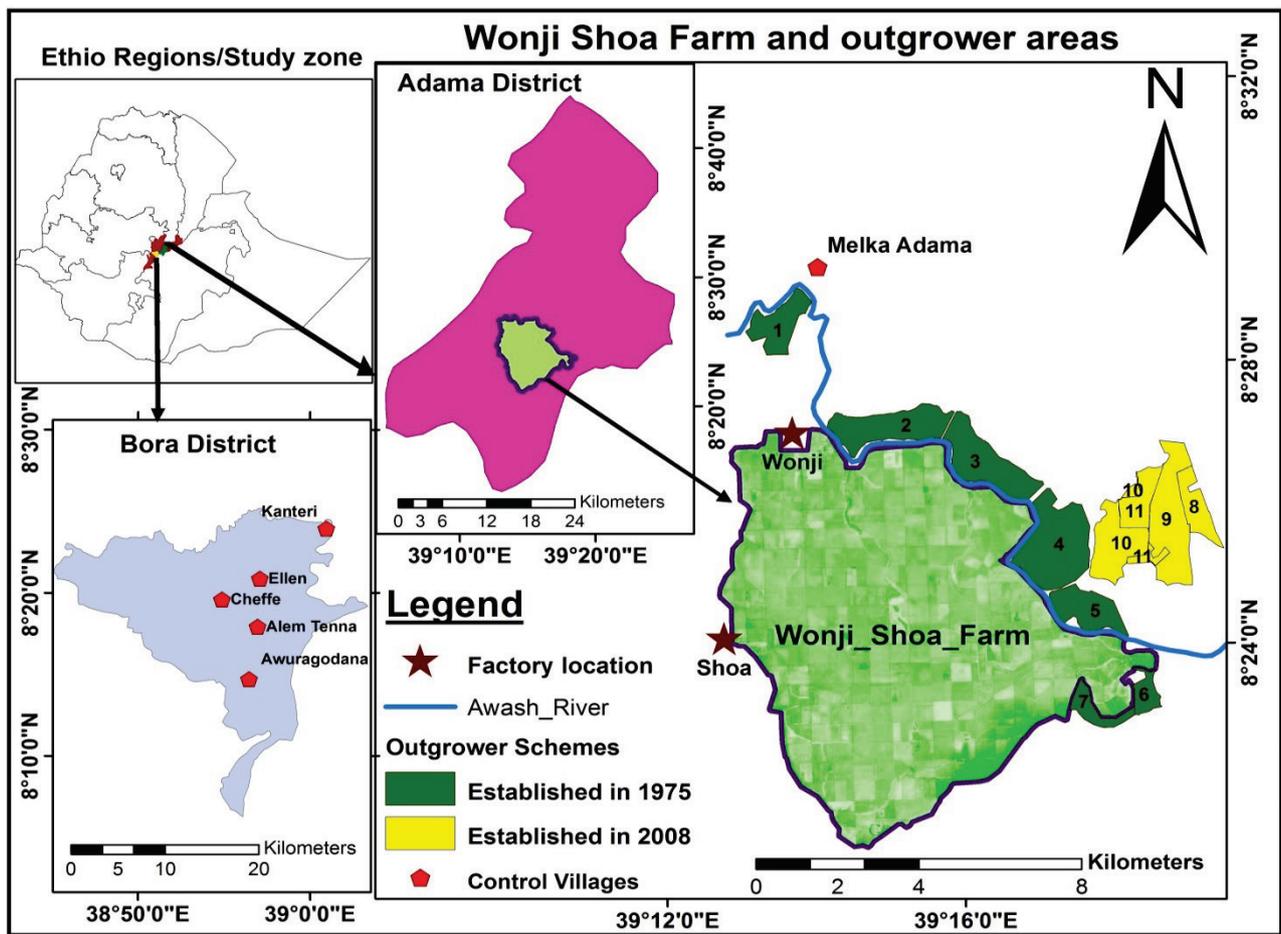
Figure 1. Map of the study districts

Nine out of eleven sugarcane outgrower associations in the Adama district are covered by this household survey. Two associations which had not received sugarcane payments for the 2011/12 season at the time of the data collection were not included in the survey. Since they are similar to the other outgrowers associations, their omission does not affect the findings of our study. The control group was randomly sampled in the non-outgrower village in the Adama district, which is located closest to the outgrower schemes and in five of the 10 villages with access to irrigation water in the Bora district.

Within the selected villages, both outgrower and non-outgrower households were randomly selected. Lists of outgrower and non-outgrower farmers were obtained from the outgrower associations and village heads, respectively, and used as sampling frames. The number of households sampled in each outgrower association or control village was determined based on the total number of farmers on each list. The sampling intensity for the outgrower and non-outgrower villages was about 7% and 10%[8], respectively.

---

[8] According to information from the Bora District Agricultural Office, about 2,000 households practice small-scale irrigated agriculture in the district.

A structured questionnaire adapted from the living standard measurement survey questionnaire designed for developing countries by the World Bank (Grosh and Glewwe, 2000) was used to gather household level data on, among other things, household demographic characteristics, agricultural land and livestock ownership, farm and household durable asset holdings and their stated values in 2013, types and volumes of crops produced, labor (family and hired) and other intermediate input use, input and output prices, and income from different sources such as farm, off-farm employment and non-employment sources, which allows us to calculate the total net income from farm and non-farm sources. The income figures are reported in net terms, i.e. the gross value minus the cost of intermediate inputs such as fertilizer, pesticides and hired labor. For the calculation of the gross value of agricultural outputs, household reported prices and the averages of prices reported by the sampled households are used for marketed and home-consumed agricultural commodities, respectively.[9] Cavendish (2002) argues that inter-household differences in household size and composition must explicitly be taken into account (i.e. households with different size and composition should be converted to a common scale) if total household income is to be used as a measure of the households´ welfare. Thus, to make the income data comparable between households, we followed Cavendish (2002) and normalized the net household income by the household size measured in adult male equivalent units (aeu). The livestock holdings were converted into tropical livestock units (TLU) based on the conversion coefficients for Sub-Saharan Africa (Chilonda and Otte, 2006).

Additionally, data were collected on the ownership of two types of household assets: (i) productive assets (irrigation water pumps, horse and donkey carts, chemical sprayers, and motor cycles), and; (ii) consumer durables (TVs, satellite dishes, sofas, DVD players and cabinets). Irrigation water pumps and sprayers are the two most important farm tools for farmers engaged in irrigated agriculture. Donkey carts are the main means of transporting harvested output from farm to home, nearby market places or to the point of tarmac road access to sell to wholesale traders. It is also a means of generating off-farm income. Horse carts are the main means of transportation from villages to towns and vice versa and thus, are an important source of off-farm income. Motorcycle ownership helps farmers to easily coordinate production activities, e.g. to pick up laborers from local labor markets in the morning, to easily move between different plots for supervision, and to collect inputs such as pesticides from nearby towns as soon as they observe pests on their crops. We considered the most common consumer durables, which were identified during the pre-test survey, and these consumer durables are considered to be wealth indicators by the local community in the study area. The current values of the assets were estimated by inquiring about the quantity held and its stated value in 2013 (i.e. we asked the household if he/she wanted to sell the asset and how much he/she could sell it for at the time of the survey).

In addition to the household survey, semi-structured interviews were conducted with members of the outgrower scheme management committees, village heads, development agents supervising the schemes, the head of the outgrowers' union, and the heads of the Wonji-Shoa Sugar Factory´s Agricultural Operations and Outgrowers' Department to get an in-depth understanding of the scheme management, the price negotiation process, scheme power dynamics and other related

---

[9] Average reported crop prices (e.g. onion, tomato, maize, teff) are similar (not statistically different from each other) across the outgrowers and non-outgrowers.

issues. The semi-structured interviews also confirmed information from outgrowers about eligibility criteria for membership of the outgrower schemes and helped to identify non-outgrower villages which had similar characteristics to the outgrowers' villages. Five focus group discussions, each consisting of six to eight participants, were also conducted in order to obtain a detailed understanding of the establishment of the schemes, the historical context of the scheme operations, and the effects of sugarcane outgrower schemes on household income and overall livelihoods. Additional information was collected through participation in meetings held between representatives of the sugar factory and representatives of the outgrowers' management committees and through direct field observations.

(c) Descriptive statistics

A summary of the descriptive statistics for the sampled households is presented in Table 1. The descriptive statistics show that sugarcane outgrowers are, on average, older than the non-outgrowers. While the household size in the scheme established in 1975 is significantly larger than the household size of non-outgrowers (at 5% significance level), there is no significant difference in household size between outgrowers established in 2008 and non-outgrowers. The total land owned by the outgrowers is significantly greater than that owned by non-outgrower farmers. Compared to outgrowers, non-outgrower farmers own significantly more irrigated land used for non-sugarcane crop production. This is mainly used for tomato and onion production, which contributes to a large share of non-outgrowers' total household income. On the other hand, most land owned by outgrowers is allocated to sugarcane production, representing about 64.4% and 57.4% of the total land owned by outgrowers in schemes established in 1975 and 2008, respectively.

Underlying these differences, the descriptive statistics show that tomato and onion production generates four to seven fold higher net income per hectare per season than sugarcane even before taking into account the frequency with which different crops are harvested. While tomatoes and onions can be produced twice per year, sugarcane takes 14-24 months to harvesting. Teff, which is produced once per year under rain-fed conditions, generates a similar net income per hectare to irrigated sugarcane production. Non-outgrowers have statistically significantly higher net incomes per adult equivalent than outgrowers.[10] While there is no significant difference in the livestock units owned by the outgrowers and non-outgrowers, asset ownership (both productive assets and consumer durables) is significantly higher for non-outgrowers compared to outgrowers. The relative difference between the asset stocks of the two groups (particularly between outgrowers in the scheme established in 1975 and non-outgrowers) is considerably greater than the relative difference between the current incomes of the two groups.

---

[10] Wendimu et al. (2015) report that Ethiopia has the second highest sugarcane yield per hectare in the world with an average yield of 145 tons per hectare for the production year 2011-2012 in the 1975 outgrowers' scheme. The price per ton of sugarcane (which the outgrowers received in 2011/2012) was 360 ETB. Considering these values, the gross revenue of sugarcane per hectare is 52,220 ETB/ha, where the outgrowers receive about one-fourth of the gross revenue.

Table 1. Descriptive statistics

Variable	1975 Outgrowers	2008 Outgrowers	Non-outgrowers
Female-headed households (%)	20.8	29.4	8.7
Age of household head (years)	48.4***	47.8***	41.3
Household heads with primary education (%)	50.5	36.8	48.7
Household heads with secondary education (%)	5.9	5.9	11.8
Household heads married (%)	74.3	73.5	87.7
Household size (persons living in household)	5.7**	4.9	4.9
Household size in adult equivalent unit (aeu)	5.0***	4.5	4.3
Household labor force (persons aged 15-65)	3.3	3.3	3.1
Number of dependent persons in the household	2.4***	1.6	1.8
Total agricultural land area owned per aeu (ha)	0.45***	0.47***	0.30
Total land area under sugarcane per aeu (ha)	0.29***	0.27***	0.00
Irrigated area used for non-sugar crops production per aeu (ha)	0.02***	0.07***	0.13
Total rain-fed land area owned per aeu (ha)	0.14	0.13	0.17
Sugarcane net income per ha (ETB) per growing period (14-24 months), including down-payments for labor	10,033	11,096	-
Onion net income per ha (ETB) per growing period (3-5 months)	40,735**	33,651***	64,445
Tomato net income per ha (ETB) per growing period (3-5 months)	69,905**	54,973	54,490
Teff net income per ha (ETB) per year	7,891***	11,228	11,143
Non-outgrower sugarcane net income per ha (ETB) per year	-	48.050	59,050
Livestock assets per aeu (TLU)	0.50	0.57	0.58
Asset stocks per aeu (ETB)	373***	1,424**	3,018
Total net income per aeu (ETB)	6,449***	8,460***	13,196
Sugarcane net income per aeu (ETB)	2,648***	2,698***	0.00
Non-sugarcane crop net income per aeu (ETB)	2,109***	4,360***	12,019
Share of vegetable income in total net income (%)	8.9***	17.8***	44.6
Share of sugarcane income in total net income (%)	43.4***	35.1***	0.00
Number of observations	101	68	195

Notes: we use t-tests to test for equal mean values between outgrowers and non-outgrowers while allowing for different variances in the two subsets, whereas *, **, and *** indicate significance levels of 5%, 1% and 0.1%, respectively. The distributions of the total income per adult equivalent unit are given in Figures A1 and A2 in Appendix A. In the production year covered by the survey (2011-2012), 100 ETB = US$ 5.66.

4. EMPIRICAL MODEL

Since outgrowers and non-outgrowers may have different characteristics in addition to their involvement in sugarcane production, and since these characteristics may contribute to the observed differences in net household income and asset stocks (see Table 1), we control for these differences when assessing the causal effect of participating in the outgrower schemes.

(a) Estimation of treatment effects

The construction of unobserved counterfactual outcomes, i.e. what would have happened to the outcome of interest if the household had not participated in the program, is the main challenge of any study that tries to estimate the causal effects of a program using observational data (Smith and Todd, 2005). The effect of a policy program or a treatment found by comparing the treated group with a control using observational data can be biased by the self-selection of the participants into the program or by some systematic decisions made by an external source in selecting and assigning participants to the treatment (Dehejia and Wahba 2002). Different statistical methods have been developed to overcome the unobserved data problem and selection bias.

Matching methods are frequently used for estimating average treatment effects. Matching methods can be used to consistently estimate the causal impact of program participation on the outcome of interest, if two crucial assumptions hold (Deheji and Wahba, 1999; Barrett et al., 2012): (i) selection into the program or treatment should be exclusively based on observable characteristics (i.e. selection on observables), and (ii) there must be a sufficient overlap in the distributions of the variables used for matching (e.g. the estimated propensity scores) between program participants and nonparticipants (i.e. the common support assumption). The main limitation of matching estimators arises from the unknown effect of unobservable characteristics that could systematically differ between participants and nonparticipants and potentially affect both participation in the program and the outcome variable(s).

In our study, matching is a suitable empirical method to examine the effects of participation in sugarcane outgrower schemes because of the following two reasons. First, participation in the sugarcane outgrower schemes is mandatory, which avoids potential biases due to farmers' self-selection into the outgrower schemes. Second, selection into these outgrower schemes is based on a clear and pre-defined eligibility criterion (i.e. having plots in the sugarcane project areas) so that the 'selection on observables' condition is satisfied. Because of these two reasons, Ordinary Least Squares (OLS) with a dummy variable for sugarcane outgrowers as an explanatory variable could give consistent estimates of the treatment effect. Regression-based methods on participants and nonparticipants using propensity scores as weights can lead to more efficient estimates (Khandker et al., 2010). For estimating average treatment effects using weighted least squares (WLS), Hirano and Imbens (2001) suggest using the inverse values of the propensity scores as weights. We use OLS and WLS as robustness checks in our estimations of the treatment effects.

(b) Model specification

Let Y_1 denote the outcome of a household that participates in the outgrower scheme and Y_0 the outcome for the same household if it did not participate in the outgrower scheme. In principle, the

average effects of participating in the sugarcane outgrower schemes on the outgrowers' total net income (total asset stocks) is the difference between their expected total net income (total asset stocks) while participating in the outgrower scheme and the expected total net income (total asset stock) if they had not participated in the scheme. Following Heckman et al. (1997) and Smith and Todd (2005), this can formally be represented as:

$$ATT = E(Y_1 - Y_0|X, P = 1) = E(Y_1|X, P = 1) - E(Y_0|X, P = 1), \qquad (1)$$

where ATT is the average effect of participation in the sugarcane outgrower scheme on the outgrowers' total net income (total asset stocks); X denotes a vector of observed individual household characteristics that may affect 'forced' participation in the outgrower scheme and/or household income (total asset stocks) and that are used as conditioning variables; and P indicates participation in the outgrower scheme ($P = 1$, if the household participates in a sugarcane outgrower scheme and $P = 0$ otherwise).

The problem with estimating the average treatment effects on the treated given in the above equations is that $E(Y_0|X, P = 1)$ is unobserved, i.e. we cannot observe the outcomes in case of non-participation for actually participating households. As suggested by Rosenbaum and Rubin (1983), this problem can be solved by substituting the expected value of the total net income of matched non-outgrowers $E(\overline{Y_0}|X, P = 0)$ for the missing (unobserved) outcomes of outgrowers ($E(Y_0|X, P = 1)$), where $E(\overline{Y_0}|X, P = 0)$ is the average predicted value of the outcome variable for observations under the counterfactual condition. Once the outgrowers and non-outgrowers are matched on their observable characteristics that affect both participation and the outcome variable, the difference in average outcome can be inferred as the effects of participation in the outgrower sugarcane production (Smith and Todd, 2005):

$$ATT = E(Y_1 - Y_0|X, P = 1) = E(Y_1|X, P = 1) - E(\overline{\overline{Y_0}}|X, P = 0) \qquad (2)$$

Estimating the causal effect of participation in outgrower sugarcane production on the total net income (total asset stocks) involves: (i) selection of the variables that should be used for matching; (ii) choice of the matching algorithm; (iii) genetic matching or estimation of the propensity scores and matching based on the estimated propensity scores; (iv) checking and testing the covariate balance for the matched data and; (v) estimation of the impacts from the matched data set.

(c) Variable selection

A crucial issue with matching methods is the selection of the variables that should be used for matching, i.e. identification of those variables that determine participation (Heinrich, 2010). The variables used for matching are highly important to justify the assumption that, once all important observed characteristics have been controlled for, non-outgrowers have, on average, the same outcome that outgrowers would have had if they had not participated in the program (Caliendo and Kopeining, 2008). In principle, the variables used in matching should simultaneously affect participation in the program and the outcome variable (Caliendo and Kopeining, 2008). Economic theory, local knowledge that guides selection into the program (eligibility criteria), and knowledge of previous research should be used when determining the variables that are to be used for matching (Lechner, 2002; Sianesi, 2004; Smith and Todd, 2005; Caliendo and Kopeining, 2008).

In our study, we use both the eligibility criterion and economic theory when choosing the variables. From interviews with the union, outgrowers associations and the factory management, we concluded that land use right at the scheme locations was the only eligibility criterion for selecting outgrowers into the schemes. The first sugarcane outgrower scheme established in 1975 was deliberately located in areas (villages) around the factory plantation, where farms had access to irrigation. However, in 2008, because of the absence of further land with access to irrigation in the vicinity of the factory plantation, villages which were close to the factory plantation and which had rain-fed land suitable for mechanization were selected to be included in the new outgrower schemes. On these plots, the Wonji-Shoa Sugar Factory installed irrigation systems when the outgrower schemes were established. All farmers who had land in the scheme areas were forced to participate in sugarcane production, unless they gave up their use right over the land (which none appeared to do). In order to account for the different income generating potentials of irrigated land and rain-fed land, we use both irrigated land and rain-fed land as two confounding variables for the matching. As the matching must be based on pre-treatment variables (or variables that are not affected by the treatment), the sugarcane land area of the households in the outgrower schemes established in 1975 is included in their irrigated land area, while the sugarcane land area of the households in the outgrower schemes established in 2008 is included in their rain-fed land area.[11] In addition to the land areas, we have included the age and gender of the household head and the labor availability in the household in the matching procedures.

Initially, we also used the household head´s education for matching outgrowers and non-outgrowers, but we excluded education in the final matching for two main reasons: (i) there is no significant (at the 5% significance level) difference in the household head's education between outgrowers and non-outgrowers in the original (unmatched) sample; (ii) without using education as one of the matching variables, the balance of most variables (e.g. land) after matching is better than the balance after matching when using education (including the balance for education; for comparison see Tables B3 and B5 in Appendix B). Livestock and asset ownership are not included in the matching because they are likely affected by participation in the outgrower schemes and are, thus, endogenous (Maertens et al., 2009).

When using the confounding variables described above for matching, the estimated treatment effects of participating in the outgrower schemes established in 1975 indicate the long-term effects on households who contributed irrigated land to the outgrower scheme, while the estimated treatment effects of participating in the outgrower schemes established in 2008 indicate the short-term effects on households who contributed rain-fed land to the outgrower scheme. In order to distinguish the short-term and long-term effects from the effects of the income generating potential of the land that the households contributed to the outgrower scheme, we estimate the (hypothetical) long-term effects on households who contributed rain-fed land to the outgrower scheme by including the sugarcane land area of households in the outgrower schemes established in 1975 in their rain-fed land area, i.e. constructing the counterfactual as if the households in the outgrower schemes established in 1975 had contributed rain-fed land to the outgrower scheme. Similarly, we

---

[11] The semi-structured interviews with the village heads and management committees of the outgrower schemes and information gathered during the pre-test survey indicate that land ownership in the study area has remained the same since the schemes were initiated. Legal restrictions on the transfer of land in Ethiopia underwrite an apparent general stability in land ownership in the country (Bezu and Holden, 2014). .

estimate the (hypothetical) short-term effects on households who contributed irrigated land to the outgrower scheme by including the sugarcane land area of the households in the outgrower schemes established in 2008 in their irrigated land area, i.e. constructing the counterfactual as if the households in the outgrower schemes established in 2008 had contributed irrigated land to the outgrower scheme.

(d) Choice of matching algorithm and propensity score estimation

The most commonly used matching algorithms in PSM are 'nearest neighbor' matching (with or without replacement and matching one treated unit to one or more control units), optimal matching and full matching. Although all the matching algorithms asymptotically give the same results with increasing sample size (Smith, 2000), the choice of the matching algorithm is important in the case of a small sample size (Heckman et al., 1997a). The choice of the matching algorithm involves making a compromise between bias and variance (Caliendo and Kopeining, 2008). For instance, by choosing only the nearest neighbor, one can minimize bias by only using observations with the most similar characteristics, but doing so leads to ignoring much information that may result in less efficient estimates.

Diamond and Sekhon (2012) argue that matching based on propensity scores does not guarantee an improvement in covariate balance post-matching, while there is also no consensus in the literature on how to best test or measure covariate balance. Thus, Diamond and Sekhon (2012) propose a genetic matching method which maximizes covariate balance through automatic searches. The merit of using genetic matching lies in the fact that it directly optimizes the distribution of the covariate balance between the treatment group and the control group, which avoids the manual process of checking the covariate balance in the matched samples and then re-specifying the propensity score model until a good match is obtained (Diamond and Sekhon, 2012). In this study, we estimate the ATT using one-to-one genetic matching and propensity score matching with one-to-one nearest neighbor matching, both with replacement. In the case of propensity score matching, the propensity scores are re-estimated after the observations outside the common support region have been excluded. Since other matching methods that use information from all samples may result in more efficient estimates, we also estimate the ATT using full matching and optimal matching as robustness checks. We use a probit model for estimating the propensity scores for the nearest neighbor matching. When conducting PSM with nearest-neighbor matching, we impose a common support region using the minima and maxima method, i.e. all observations with the propensity score smaller than the minimum and larger than the maximum in the opposite group are excluded (Becker and Ichino, 2002). Finally, we assess the covariate balance using paired t-tests and the standardized mean bias difference.[12] The empirical analysis was performed within the statistical software environment "R" (R Core Team, 2014) using the add-on packages 'Matching' for genetic matching (Sekhon, 2011) and 'MatchIt' (Ho et al., 2011) for matching using nearest neighbor matching, full matching and optimal matching.

---

[12] For nearest neighbor matching, full matching and optimal matching, we use the two-sided Fisher test to test the balances of categorical variables before and after matching.

5. EMPIRICAL RESULTS

(a) Estimation of propensity scores for nearest-neighbor matching

The results of the probit model estimation of the probability of (forced) participation in sugarcane outgrower schemes are presented in Table 2.[13] The results for the 1975 outgrower scheme reveal that ownership of irrigated land positively and significantly influenced the probability of (forced) participation, while ownership of rain-fed land had a significantly negative influence on the probability of (forced) participation in the scheme. Conversely, ownership of rain-fed land had a significantly positive influence on being (forcibly) selected into the scheme in 2008. As farmers' irrigated plots further along the Awash River were not included in the 2008 scheme, ownership of irrigated land had a significantly negative influence on (forcible) selection into the scheme. The results also show that households with heads who were older and female had a higher probability of participating in the 1975 and 2008 outgrower schemes, respectively. The size of the household's labor force had no significant effect on the likelihood of participation. The distributions of the propensity scores and the balancing properties of the covariates in the unmatched samples as well as in the matched samples using one-to-one nearest neighbor matching with replacement are given in Figures A3 and A4 in Appendix A and Tables B2 and B3 in Appendix B, respectively. As indicated in Tables B2 and B3, when one-to-one nearest neighbor matching is used, the balancing properties for some covariates are not satisfied, particularly for the 1975 outgrower.

Table 2. Estimated parameters of two Probit models for forced participation in sugarcane outgrower schemes (1975 and 2008) after excluding observations outside the common support region.

	1975 Outgrowers		2008 outgrowers	
Variables	Coefficient	standard error	Coefficient	standard error
Intercept	-2.43***	0.37	-2.18***	0.62
Female-headed household	0.01	0.28	1.44***	0.43
Age of household head (years)	0.02**	0.01	0.02	0.01
Working age household members (15-65 years)	-0.08	0.06	-0.11	0.11
Irrigated land owned (ha)	1.87***	0.24	-1.74***	0.51
Rain fed land owned (ha)	-0.28*	0.14	0.97***	0.19

Note: In a first step, two Probit models for forced participation in sugarcane outgrower schemes (1975 and 2008) are estimated for the entire sample. Then the propensity scores obtained from these estimations are used to exclude observations outside the common support region. * = Significance at 5% level, ** = Significance at 1% level, and *** = Significance at 0.1% level.

---

[13] The estimated parameters of the two Probit models for forced participation in sugarcane outgrower schemes (1975 and 2008) for the matching for estimating the "hypothetical" effects are presented in Table B1 in Appendix B.

Table 3 reports the results of the balancing test for one-to-one genetic matching with replacement.[14] These balancing tests show that for both the 1975 outgrowers and the 2008 outgrowers, more than half of the variables used for matching outgrowers and non-outgrowers have significantly different mean values before matching. However, after matching, there are no statistically significant differences in the mean values of the covariates between the two groups, while the smallest *p*-value from the paired *t*-tests after matching is 0.132.

As an additional balancing test, Table 3 also reports the percent standardized mean difference and the percent reduction in bias. Stuart and Rubin (2007) suggest that the absolute percent standardized difference in means in matched samples should be less than 25%. The percent standardized difference in means bias between outgrowers and non-outgrowers for the matched sample is less than 15% for all confounding variables. Outgrowers and non-outgrowers have a better balance after matching than pre-matching for all variables except for the proportion of household heads with primary education. As this variable has a very small initial (unmatched) mean sample bias between the participant and nonparticipant groups, it is not unusual that the sample percent reduction is quite unstable (Rosenbaum and Rubin 1985). Thus, Rosenbaum and Rubin (1985) only report percent reductions in bias for covariates with initial standardized mean differences above 20%. Since the balancing tests are satisfied for all variables after matching, the ATT can be meaningfully estimated (Rosenbaum and Rubin, 1985).

(c) Treatment effects

As there is no general consensus as to whether it is more suitable to analyze the effects on total net income and asset stocks of the household or the effects on net income and asset stocks per adult equivalent, we estimate the ATT using welfare measures both per household and per adult equivalent. These estimated ATT are provided in Table 4[15] which reports results based on both one-to-one genetic matching and nearest neighbor matching with replacement. In the following, we only discuss the results based on one-to-one genetic matching because this matching method achieved the best covariate balance after matching, and the estimated ATT based on the two matching methods are similar in most cases.

---

[14]The covariate balancing test for genetic matching for estimating the hypothetical effects is given in Table B4 in Appendix B. We report the balancing properties of the covariates in the outgrowers and non-outgrowers (based on genetic matching) where education of the household head is included in the list of matching variables in Table B5 in Appendix B.

[15]The ATT estimates based on genetic matching and nearest neighbor matching without replacement, optimal matching, full matching, OLS, and WLS are given in Table B6 in Appendix B.

Table 3. Balancing properties of covariates in the outgrowers and non-outgrowers samples before and after genetic matching

Outgrowers established in 1975		Mean				
Covariate	Sample	Treated	Control	% Bias	% Reduction in Bias	*P-value*
Female-headed household	Unmatched	0.21	0.09	29.61		0.009
	Matched	0.21	0.15	14.57	50	0.132
Age of household head (years)	Unmatched	48.41	41.33	52.12		< 0.001
	Matched	48.41	47.73	4.96	90	0.231
Household head with primary education	Unmatched	0.50	0.49	3.54		0.773
	Matched	0.50	0.48	4.93	-100	0.699
Household head with secondary school education	Unmatched	0.06	0.12	-24.64		0.078
	Matched	0.06	0.02	14.59	-33	0.134
Working age household members (15-65 years)	Unmatched	3.32	3.11	12.61		0.303
	Matched	3.32	3.19	8.57	38	0.291
Irrigated land owned (ha)	Unmatched	1.20	0.45	155.7		< 0.001
	Matched	1.20	1.17	4.38	96	0.204
Rain fed land owned (ha)	Unmatched	0.45	0.57	-22.03		0.155
	Matched	0.45	0.44	1.83	-92	0.854
Outgrowers established in 2008						
Female-headed household	Unmatched	0.29	0.09	45.08		< 0.001
	Matched	0.29	0.29	0	100	1
Age of household head (years)	Unmatched	47.79	41.33	46.29		< 0.001
	Matched	47.79	47.16	4.53	90	0.452
Household head with primary education	Unmatched	0.37	0.49	-24.61		0.086
	Matched	0.37	0.37	0	100	1
Household head with secondary school education	Unmatched	0.06	0.12	-24.64		0.111
	Matched	0.06	0.06	0	100	1
Working age household members (15-65 years)	Unmatched	3.28	3.11	10.41		0.461
	Matched	3.28	3.31	-1.84	82	0.803
Irrigated land owned (ha)	Unmatched	0.30	0.45	-39.93		0.006
	Matched	0.30	0.30	0	100	0.889
	Unmatched	1.38	0.57	93.89		< 0.001
Rain fed land owned (ha)	Matched	1.38	1.34	5.56	95	0.461

Note: the *p*-values are obtained from unpaired (paired) t-tests for the unmatched (matched) samples. The null hypothesis of these *t-tests* is mean (outgrowers) = mean (non-outgrowers). For each covariate, the standardized mean percent reduction in bias is calculated as one minus the difference in means between outgrowers and non-outgrowers after matching divided by the difference in means between outgrowers and non-outgrowers before matching (Maertens and Swinnen, 2009).

The estimation results show that participation in the 1975 outgrower scheme has a statistically and economically significant negative effect on the net income and the asset stocks (both measured per household and measured per adult equivalent), while participation in the 2008 outgrower scheme has no significant impact on the net income or asset stocks.[16] The net incomes and total asset stocks per adult equivalent of the 1975 outgrowers are on average 10,561 ETB and 3,014 ETB, respectively, less than they would have been if they had not participated in the scheme. Given the currently very low levels of income and asset stocks of the 1975 outgrowers (see Table 1), our results indicate that their income (asset stocks) would be around 2 times (10 times) higher than it is now if they were allowed to freely choose which crops to grow on their plots.

The estimated (hypothetical) short-term effects on the income of households who contributed irrigated land to the outgrower scheme are statistically significantly negative and very similar to the corresponding long-term effects. The estimated (hypothetical) long-term effects on the income of households who contributed rain-fed land to the outgrower scheme are also statistically significantly negative, but much smaller than the short-term effects and the long-term effects on households who contributed irrigated land to the outgrower scheme. As the long-term effects on income are very similar to the short-term effects when irrigated land was contributed or more negative than short-term effects when rain-fed land is contributed to the outgrower association, our results indicate that the participating households do not (or cannot) adjust their income generating activities to reduce the negative income effect in the long-term.

The hypothetical effects on asset stocks are not significantly different from zero. This indicates that participation in the outgrower schemes reduces asset stocks only in the long-term if irrigated land is contributed to the outgrower association, while the households' asset stocks are not significantly affected in the short-term (regardless of whether rain-fed land or irrigated land was contributed to the outgrower association) or if rain-fed land is contributed to the outgrower association (neither in the short-term nor in the long-term).

The estimated ATT are rather similar for the different matching methods and for using OLS and WLS (see Table B6 in Appendix B). Our findings are also consistent with the findings of previous studies that used qualitative methods (mostly based on the outgrowers' perceptions of the effect) to analyze the effect of participation in outgrower schemes, where participation is compulsory and/or the contracting agribusiness company has monopsony market power (e.g. Isaacman, 1981; White, 1997; Taruvinga, 2011).

---

[16] The perceived effect of participation in the sugarcane outgrower schemes on the households' living conditions (e.g. food security) is indicated in Figure A7 in Appendix A.

Table 4. Estimated average treatment effects of participation in sugarcane outgrower schemes on outgrowers' income and asset stocks

Dependent variable	Genetic Matching with replacement	Nearest Neighbor matching with replacement
Long-term effect when irrigated land is contributed (1975)		
Total net income per adult equivalent	-10,561***	-12,377***
Total net household income	-47,458***	-55,181***
Total asset stocks per adult equivalent	-3,014**	-3,050
Total household asset stocks	-10,113**	-11,753
Short-term effect when rain-fed land is contributed (2008)		
Total net income per adult equivalent	-2,194	-3,046***
Total net household income	-5,796	-11,652***
Total asset stocks per adult equivalent	678	2
Total household asset stocks	2,052	-893
Hypothetical long-term effect when rain-fed land is contributed		
Total net income per adult equivalent	-4,919*	-5,319***
Total net household income	-16,587**	-15,656*
Total asset stocks per adult equivalent	-135	-899
Total household asset stocks	342	-2,152
Hypothetical short-term effect when irrigated land is contributed		
Total net income per adult equivalent	-11,307***	-9,494***
Total net household income	-46,705***	-39,771***
Total asset stocks per adult equivalent	-2,659	-1,659
Total household asset stocks	-6,620	-5,306

Note: * Significance at 5% level, ** Significance at 1% level, ***Significance at 0.1% level.

(d) Sensitivity analysis

Since matching estimators are not robust to a hidden bias that might arise if there are unobserved variables, which simultaneously affect assignment on the treatment and the outcome variables (e.g. the quality of land could differ between land selected for sugarcane outgrower schemes and land not selected for sugarcane outgrower schemes, apart from access to irrigation), we follow Rosenbaum (2002) and perform a sensitivity analysis to determine the extent to which the estimated ATTs are sensitive to unobservable factors. Rosenbaum´s (2002) procedure for sensitivity analysis depends

on the sensitivity parameter Γ that measures the degree of departure from the random assignment of outgrowers into sugarcane scheme participation (Keele, 2010); in this case there is unobservable bias only if two households with the same observable characteristics have different probabilities of participating in an outgrower scheme. For the 1975 outgrowers, when Γ=1 (i.e. under the assumption that there is no hidden bias), the result is similar with the estimated ATT and is significantly different from zero at any conventional significance level for all Γ ≤ 2. The sensitivity analysis indicates that our results are insensitive to a bias (due to unobservable factors) that would double the odds of outgrowers participating in a scheme compared to the non-outgrowers. If the odds of the households participating in the 1975 outgrower scheme were twice as high as the odds of the counterfactuals, the estimated ATT would still be significant at the 0.01% significance level. Sensitivity analysis for the 2008 outgrowers also shows that the estimated ATT would still be insignificant even if the odds of the matched samples participating in the scheme differed by a factor of 2. The ATT estimates for total asset stocks per adult equivalent (both for the 1975 and 2008 outgrowers) are also insensitive to unobservable factors if the odds of the matched samples participating in the outgrower scheme differed by the same factor of 2.

6. DISCUSSION

High productivity of family labor and easy access to credit and modern technology (supplied by the sugar factory) enable the sugarcane outgrowers in Wonji-Shoa to achieve higher productivity levels than the adjacent factory plantation (Wendimu et al., 2015). However, the profitability of outgrower sugarcane production is still much lower than the profitability of alternative crops produced on irrigated plots so that (compulsory) participation in the outgrower schemes significantly reduces total household income, particularly if the outgrowers contributed irrigated land to the outgrower association. While there may be several reasons for this, we focus here on the main ones raised by outgrowers themselves during the semi-structured interviews and focus group discussions. The most important reason for the negative effect of compulsory participation in the outgrower schemes is the low sugarcane price that the Wonji-Shoa Sugar Factory pays to the outgrowers. Since the Wonji-Shoa Sugar Factory is the only buyer of sugarcane from outgrowers for industrial processing, a competitive market price for the sugarcane is unavailable.

The existing practice for setting the outgrower sugarcane price is based on the estimated average production cost per ton of sugarcane while providing some profit margin to the outgrowers. The estimation of the average production cost assumes an average sugarcane yield of 151 tons per hectare, which is higher than the average yield achieved by the factory plantation and the outgrowers (Wendimu et al., 2015). Furthermore, the union and the outgrowers' associations argue that the factory deliberately underestimates the average sugarcane production cost on outgrowers' fields in order to depress the sugarcane price. In 2013/2014, the price at which the sugar corporation sold one ton of milled sugar to wholesalers varied between 14,000 ETB and 16,000 ETB. In the same year, the price of one ton of cane was 360 ETB. With an average cane to sugar transformation ratio of 11%, the outgrowers only received between 20.5% and 23.4% of the gross value of raw sugar. Furthermore, outgrowers do not receive any payments for byproducts such as molasses,

ethanol, or electricity generated from bagasse, although the sugar factory generates income from selling these byproducts.

About 11% of the sampled households produce sugarcane without a contract with the sugar factory to supply the local 'chewing' market. The descriptive statistics (Table 1) show that the net income per hectare of sugarcane for these farmers is about five times higher than for farmers in the outgrower scheme (i.e. 53,550 ETB/ha versus 10,565 ETB/ha), although the growing period is shorter for sugarcane for chewing (about 12 months) than for sugarcane for processing (14-24 months). However, as the market for chewing cane is small, it could only absorb a very small fraction of the outgrowers' sugarcane production and its profitability would drop if the outgrowers were to supply this market. Thus, the market price for chewing sugarcane cannot be used as a suitable reference to determine the price that the outgrowers should receive for their sugarcane.

In the absence of direct pricing methods, a 'fair' price for the sugarcane produced by the outgrowers could be determined by setting the price so that outgrowers would earn approximately the same as if they were allowed to grow other crops on their sugarcane land (i.e. taking into account the opportunity cost of land). Another option would be to calculate the sugarcane price based on the prices of sugar and by-products (e.g. molasses, ethanol, electricity generated from bagasse) on the domestic or international market and to subtract the costs for processing and trading. A further option could be to make the outgrowers co-owners (e.g. shareholders) of the Wonji-Shoa Sugar Factory, so that their interests are taken into account in the factory, and their income would depend less on the sugarcane price because a low sugarcane price results in high profit payouts, while a high sugarcane price would result in low profit payouts from the sugar factory to the outgrowers. Finally, the Ethiopian government could introduce a regulation that guarantees that sugarcane outgrowers receive a sufficiently high fraction of the factory's revenue from selling raw sugar and byproducts, as has been done in other countries, e.g. 43% in Zambia, 73.5% in Zimbabwe (Shumba et al. 2011) and 70% in Thailand (Eaton and Shepard, 2001). Currently, none of these alternatives are taken into account when setting the price of sugarcane produced by the outgrowers.

The other main reason for the negative effect of participating in the sugarcane outgrower scheme on household income is the high profitability of vegetables and other crops, which the outgrowers could produce on their sugarcane land if they were not forced to participate in the sugarcane outgrower scheme. While the productivity of irrigated vegetable crops in the study area is one of the highest in the country, its marketing also benefits from excellent road access to regional and national markets, making the opportunity cost of land very high. The average rental price for irrigated land in our survey was about 10,344 ETB per hectare for one cropping season (i.e. up to six months). Thus, outgrowers in the associations that were established in 1975 who receive on average 10,033 ETB per growing period (14-24 months, see Table 1) would receive two to four times the net income they currently get from a hectare of sugarcane if they rented out their irrigated land, while they could earn additional income from other activities instead of working on their sugarcane fields. As the outgrowers in the associations established in 2008 contributed rain-fed land, which has much lower opportunity cost, participation in outgrower sugarcane production had no significant effect on the total income of these households—at least not in the short-term. Furthermore, the new access to irrigation could make them less susceptible to shocks such as drought. Thus, if the same sugarcane outgrower scheme was implemented in a location where the

opportunity cost of land is low, it may have a positive welfare impact. During the semi-structured interviews and focus group discussions, the majority of the outgrowers revealed that they would be very happy to stop producing sugarcane if they were allowed to do so without losing their land. Some outgrowers also had the opinion that sugarcane production could be profitable even compared to vegetable crops if there was a fair mechanism for price setting and transparency when determining the sugarcane production costs, neither of which is currently the case. Interviews with the outgrower associations' management committees and the union reveal that the factory does not inform the outgrower associations or the union about how it calculates about 30% of the total production costs (e.g. costs for utilities such as electricity, irrigation equipment and maintenance costs). Knowing that the outgrowers have no exit option from the scheme, the Wonji-Shoa factory insists on a sugarcane price that the outgrowers consider to be unfair and too low, but which the factory claims is fair.

Related to their low incomes from outgrower sugarcane production, an important concern for outgrowers is food insecurity. Focus group discussions both with outgrowers and non-outgrowers suggest that while food security in outgrower villages has deteriorated over time, it has improved in non-outgrower villages. The majority of outgrowers have to use more than half of their land for sugarcane production so that they have little land left for producing food crops and, thus, have to buy most of their food items from the markets. They argue that the income they get from sugarcane production (which takes most of their land and labor) is insufficient to cover the costs of basic household consumption items. As indicated in the descriptive statistics, non-outgrowers, on the other hand, allocate all of their land to food crop production. Although non-outgrowers indicate that vegetable production involves high risks (due to price fluctuations and the occurrence of pests and diseases), they argue that it is still highly profitable compared to any rain-fed production. Non-outgrowers also state that high incomes from vegetable crops help them invest in improved seeds, fertilizers and other farm implements to increase the productivity of food crops which improves their household's food security. Our analysis also shows that outgrowers who contributed irrigated land to the outgrower associations have (in the long-term) accumulated significantly smaller asset stocks, which likely has negative implications both for future household income and food security.

It is widely recognized in the literature that monopsonies and unequal power relations in outgrower schemes potentially lead to the exploitation of farmers (e.g. Isaacman, 1981; Clapp 1988; Little, 1994; Porter and Phillip-Howard, 1997; White 1997). The greatest potential for exploitation probably occurs when farmers are locked into the contract due to sizeable investments, when there are public monopsonies, i.e. where the prices are set by the government, and/or when farmers have no exit option at least in the short-term (Eaton and Shepard, 2001). The arrangements examined in the present study have very remarkable similarities to those described by White (1997), who shows that smallholder farmers who are forced to grow hybrid coconuts in Upland Java, Indonesia, struggle to ensure their livelihood. The first similarity is that, in both cases, the outgrower schemes were established on farmers' land without their consent. Secondly, in both schemes, outgrowers have no control over the price setting mechanism for their produce and there are many deductions from the final price, the source of which is not known to outgrowers. Lastly, the contracting company exercises a monopsony over the outgrowers' produce in both cases. Our findings are also similar to those of Taruvinga (2011) who documents how rural communities in Mafucula, Swaziland, were forced to participate in sugarcane outgrower production, but were unable to repay

the loans given to them to establish scheme infrastructure after seven years and remain in poverty. On the other hand, when participation is on a voluntary basis and there is no price fixing by a single buyer, most studies show that participation in contract farming/outgrower schemes has significant positive effects on household income (Buch-Hansen and Marcussen, 1982; Kennedy and Coggil, 1988).

7. CONCLUSION

The extent to which small-scale farmers benefit from outgrower schemes remains ambiguous, not least because of the high diversity of contract farming and outgrower scheme arrangements. Nonetheless, many donor agencies, nongovernmental organizations and governments of developing countries are increasingly pushing for contract farming and outgrower schemes as an instrument to commercialize small-scale farming. Their desire for such arrangements is further reinforced by the recent rush for large-scale agricultural land acquisitions in most developing countries, often described as 'land grabbing,' because contract farming and outgrower schemes can result in the same advantages as large-scale farming, but avoid its main drawback, namely the displacement of the current land-users. Using data from the oldest and some more recently established sugarcane outgrower schemes in Ethiopia, this paper examines the effects of participation in sugarcane outgrower production on total household income and asset stocks. Because outgrowers and non-outgrowers may have some differences prior to joining sugarcane outgrower schemes, we use genetic matching and propensity score matching to make the two groups comparable based on their observable characteristics. Since participation in outgrower schemes was mandatory and based on clear eligibility criteria (geographical location of the farmers' plots), the use of matching methods is justified because these methods assume that the selection is only based on observables. Our analysis takes into account the fact that the effects of participating in the outgrower scheme on the households' income and asset stocks may depend on the income generating potential of the land that the households have to devote to sugarcane production.

Our results indicate that the participation in outgrower schemes has a huge negative effect on the income and asset stocks of outgrowers whose land had a high potential for income generation due to access to irrigation prior to participation in sugarcane schemes (i.e. participants in outgrower schemes established in 1975). Further analyses of the effects of contributing irrigated land to sugarcane outgrower associations indicate that the short-run effect on income is similar to the long-run effect, but that participation only affects asset stocks in the long-run. For the outgrower schemes established in 2008, where outgrowers contributed land with a low potential for income generation due to no access to irrigation before joining the scheme, participation has no significant effects on total net income per adult equivalent or asset stocks. Further analyses of the effects of contributing rain-fed land to sugarcane outgrower associations indicate that participation may reduce income— but not asset stocks—in the longer term. Our results suggest that outgrowers who contributed irrigated land to the sugarcane outgrower association would be better off allocating their land to the production of other high value crops. This result is not surprising given the high profitability of vegetable crops compared to sugarcane to which outgrowers allocate the majority of their land. Our

estimated results are consistent across different matching algorithms and are insensitive to unobservable factors.

The external validity of our conclusion is limited to outgrower scheme arrangements where farmers are forced to participate and where the monopsony buyer has depressed the producer price. If governments encourage or even force smallholder farmers to participate in outgrower schemes and if they also want smallholders to benefit from participating in outgrower schemes, they should at least properly address the price setting issue. We have discussed various ways of ensuring 'fair' prices for outgrowers, e.g. based on outgrowers' best alternative option with the same or less risk in the absence of these schemes (i.e. the buyer should offer outgrowers a price that is equivalent to the best alternative crop in the area). Furthermore, the government could avoid the exploitation of outgrowers by establishing a clear legal framework for contracts between outgrowers and buyers. If pricing mechanisms are properly addressed by taking into account farmers' best alternatives and given that outgrowers can achieve a higher productivity than large-scale factory managed plantations (Wendimu et al., 2015), the on-going large expansion of sugarcane production using outgrower schemes in Ethiopia may benefit smallholder farmers while avoiding their displacement.

ACKNOWLEDGMENT

REFERENCES

Abadie, A. and Imbens, G., 2006. Large Sample Properties of Matching Estimators for Average Treatment Effects. Econometrica 74: 235–267.

Ameha, A., Nielsen, O., and Larsen, H., 2014. Impacts of access and benefit sharing on livelihoods and forest: Case of participatory forest management in Ethiopia. Ecological Economics, 97: 162–171

Amrouk, M., Rakotoarisoa, M. and Chang, K., 2013. Structural Changes in the Sugar Market and Implications for Sugarcane Smallholder in Developing Countries. Country Case Studies for Ethiopia and The united Republic of Tanzania. FAO Commodity and Trade Policy Research Working Paper No. 37.

Awulachew, S. B.; Merrey, D.; Kamara, A.; Koppen, B. V.; de Vries, F. P.; Boelee, E.; Makombe, G., 2005. Experiences and Opportunities for Promoting Small-scale/micro-irrigation and Rainwater Harvesting for Food Security in Ethiopia. Colombo, Sri Lanka: International Water Management Institute. IWMI Working Number 98.

Bachke, E., 2010. Do farmers' organizations enhance the welfare of small-scale farmers? Working Paper, Norwegian University of Life Sciences.

Barrett, B., Bachke, M. Bellemare, M., Michelson, H., Narayanan, S., Walker, T., 2012. Smallholder participation in contract farming: Comparative evidence from five countries. World Development, 40: 715-730.

Becker, S., and Ichino, A., 2002. Estimation of Average Treatment Effects Based on Propensity Scores. The Stata Journal, 2: 358–377.

Bellemare, M., 2012. As You Sow, So Shall You Reap: The Welfare Impacts of Contract Farming. World Development 40: 1418–1434.

Berhe, F., Melesse, A., Hailu, D., Seleshi, Y., 2013. Water use allocation modeling using MODISM in the Awash River basin. Journal of Catena, DOI: 10.1016.

Beshir, B. and Nishikawa, Y., 2012. Cost-Benefit Analysis of Small-Scale Onion and Tomato Farming in Melkassa Area: Central Rift Valley of Ethiopia. Journal of Tropical Agricultural Development 56: 143-150.

Bezu, S. and Holden, S.. 2014. Are Rural Youth in Ethiopia Abandoning Agriculture? World Development 64:259–272.

Bolwig, S., Gibbon, P., and Jones, S., 2009. The Economics of Smallholder Organic Contract Farming in Tropical Africa. World Development, 37: 1094–104.

Buch-Hansen, M. and Marcussen, H., 1982. Contract Farming and the Peasantry: Cases from Western Kenya. Review of African Political Economy, 23: 9-36.

Caliendo, M. and Kopeinig, S., 2008. Some practical guidance for the implementation of propensity score matching. Journal of Economic Surveys, 22: 31-72.

Cavendish, W., 2002. Quantitative methods for estimating the economic value of resource use to rural households. In: Campbell, B.M. and Luckert, M.K. (eds.) Uncovering the hidden harvest: Valuation methods for woodland and forest resources. People and Plants conservation series. Earthscan, London, U.K.

Chilonda P. and Otte J., 2008. Indicators to monitor trends in livestock production at national, regional and international levels. Livestock Research for Rural Development, 18 (117).

Clapp, R., 1988. Representing reciprocity, reproducing domination: ideology and the labour process in Latin American contract farming. The Journal of Peasant Studies 16: 5–39.

Cotula, L., Vermeulen, S., Leonard, R. and Keeley, J. 2009. Land Grab or Development Opportunity? Agricultural Investment and International Land Deals in Africa. London/ Rome: IIED/FAO/IFAD

Cotula, L., Oya, C., Codjoe, E., Eid, A., Kakraba-Ampeh, M., Keeley,J., Kidewa, D., Makwarimba, M., Seide, W., Nasha, O., Asare, R., and Rizzo, M., 2014. Testing Claims about Large Land Deals in Africa: Findings from a Multi-Country Study. The Journal of Development Studies, 50: 903-925.

Dehejia, R., and Wahba, S., 2002. Propensity Score Matching Methods for Nonexperimental Causal Studies. The Review of Economics and Statistics, 84: 151–161.

Dehejia, R., and Wahba, S., 1999. Causal Effects in Nonexperimental Studies: Reevaluating the Evaluation of Training Programs. Journal of the American Statistical Association, 94: 1053–1062.

Diamond A, and Sekhon J., 2013. Genetic Matching for Estimating Causal Effects: A General Multivariate Matching Method for Achieving Balance in Observational Studies. Review of Economics and Statistics, 95: 932-945.

Eaton, C. and Shepard, A., 2001. Contract farming: Partnerships for growth. FAO Agricultural Services Bulletin 145.

Ethiopian Agricultural Transformation Agency (EATA), 2012. Transforming Agriculture in Ethiopia. Annual Report, Addis Ababa, Ethiopia.

FAOSTAT, 2015. http://faostat3.fao.org/download/Q/QC/E. Accessed on 30-01-2015.

Fufa, B., Behute, B., Simons, S. and Berhe, T., 2011. Strengthening the Teff Value Chain in Ethiopia. Ethiopian Agricultural Transformation Agency, Addis Ababa, Ethiopia.

Gibbon, P., Akyoo, A., Bolwig, S., Jones, S., Lin, Y., and Rants, L., 2010. An Analysis of Organic Contract Farming Schemes in East Africa in Gibbon, P., Ponte, S., and Lazaro, E., eds, *Global Agro-food and Trade Standards: Challenges for Africa*.

Glover, D., 1984. Contract farming and smallholder outgrower schemes in less-developed countries. World Development, 12: 1143-57.

Glover, D., 1987. Increasing the benefits to smallholders from contract farming: problems for farmers´ organizations and policy makers. World Development, 15: 441-48.

Glover, D., 1990. Contract Farming and Outgrower Schemes in East and Southern Africa. Journal of Agricultural Economics, 41: 303–15.

Grosh, M., and Glewwe, P., 2000. Designing Household Survey Questionnaires for Developing Countries: Lessons from 15 Years of the Living Standards Measurement Study. New York: Oxford University Press.

Hassan, S., 2008. Development of Sugar industry in Africa. Sugar Tech 10: 197-203.

Heckman, J., Ichimura, H. and Todd, P., 1998. Matching as an econometric evaluation estimator. Review of Economic Studies 65: 261–294.

Heckman, J., Ichimura, H., and Todd, T., 1997. Matching as an Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Programme. Review of Economic Studies, 64: 605–654.

Heckman, J., smith, J. and Clements, N., 1997. Making the Most Out of Social Experiments: Reducing the Intrinsic Uncertainty in Evidence From Randomized Trials With An Application to the National JTPA Experiment, Review of Economic Studies, 64: 487-535.

Heinrich, C., Maffioli, A. and Vázquez, G., 2010. A primer for applying propensity-score matching primer for applying propensity-score matching Working paper 1005. Inter-American Development Bank, Office of Strategic Planning and Development Effectiveness (SPD).

Hirano, K., and Imbens, G., 2001. Estimation of Causal Effects Using Propensity Score Weighting: An Application of Data on Right Hear Catherization. Health Services and Outcomes Research Methodology, 2: 259-278.

Ho, D. Imai, K., King, G. and Staurt, E., 2011. MatchIt: Nonparametric Preprocessing for Parametric Causal Inference. Journal of Statistical Software 42: 1-28.

Imbens, G., 2004. Nonparametric estimation of average treatment effects under exogeneity: a review. Review of Economics and Statistics 86: 4–29.

Isaacman, A., 1981. The Mozambican cotton cooperative: the creation of a grassroots alternative to forced commodity production. Journal of African Studies Review, 25: 5- 25.

Jalan and Ravallion, M., 2003. Estimating the Benefit Incidence of an Antipoverty program by Propensity Score Matching. Journal of Business and Economic Statistics, 21: 19-30.

Jones, S., and Gibbon, P., 2011. Developing Agricultural Markets in Sub-Saharan Africa: Organic Cocoa in Rural Uganda. Journal of Development Studies, 47: 1595–1618.

Keele, L., 2010. An overview of rbounds: An R package for Rosenbaum bounds sensitivity analysis with matched data.

Kennedy, E., and Cogill, B., 1987. Income and Nutritional Effects of Sugarcane Productions in South Western Kenya. Research Report Number 63, International Food Policy Research Institute, Washington, DC.

Khandker, S., Koolwal, G.. and Samad, H., 2010. Handbook on Impact Evaluation. Quantitative Methods and Practices. The World Bank. Washington, D. C.

Kleemann, L., Abdulai, A., and Buss, M., 2014. Certification and Access to Export Markets: Adoption and Return on investment of Organic-Certified Pineapple Farming in Ghana. World Development, 64: 79-92.

Lechner, M., 2002. Some practical issues in the evaluation of heterogenous labour market programmes by matching methods," Journal of the Royal Statistical Society, A, 165: 59–82.

Little, D., 1994. Contract farming and the development question, ed. P.D. Little, and M.J. Watts. Living under contract: Contract farming and agrarian transformation in Sub-Saharan Africa. Wisconsin, The University of Wisconsin Press.

Little, D. and Watts, M., 1994. Living under Contract: Contract Farming and Agrarian Transformation in Sub-Saharan Africa. Madison, WI: University of Wisconsin Press.

Maertens, M. and Swinnen, M., 2009. Trade, Standards and Poverty: Evidence from Senegal'. World Development, 37: 161–78.

Maertens, M., Randrianarison, L., Swinnen, M., 2009. Global retail and poor farmers: Evidence from Madagascar. World Development, 37: 1728–1741.

Michelson, H., 2013. Small Farmers, NGOs, and a Walmart World: Welfare Effects of Supermarkets Operating in Nicaragua. American Journal of Agricultural Economics, 95: 628-649.

Miyata, S., Minot, N., and Hu, D., 2009. Impact of contract farming on income: linking small farmers, packers, and supermarkets in China. World Development, 37: 1781-1790.

Oya, C. 2012. Contract Farming in Sub-Saharan Africa: A Survey of Approaches, Debates and Issues. Journal of Agrarian Change 12: 1–33.

Porter, G. and Phillips-Howard, K., 1997. Comparing Contracts: An Evaluation of Contract Farming Schemes in Africa. World Development, 25: 227–38

Rosenbaum, Paul R., 2002. Observational Studies. 2nd ed. New York, NY: Springer

Rosenbaum, P. and Rubin, D., 1985. Constructing a Control Group Using Multivariate Matched Sampling Methods that Incorporate the Propensity Score. The American Statistician 39: 33–38.

Rosenbaum, P. and Rubin, D., 1984. Reducing bias in observational studies using subclassification on the propensity score. Journal of the American Statistical Association 79:516–524.

Rosenbaum, P., and Rubin, D., 1983. The Central Role of the Propensity Score in Observational Studies for Causal Effects. Biometrika, 70: 41–50.

R Core Team, 2014. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. URL: http://www.R-project.org.

Schoneveld, G.C., 2014. The geographic and sectoral patterns of large-scale farmland investments in sub-Saharan Africa. Food Policy, 48: 34-50.

Sekhon, S. 2011. Multivariate and propensity score matching software with automated balance optimization: The Matching package for R. Journal of Statistical Software, 42: 1-52.

Sianesi, B., 2004. An evaluation of the Swedish system of active labour market programmes in the 1990s. Review of Economics and Statistics 86: 133–155.

Sivramkrishna, S. and Jyotishi, A., 2008. Monopsonistic exploitation in contract farming: Articulating a strategy for grower cooperation. Journal of International Development, 20: 280–296.

Shumba, E., Roberntz, P. and Kuona, M., 2011. Assessment of sugarcane outgrower schemes for bio-fuel production in Zambia and Zimbabwe. WWF-World Wide Fund for Nature, Harare, Zimbabwe.

Singh, S., 2002. Contracting out solutions: political economy of contract farming in the Indian Punjab. World Development, 30: 1621-1638.

Smalley, R., 2013. Plantations, Contract Farming and Commercial Farming Areas in Africa: A Comparative Review. Future Agricultures Working Paper 55. Institute of Development Studies: University of Sussex.

Smith, J., 2000. A Critical Survey of Empirical Methods for Evaluating Active Labor Market Policies. Schweizerische Zeitschrift fr Volkswirtschaft und Statistik, 136: 1–22.

Smith, J., and Todd, P., 2005. Does Matching Overcome LaLonde's Critique of Nonexperimental Estimators? Journal of Econometrics, 125: 305–353.

Stuart, A. and Rubin, B., 2007. Best Practices in Quasi-Experimental Designs: Matching methods for causal inference. Chapter 11 (pp. 155-176) in Best Practices in Quantitative Social Science. J. Osborne (Ed.). Thousand Oaks, CA: Sage Publications

Taruvinga, M., 2011. Commercialising Subsistence Farmers: A Benefit of Detriment to the Poor?', MA thesis, Faculty of Humanities, University of Witwatersrand, Johannesburg.

Tiffen, M. and Mortimore, M., 1990. Theory and Practice in Plantation Agriculture. London: ODI.

Verhofstadt, E., and Maertens, M. 2014. Smallholder cooperatives and agricultural performance in Rwanda: do organizational differences matter? Agricultural Economics, 45: 39-54.

Warning, M. and Key, N., 2002. The social performance and distributional consequences of contract farming: an equilibrium analysis of the Arachide de Bouche program in Senegal. World Development, 30: 255-263.

Wendimu, M. and Gibbon, P., 2014. Labour markets for irrigated agriculture in central Ethiopia: Wage premiums and segmentation. IFRO Working Paper 2014/06, Department of Food and Resource Economics, University of Copenhagen.

Wendimu, M., Henningsen, A., and Czekaj T., 2015. Incentives and Moral Hazard: Plot Level Productivity of Factory-Operated and Outgrower-Operated Sugarcane Production in Ethiopia IFRO Working Paper 2015/02, Department of Food and Resource Economics, University of Copenhagen.

White, B. 1997. Agroindustry and contract farmers in Upland West Java. Journal of Peasant Studies 24: 100–136.

World Bank, 2007. WDR 2008. World Development Report 2008: Agriculture for Development. Washington, DC: World Bank.

APPENDIX A: SUPPLEMENTARY FIGURES
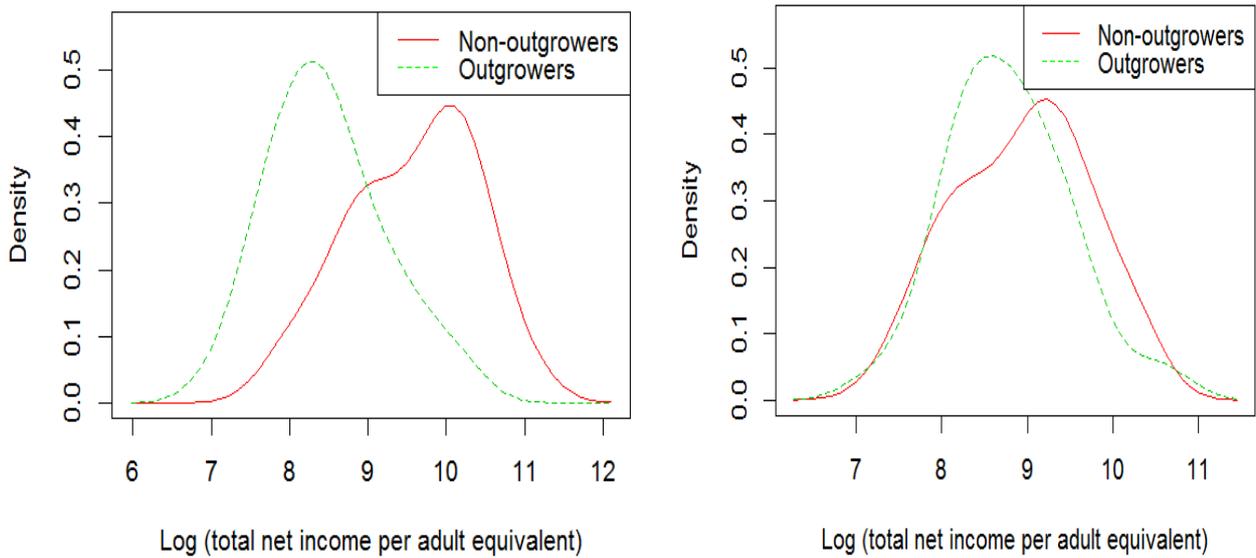
Figure A1. Distribution of total net income per adult equivalent for the 1975 outgrowers (figure on the left-hand side) and the 2008 outgrowers (figure on the right-hand side) compared to non-outgrowers (samples matched by one-to-one nearest neighbor matching with replacement)
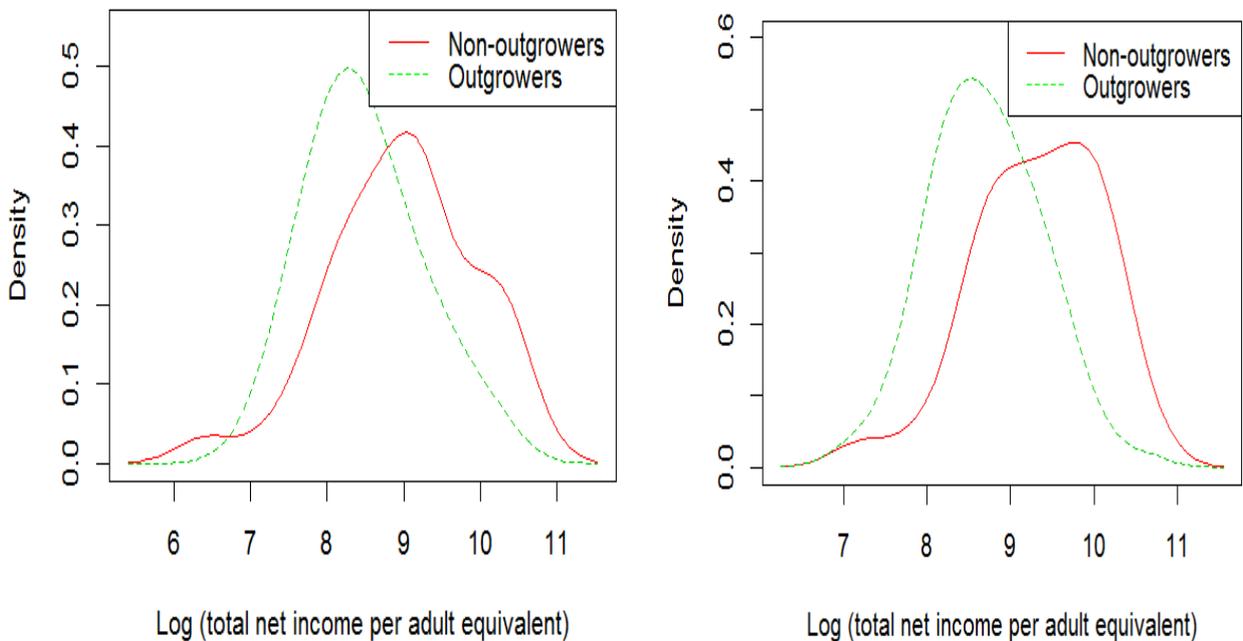
Figure A2. Distribution of (hypothetical) net income per adult equivalent for the 1975 outgrowers when rain-fed land is contributed (figure on the left-hand side) and the 2008 outgrowers when irrigated land is contributed (figure on the right-hand side) compared to non-outgrowers (samples matched by one-to-one nearest neighbor matching with replacement)
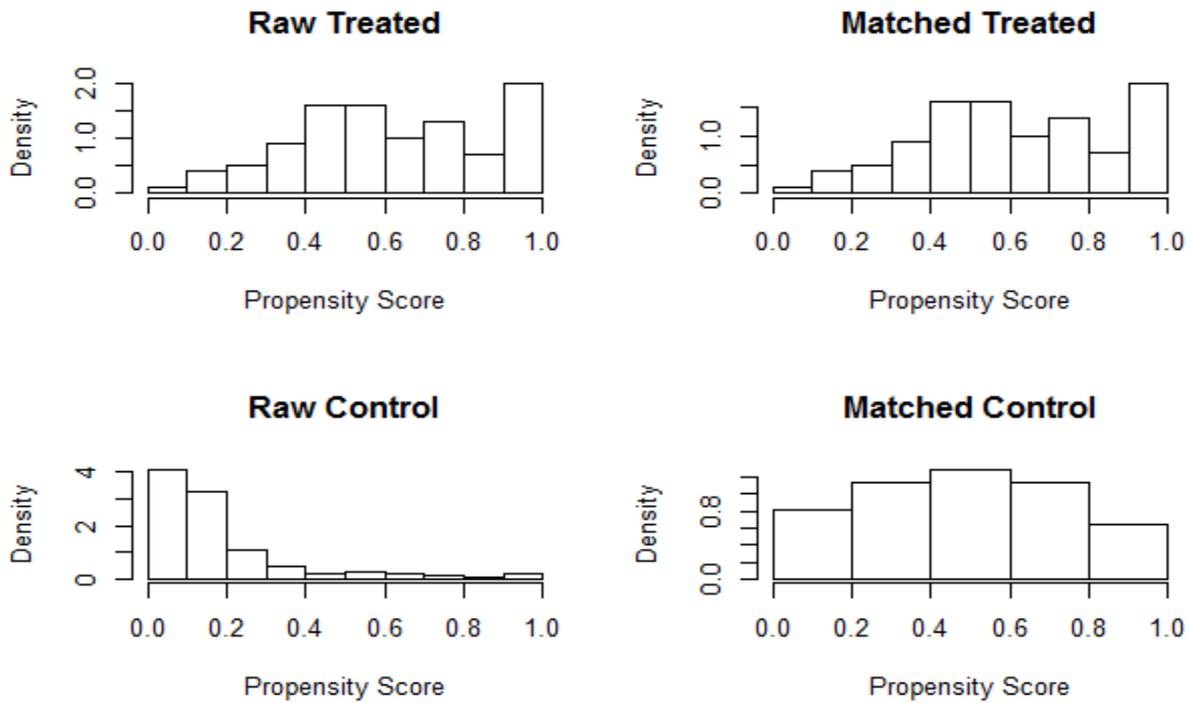
Figure A3. Distribution of propensity scores for the outgrowers and non-outgrowers before and after matching using nearest neighbor matching with replacement (for the 1975 outgrowers)
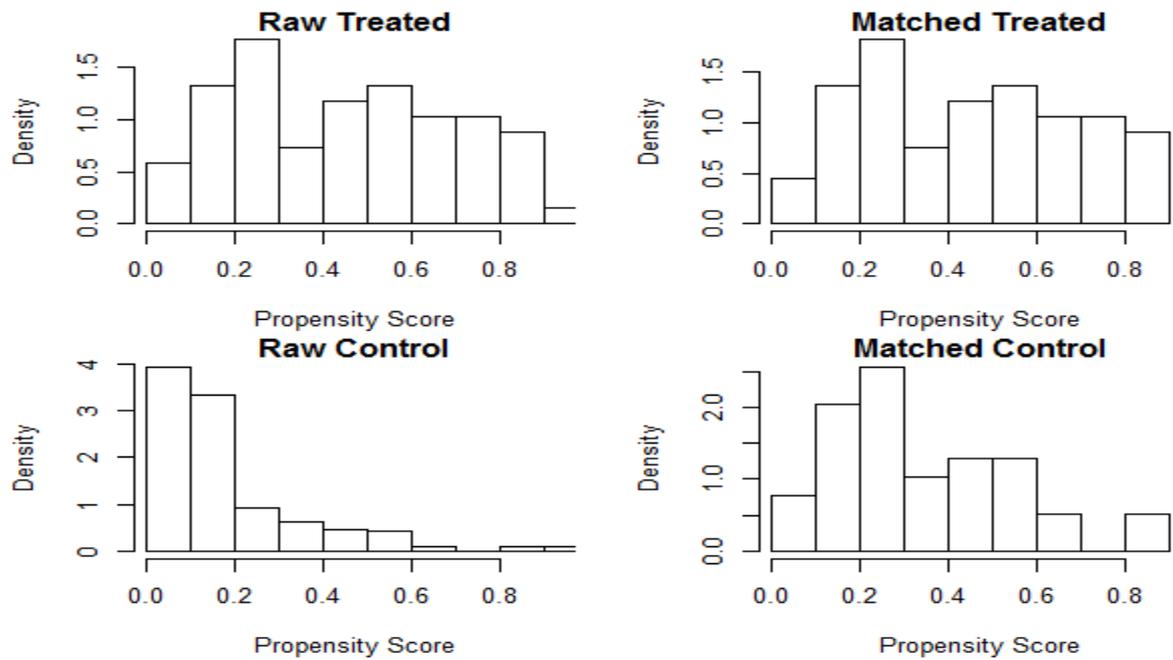
Figure A4. Distribution of propensity scores for the outgrowers and non-outgrowers before and after matching using nearest neighbor matching with replacement (for the 2008 outgrowers).
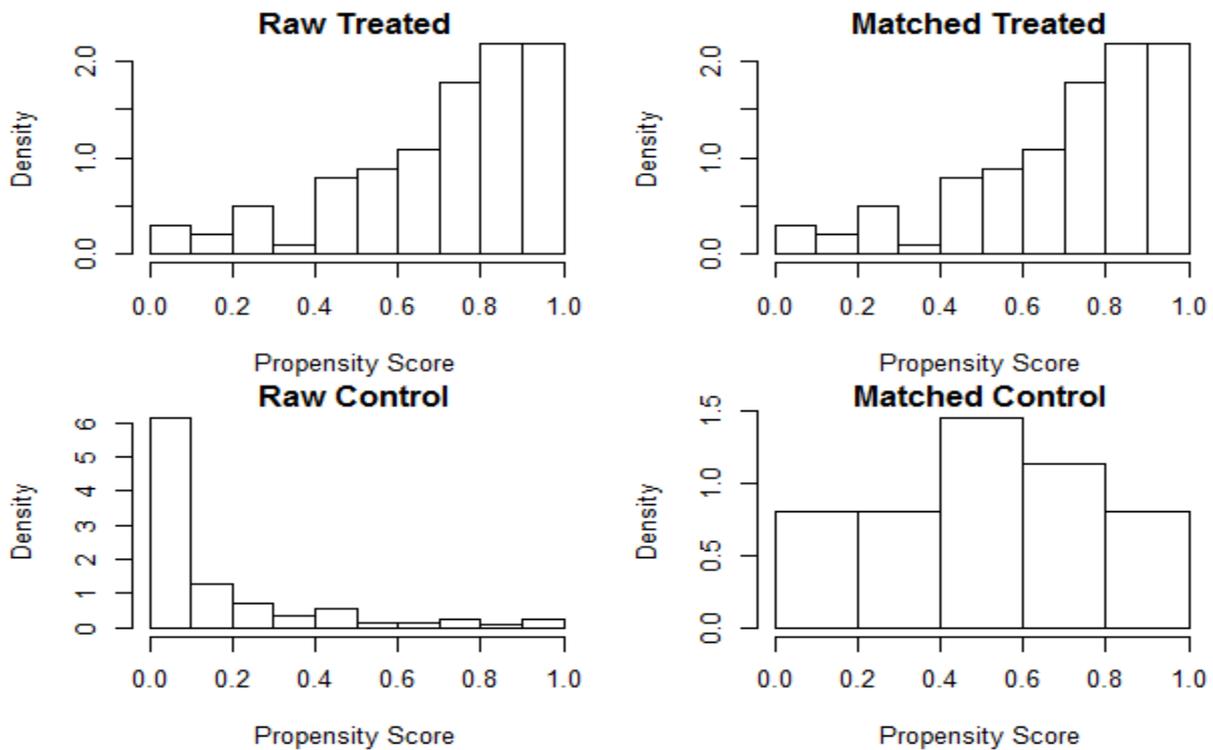
Figure A5. Distribution of propensity scores (for estimating the "hypothetical" effects) for the outgrowers and non-outgrowers before and after matching using nearest neighbor matching with replacement (for the 1975 outgrowers)
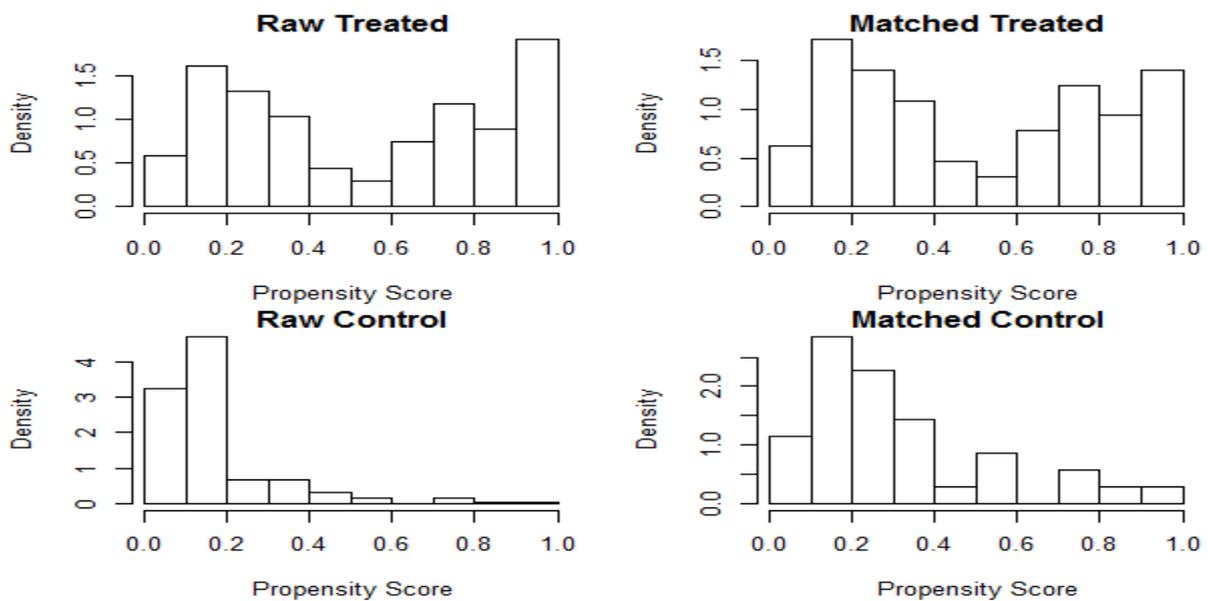
Figure A6. Distribution of propensity scores (for estimating the "hypothetical" effects) for the outgrowers and non-outgrowers before and after matching using nearest neighbor matching with replacement (for the 2008 outgrowers).
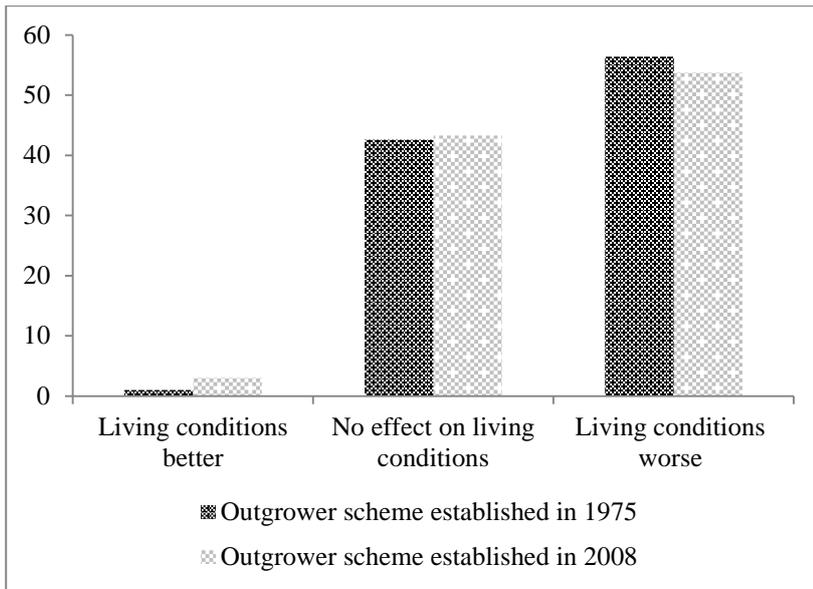
Figure A7. Outgrowers' perceived effect of participation in the sugarcane outgrower scheme.

APPENDIX B: SUPPLEMENTARY TABLES

Table B1. Estimated parameters of two Probit models for forced participation in sugarcane outgrower schemes (1975 and 2008) after excluding observations outside the common support region for estimating the "hypothetical" effects

Variables	1975 Outgrowers		2008 outgrowers	
	Coefficient	standard error	Coefficient	standard error
Intercept	-1.15***	0.38	-3.38***	0.83
Female-headed household	0.64*	0.29	1.07*	0.45
Age of household head (years)	0.01	0.01	0.02	0.02
Working age household members (15-65 years)	-0.01	0.07	0.003	0.12
Irrigated land owned (ha)	-2.72***	0.42	2.00***	0.33
Rain-fed land owned (ha)	1.04***	0.13	-0.35	0.24

Table B2. Balancing properties of covariates in the outgrowers and non-outgrowers samples before and after matching based on one-to-one nearest neighbor matching with replacement

Outgrowers established in 1975		Mean		
Covariate	Sample	Treated	Control	*P-value*
Female-headed household	Unmatched	0.21	0.09	0.005
	Matched	0.28	0.22	0.801
Age of household head (years)	Unmatched	48.41	41.33	< 0.001
	Matched	48.47	42.35	< 0.001
Household head with primary education	Unmatched	0.50	0.49	0.807
	Matched	0.51	0.58	0.541
Household head with secondary school education	Unmatched	0.06	0.12	0.148
	Matched	0.06	0.03	1
Working age household members (15-65 years)	Unmatched	3.32	3.11	0.303
	Matched	3.31	3.05	0.201
Irrigated land owned (ha)	Unmatched	1.20	0.45	< 0.001
	Matched	1.18	1.28	< 0.001
Rain fed land owned (ha)	Unmatched	0.45	0.57	0.155
	Matched	0.45	0.62	0.129
Outgrowers established in 2008				
Female-headed household	Unmatched	0.29	0.09	< 0.001
	Matched	0.29	0.23	0.489
Age of household head (years)	Unmatched	47.79	41.33	0.001
	Matched	47.65	50.48	0.194
Household head with primary education	Unmatched	0.37	0.49	0.092
	Matched	0.38	0.31	0.529
Household head with secondary school education	Unmatched	0.06	0.12	0.245
	Matched	0.06	0.05	1
Working age household members (15-65 years)	Unmatched	3.28	3.11	0.462
	Matched	3.23	3.36	0.649
Irrigated land owned (ha)	Unmatched	0.30	0.45	0.006
	Matched	0.27	0.23	0.430
Rain fed land owned (ha)	Unmatched	1.38	0.57	< 0.001
	Matched	1.36	1.35	0.934

Note: see note below Table 3.

Table B3. Balancing properties of covariates in the outgrowers and non-outgrowers samples before and after matching based on one-to-one nearest neighbor matching with replacement (for estimating the "hypothetical" effects)

| **Outgrowers established in 1975** | | Mean | | |
Covariate	Sample	Treated	Control	*P-value*
Female-headed household	Unmatched	0.21	0.09	0.005
	Matched	0.21	0.17	0.193
Age of household head (years)	Unmatched	48.41	41.33	< 0.001
	Matched	48.41	44.00	0.001
Household head with primary education	Unmatched	0.50	0.49	0.807
	Matched	0.50	0.42	0.420
Household head with secondary school education	Unmatched	0.06	0.12	0.148
	Matched	0.06	0.13	0.244
Working age household members (15-65 years)	Unmatched	3.32	3.11	0.303
	Matched	3.32	3.36	0.872
Irrigated land owned (ha)	Unmatched	0.09	0.45	< 0.001
	Matched	0.09	0.17	0.002
Rain fed land owned (ha)	Unmatched	1.55	0.57	< 0.001
	Matched	1.55	1.81	< 0.001
Outgrowers established in 2008				
Female-headed household	Unmatched	0.29	0.09	< 0.001
	Matched	0.27	0.34	0.009
Age of household head (years)	Unmatched	47.79	41.33	< 0.001
	Matched	47.23	44.17	0.173
Household head with primary education	Unmatched	0.37	0.49	0.092
	Matched	0.38	0.37	0.156
Household head with secondary school education	Unmatched	0.06	0.12	0.245
	Matched	0.06	0.09	0.530
Working age household members (15-65 years)	Unmatched	3.28	3.11	0.462
	Matched	3.34	3.02	0.189
Irrigated land owned (ha)	Unmatched	1.32	0.45	< 0.001
	Matched	1.21	1.25	0.373
Rain fed land owned (ha)	Unmatched	0.36	0.57	0.047
	Matched	0.38	0.54	0.584

Note: see note below Table 3.

Table B4. Balancing properties of covariates in the outgrowers and non-outgrowers samples before and after genetic matching (for estimating the "hypothetical" effects)

Outgrowers established in 1975		Mean			% Reduction in Bias	
Covariate	Sample	Treated	Control	% Bias		*P*-value
Female-headed household	Unmatched	0.21	0.09	29.61		0.009
	Matched	0.21	0.21	0	100	1
Age of household head (years)	Unmatched	48.41	41.33	52.12		< 0.001
	Matched	48.41	47.49	6.78	87	0.105
Household head with primary education	Unmatched	0.50	0.49	3.54		0.773
	Matched	0.50	0.46	9.85	-300	0.398
Household head with secondary school education	Unmatched	0.06	0.12	-24.64		0.078
	Matched	0.06	0.02	16.67	-33	0.156
Working age household members (15-65 years)	Unmatched	3.32	3.11	12.61		0.303
	Matched	3.32	3.44	-7.34	-34	0.460
Irrigated land owned (ha)	Unmatched	0.09	0.45	-168.3		< 0.001
	Matched	0.09	0.10	-4.13	97	0.909
Rain fed land owned (ha)	Unmatched	1.55	0.57	168.5		< 0.001
	Matched	1.55	1.47	14.5		0.101
Outgrowers established in 2008						
Female-headed household	Unmatched	0.29	0.09	45.08		< 0.001
	Matched	0.29	0.35	-12.82	92	0.494
Age of household head (years)	Unmatched	47.79	41.33	46.29		< 0.001
	Matched	47.79	46.98	5.84	99	0.187
Household head with primary education	Unmatched	0.37	0.49	-24.61		0.087
	Matched	0.37	0.31	13.72	-50	0.407
Household head with secondary school education	Unmatched	0.06	0.12	-24.94		0.111
	Matched	0.06	0.09	-14.48	-50	0.400
Working age household members (15-65 years)	Unmatched	3.28	3.11	10.41		0.461
	Matched	3.28	3.31	-1.84	-82	0.806
Irrigated land owned (ha)	Unmatched	1.32	0.45	98.39		< 0.001
	Matched	1.32	1.27	5.32	94	0.880
Rain fed land owned (ha)	Unmatched	0.36	0.57	-30.89		0.047
	Matched	0.36	0.40	-5.82	81	0.659

Note: see note below Table 3.

Table B5. Balancing properties of covariates in the outgrowers and non-outgrowers samples before and after matching based on genetic matching if education of the household is used in matching

Outgrowers established in 1975		Mean				
Covariate	Sample	Treated	Non-outgrowers	% Bias	% Reduction in Bias	*P-value*
Female-headed household	Unmatched	0.21	0.09	29.61		0.009
	Matched	0.21	0.15	14.57	50	0.132
Age of household head (years)	Unmatched	48.41	41.33	52.12		0.001
	Matched	48.41	46.29	15.60	68.6	0.047
Household head with primary education	Unmatched	0.50	0.49	3.54		0.773
	Matched	0.50	0.47	7.88	-200	0.044
Household head with secondary school education	Unmatched	0.06	0.12	-24.64		0.078
	Matched	0.06	0.03	12.50	150	0.082
Working age household members (15-65 years)	Unmatched	3.32	3.11	12.61		0.303
	Matched	3.32	3.24	4.89	62	0.462
Irrigated land owned (ha)	Unmatched	1.20	0.45	155.73		0.001
	Matched	1.20	1.15	9.99	93.3	0.050
Rain-fed land owned (ha)	Unmatched	0.45	0.57	-22.03		0.155
	Matched	0.45	0.43	2.90	116.7	0.599
Outgrowers established in 2008						
Female-headed household	Unmatched	0.29	0.09	45.08		0.001
	Matched	0.29	0.29	0	100	1
Age of household head (years)	Unmatched	47.79	41.33	46.23		0.002
	Matched	47.79	47.12	3.16	89.6	0.637
Household head with primary education	Unmatched	0.37	0.49	-24.61		0.086
	Matched	0.37	0.37	0	100	0.835
Household head with secondary school education	Unmatched	0.06	0.12	-24.94		0.111
	Matched	0.06	0.04	6.20	133.3	0.656
Working age household members (15-65 years)	Unmatched	3.28	3.11	10.41		0.461
	Matched	3.28	3.32	-2.76	23.5	0.573
Irrigated land owned (ha)	Unmatched	0.30	0.45	-39.93		0.006
	Matched	0.30	0.30	0	100	0.552
Rain-fed land owned (ha)	Unmatched	1.38	0.57	93.89		0.001
	Matched	1.38	1.35	3.88	96.3	0.671

Note: see note below Table 3.

Table B6. Estimated average treatment effects of participation in sugarcane outgrower schemes on outgrowers' income and asset stocks.

Dependent variable	GMWR	NNNM	Full Matching	Optimal Matching	OLS	WLS
Long-term effect when irrigated land is contributed						
Total net income per adult equivalent	-12,856***	-10,991***	-10,898***	-12,513***	-10,830***	-14,066***
Total net household income	-57,229***	-51,820***	-53,051***	-62,007***	-44,258***	-66,506***
Total asset stocks per adult equivalent	-5,584***	-3,015	-3,256	-3,558	-3,544***	-3,645***
Total household asset stocks	-21,777***	-13,194**	-14,600***	-13,818***	-13,880***	-15,395***
Short-term effect when rain-fed land is contributed						
Total net income per adult equivalent	-3,885*	-3,874	-4,909	-3,916	-4,405*	-1,923
Total net household income	-12,021	-15,491	-17,153***	-11,789	-16,184**	-10,314
Total asset stocks per adult equivalent	417	-379	-458	-790	-1,078	-1,489
Total household asset stocks	702	-1,901	-1,244	4,615	-4,148	-6,366
Hypothetical long-term effect when rain-fed land is contributed						
Total net income per adult equivalent	-4,989**	-4,827***	-5,627	-7,392	-5,238**	-4,933***
Total net household income	-18,871***	-16,964***	-18,005	-20,346	-18,168***	-15,155***
Total asset stocks per adult equivalent	-2,178*	-951	-643	-187	-1,47	-368
Total household asset stocks	-7,027	-3,077	-918	2,054	-4,977*	-443
Hypothetical short-term effect when irrigated land is contributed						
Total net income per adult equivalent	-7,405***	-10,049***	-9,250***	-11,59	-8,032***	-9,884**
Total net household income	-33,173***	-45,439***	-44,809***	-65,86	-36,302***	-31,685***
Total asset stocks per adult equivalent	-3,156*	-1,938	-1,688	-1,874	-1,888	-2,628**
Total household asset stocks	-11,689**	-8,314	-8,897***	-8,164	-8,953***	-8,381***

Note: GMWR (One-to-one genetic matching without replacement), NNNR (One-to-one nearest neighbor matching without replacement).