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

Mengistu Assefa Wendimu[a] · **Arne Henningsen**[b] · **Peter Gibbon**[c]

[a] Department of Sociology, University of Manitoba, Canada.

[b] Department of Food and Resource Economics, University of Copenhagen, Denmark.

[c] Danish Institute for International Studies, Denmark.

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HIGHLIGHTS

- We examine the effects of compulsory participation in sugarcane outgrower schemes
- We apply genetic and propensity score matching methods.
- Compulsory participation reduces welfare when irrigated land is contributed.
- Compulsory participation has no significant effect when rain-fed land is contributed.
- We provide several explanations and discuss policy implications.

ABSTRACT

Contract farming is often seen as a panacea for 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. 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 acquisition 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 compulsory 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. Our results indicate that compulsory participation in an outgrower scheme significantly reduces the income and asset stocks of outgrowers who contributed irrigated land to the outgrower scheme, while the effect is insignificant for outgrowers who contributed rain-fed land. We provide several explanations and discuss policy implications.

Key words: Compulsory outgrower schemes, contract farming, sugarcane, propensity score matching, 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 (Deininger et al., 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 (Deininger et al., 2011).

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-led contract farming and outgrower schemes, i.e. a variant of contract farming where government or a public-private agency is the contracting agent. In some types of outgrower schemes the government participates not only as organizer and sole buyer but also owns the land, so that it can make access to land conditional upon participation in the outgrower scheme. This was the case, for example, with the 'resettlement' schemes pioneered by the Kenya Tea Development Authority and financed by donors in the 1960s (Ruthenberg, 1966; Buch-Hansen and Marcussen, 1982; Buch-Hansen and Kieler, 1983).

In the last two decades, studies of contract farming have concentrated on examining the effects of participation in private-led contract farming schemes on smallholders' income. Outgrower schemes where access to land depends upon participation tend to be overlooked in the contemporary contract farming literature, even though they were a leading variant of contract farming until the mid-1990s (Gibbon et al., 2010), and continue to be the dominant form of contract farming for certain (usually industrial) crops in certain (mainly African) countries. As participation in private-led contract farming arrangements is typically voluntary, these arrangements need to provide positive incentives to encourage farmers to participate. Thus, it is not surprising that most existing studies find a positive effect of (private-led voluntary) contract farming on the participating households' income. In contrast, it is questionable whether outgrower schemes with compulsory participation also provide benefits for farmers because the farmers are forced to participate regardless of whether the participation is beneficial for them or not.

[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.'

In order to tackle this question, we use genetic matching and Propensity Score Matching (PSM) to analyze the effects of compulsory 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 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-Shoa 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. Arguably however, this distinction is inadequate. Public ownership of contract farming schemes is typically associated with monopsonistic, fully interlocked marketing systems and with multi-staged controls over participating farmers. But it may or may not predicate access to land upon participation in the contract. Where access to land is so predicated, the schemes in question may be termed ‘compulsory’. This is because participants lack alternative means of accessing cultivatable land, either because of landlessness, lack of capital or absence of land markets. Prior to around 1995,

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

much of the ‘contract farming’ literature focused upon schemes of this kind (see for example Glover, 1984; Little, 1994). Subsequently, they have commanded very little attention though. The agricultural liberalization policies of the 1990s meant that where contract farming schemes have arisen subsequently they have been not only led mostly by private firms but have also been mostly associated with competitive buying and less detailed controls over participants (Oya, 2012; Gibbon et al., 2010). Recognizing the diversity within contract farming arrangements, White (1997) points out that the existence of a contract 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, adding the distinction between voluntary and de facto (land access-related) compulsory participation.

Some studies (e.g. Glover, 1987; Sivramkrishna and Jyotishi, 2008) indicate that private scheme ownership tends to be associated with positive 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 into and remain in 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 participants’ self-selection, the majority of the recent empirical studies of private contract farming shows 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).

The earlier literature on compulsory outgrower schemes was mainly concerned with two issues. The first of these was their association with industrial crops, which was seen as a natural outcome of the need to supply continuous throughput for in-situ processing facilities with high investment costs (Binswanger and Rosenzweig, 1986). The second was the resemblance of conditions for outgrowers to situations of hired or even forced labor (Buch-Hansen and Marcussen, 1982; Kirk, 1987; Glover, 1990; Watts, 1994; Little, 1994). Little or none of the subsequent attention to the welfare implications of participation in contract farming was applied in this literature – although some of it observed that, despite the coercion involved, participants were neither poor nor especially disadvantaged (Buch-Hansen and Kieler, 1983; Kennedy and Cogill, 1987; Glover and Kusterer, 1990). Hence, to the best of our knowledge, the effects of compulsory participation in outgrower schemes have yet to be analyzed with quantitative methods.

(b) The Wonji-Shoa Area Sugarcane Outgrower Schemes

The Wonji-Shoa 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 after the 1960s without displacing small-scale farmers. 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. Furthermore, the farmers (and their associations) were forced to agree to the condition that the land incorporated into the outgrower schemes would be permanently used for sugarcane production that would be exclusively delivered to the Wonji-Shoa Sugar Factory.

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 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 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 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

[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.

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

costs and advances for labor from the sugarcane revenue, and the outgrower association distributes these net revenues among all the plot owners.

The outgrower schemes are run and managed by executive committees elected every three years, from and by the farmers. The factory and the outgrowers have a formal contract that is renegotiated every three years. Because of the agreement made at the establishment of the schemes, neither the individual outgrowers nor their associations have the power to terminate the 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 Adama and Bora districts in Oromia National Regional State, 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 (see Table B1 in Appendix B). 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., 2005). 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 Adama district, while the sampled households in Bora district mainly use underground water for irrigation. The Wonji-Shoa Sugar Factory, its plantation and the outgrower schemes examined in this study are all located in Adama district.

Sugarcane production is the main source of income for the majority of the sampled households in 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[5]. In 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 all 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.[6] Among the cereal crops produced in the study areas, teff is by far the most dominant,

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

[6] Beshir and Nishikawa (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.

both in terms of the number of households involved in production and in terms of crop area. About 47% of all 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 (Kebeles) surveyed in this study.

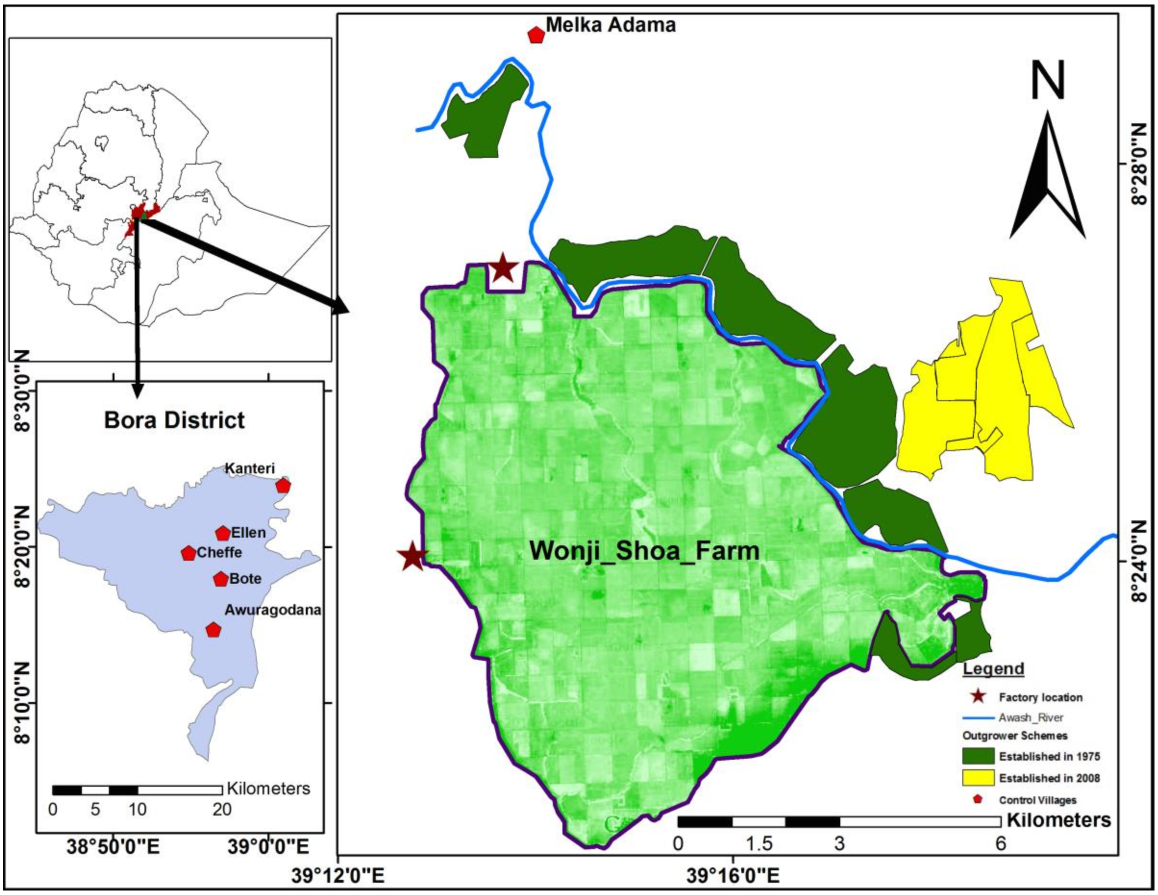

Figure 1. *Map of the study districts.*

(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. Firstly, nine sugarcane outgrower associations (five outgrower associations from the schemes established in 1975 and four outgrower associations from the schemes established in 2008) were selected. Then, 101 and 68 households were selected from the schemes established in 1975 and 2008, respectively. Secondly a total of 195 non-outgrowers (the control group) were selected from four villages in Adama district (three villages in the outgrower area and one village outside it) and five villages in Bora district.

Schemes and villages in 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 Adama district and (ii) the villages selected in Adama and Bora districts are located adjacent to the sugarcane growing areas with similar geographical and ecological characteristics and similar access to irrigation (see Table B1 in appendix B). Tarmac roads pass through both study locations connecting them to the regional and national markets.

Nine out of eleven sugarcane outgrower associations in 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 the two omitted outgrower associations are similar to the included outgrowers associations (they have the same access to technologies and the same scheme management structure and are located in the same area with other associations), their omission does not affect the findings of our study.

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%[7], respectively.

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 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.[8] 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). Livestock holdings were converted into tropical livestock units (TLU) based on the conversion coefficients for Sub-Saharan Africa (Chilonda and Otte, 2006).

[7] According to information from Bora District Agricultural Office, about 2,000 households practice small-scale irrigated agriculture in the district.
[8] Average reported crop prices (e.g. onion, tomato, maize, teff) are similar (not statistically different from each other) across the outgrowers and non-outgrowers.

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). We considered the most common productive assets and consumer durables, which were identified during the pre-test survey. These productive assets and 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 household heads 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 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 scheme management, the price negotiation process, scheme power dynamics and other related 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 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 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. While the comparison at the center of this paper is that between outgrowers and non-outgrowers, Table 1 also differentiates outgrowers established in 1975 and 2008 respectively, as this distinction plays an important role in the subsequent analysis.

Sugarcane outgrowers are, on average, older than the non-outgrowers. While household size in the scheme established in 1975 is significantly larger than 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 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 total land owned by outgrowers in schemes established in 1975 and 2008, respectively.

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: for continuous variables we use t-tests to test for equal mean values between outgrowers and non-outgrowers while allowing for different variances in the two outgrower subsets; for categorical variables we use Fisher's exact test to test whether the proportions are the same for outgrowers and non-outgrowers; *, **, and *** indicate significance levels of 5%, 1% and 0.1%, respectively. In the production year covered by the survey (2011-2012), 100 ETB = US$ 5.66. The total household income includes incomes from both agricultural and non-agricultural sources.

The descriptive statistics also show that tomato and onion production generates a 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 because non-outgrowers allocate most of their land to vegetable crops that are highly profitable in the area. While there is no significant difference in livestock units owned by 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.

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 (Dehejia 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 compulsory, which avoids potential biases due to farmers' self-selection into 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. Applying regression-based methods to participants and non-participants 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 treatment effects.

Given that the oldest outgrower scheme was established 38 years before the data collection, there could have evolved a selection bias over time, if predominantly the most capable or the least capable descendants had taken over sugarcane production from retired or deceased outgrowers.[9] Unfortunately, we do not have data to analyze the selection of the descendants who take over sugar production. As participation in the sugarcane outgrower scheme is not regarded as a relatively profitable activity (as also shown by the results of our study), it is unlikely that the most capable and most highly educated household members take over sugar cane production. On the other hand, Wendimu at al. (2015) show that the sugarcane outgrowers achieve a higher productivity than the adjacent sugarcane plantation, which suggests that outgrowers do not predominantly select the least capable descendants for taking over sugarcane production. Thus, it is unlikely that our analysis is affected by a strong selection biases due to out-migration and land inheritance practice within the households.

(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) if 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. (1997b) 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

[9] At the time of data collection, the original members of the outgrower association were still listed as members although some of them had retired or were deceased. If an original outgrower retires or passes away, his/her family members have to delegate one household member who can participate in association meetings and elections and collects the sugarcane income from the association on behalf of the retired or deceased outgrower’s family.

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):

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

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 et al., 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 scheme eligibility criterion and economic theory when choosing the variables. From interviews with the union, outgrowers associations and factory management, we concluded that land use right at 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). The interviews with the outgrower schemes' management committees also indicated that the number of outgrowers in each scheme had remained the same since their establishment. 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. The total land owned at the time of the survey in 2013 is assumed to be the same as the total land owned in 1975 and 2008.[10] 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 household heads´ 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 household heads' 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 B4 and B6 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 and Swinnen, 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 constructing the counterfactual as if the households in the outgrower schemes established in 1975 had contributed rain-fed land to the outgrower scheme, i.e. the households' sugarcane land area was

[10] The semi-structured interviews with 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).

included in their pre-1975 rain-fed land area instead of in their pre-1975 irrigated land area. Similarly, we estimate the (hypothetical) *short-term* effects on households who contributed *irrigated land* to the outgrower scheme by constructing the counterfactual as if the households in the outgrower schemes established in 2008 had contributed irrigated land to the outgrower scheme, i.e. the households' sugarcane land area was included in their pre-2008 irrigated land area instead of in their pre-2008 rain-fed land area.

(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).

Diamond and Sekhon (2013) 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 (2013) 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, 2013). 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.[11] 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), 'MatchIt' (Ho et al., 2011) for matching using nearest neighbor matching, full matching and optimal matching, and 'rbounds' (Keele, 2014) for sensitivity analysis based on Rosenbaum bounds.

[11] 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.[12] 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 B3 and B4 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 outgrowers.

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
Total number of observations	195		68	

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.

[12] The estimated parameters of the two probit models for forced participation in sugarcane outgrower schemes (1975 and 2008) used to match outgrowers and non-outgrowers for estimating the 'hypothetical' effects are presented in Table B2 in Appendix B.

(b) Genetic matching

Table 3 reports the results of the balancing test for one-to-one genetic matching with replacement.[13] 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). Since the balancing tests are satisfied for all variables after matching, the ATT can be meaningfully estimated (Rosenbaum and Rubin, 1985).

[13]The covariate balancing test for genetic matching for estimating the hypothetical effects is given in Table B5 in Appendix B. We report the balancing properties of the covariates in the outgrower and non-outgrower samples (based on genetic matching) where education of the household head is included in the list of matching variables 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
HH with primary education	Unmatched	0.50	0.49	3.54		0.773
	Matched	0.50	0.48	4.93	-100	0.699
HH 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
Total number of observations	Unmatched	101	195			
	Matched	101	34			
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
HH with primary education	Unmatched	0.37	0.49	-24.61		0.086
	Matched	0.37	0.37	0	100	1
HH 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
	Unmatched	68	195			
Total number of observation	Matched	68	41			

Note: for continuous variables the *P*-values are obtained from unpaired (paired) t-tests for equal mean values between outgrowers and non-outgrowers in the unmatched (matched) samples; for categorical variables the *P*-values are obtained from the bootstrap version of the nonparametric Kolmogorov-Smirnov (ks) test both for the unmatched samples and the matched samples. 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). HH indicates Household Head.

(c) Treatment effects

We estimate the ATT using welfare measures both per household and per adult equivalent. These estimated ATT are provided in Table 4[14] 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. The estimation results show that participation in the 1975 outgrower scheme has a statistically and economically significant negative effect on net income and asset stocks[15] (both measured per household and measured per adult equivalent), while participation in the 2008 outgrower scheme has no significant impact on 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.

In the following we investigate why participation in the outgrower scheme has large negative effects on the 1975 outgrowers but no significant effects on the 2008 outgrowers. The two groups of outgrowers differ in various ways (particularly in the type of land contributed and the duration of participation in the scheme) so that we cannot immediately attribute the differences in effects to a specific difference between the two groups. But, as explained in section 4(c), we estimate 'hypothetical effects' to investigate the causes of the different effects on the two groups. In general, the estimated (hypothetical) short-term effects on households who contributed irrigated land are very similar to the corresponding long-term effects, while the estimated (hypothetical) long-term effects on households who contributed rain-fed land are similar to the corresponding short-term effects. This indicates that the different type of land that the two groups of outgrowers contributed to the outgrower scheme is the main reason for the different effects on the two groups of outgrowers.

More specifically, 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.

[14]The ATT estimates based on genetic matching and nearest neighbor matching without replacement, optimal matching, full matching, OLS, and WLS are given in Table B7 in Appendix B.

[15] We have separately estimated the effects of compulsory participation in outgrower schemes on the outgrowers' productive asset stocks and their consumer durable asset stocks. The results (based on Genetic Matching with replacement) are presented in Table B8 in Appendix B.

[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.

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 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 ATTs are rather similar for the different matching methods and for using OLS and WLS (see Table B7 in Appendix B). Our findings are also consistent with the findings of previous studies that used qualitative methods (mostly based on 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, 1982; White, 1997; Taruvinga, 2011).

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. The distributions of the total income per adult equivalent unit are given in Figures A1 and A2 in Appendix A.

(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 $\Gamma=1$ (i.e. under the assumption that there is no hidden bias), the result is similar to the estimated ATT and is significantly different from zero at any conventional significance level for all $\Gamma \leq 2$. 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 two. 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 two.

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 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 average production costs 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 average sugarcane production costs 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 by-products such as molasses, ethanol, or electricity generated from bagasse, although the sugar factory generates income from selling these by-products.

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 by-products, 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 semi-structured interviews and focus group discussions, a majority of outgrowers indicated 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 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 (i.e. because of farmers' lack of total control over the land and irrigation infrastructure), the Wonji-Shoa Sugar Factory insists on a sugarcane price that the outgrowers consider to be unfair and too low, but which the factory claims is fair. Furthermore, lack of better outside options ─ for instance access to farmland outside the scheme area ─ or other better livelihood strategies forced the farmers to remain in the scheme.

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 inputs 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, 1982; Clapp 1988; Little, 1994; Porter and Phillip-Howard, 1997; White 1997). Indeed, Porter and Phillips-Howard (1997) clearly indicate that the outcome of contract farming significantly depends on farmers' control of land and irrigation infrastructure. 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.

7. CONCLUSION

The extent to which small-scale farmers benefit from contract farming and outgrower schemes remains ambiguous, not least because of the great diversity of scheme arrangements. Using data from the oldest and some more recently established sugarcane outgrower schemes in Ethiopia, this paper examines the effects of compulsory 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 compulsory 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 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 lack of 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. If pricing mechanisms are seriously 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 indeed benefit smallholder farmers while avoiding their displacement.

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APPENDIX

APPENDIX A: SUPPLEMENTARY FIGURES

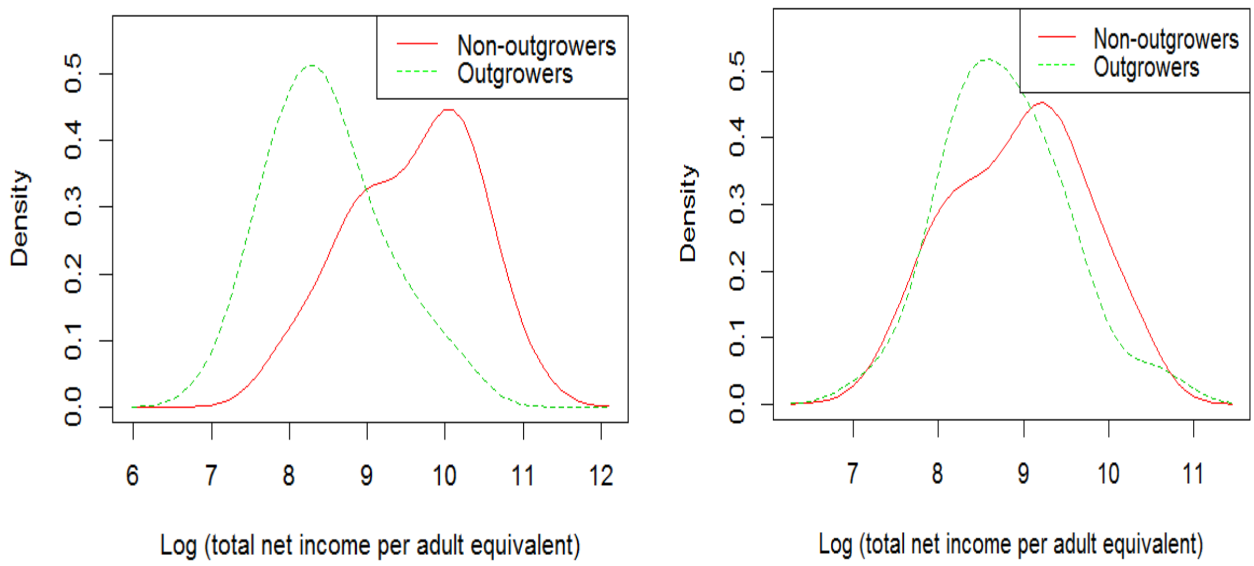

Figure A1. *Distribution of total net income per adult equivalent for the 1975 outgrowers (figure on the left-hand side) and the 2008 outgrowers (figure on the right-hand side) compared to non-outgrowers (samples matched by one-to-one nearest neighbor matching with replacement).*

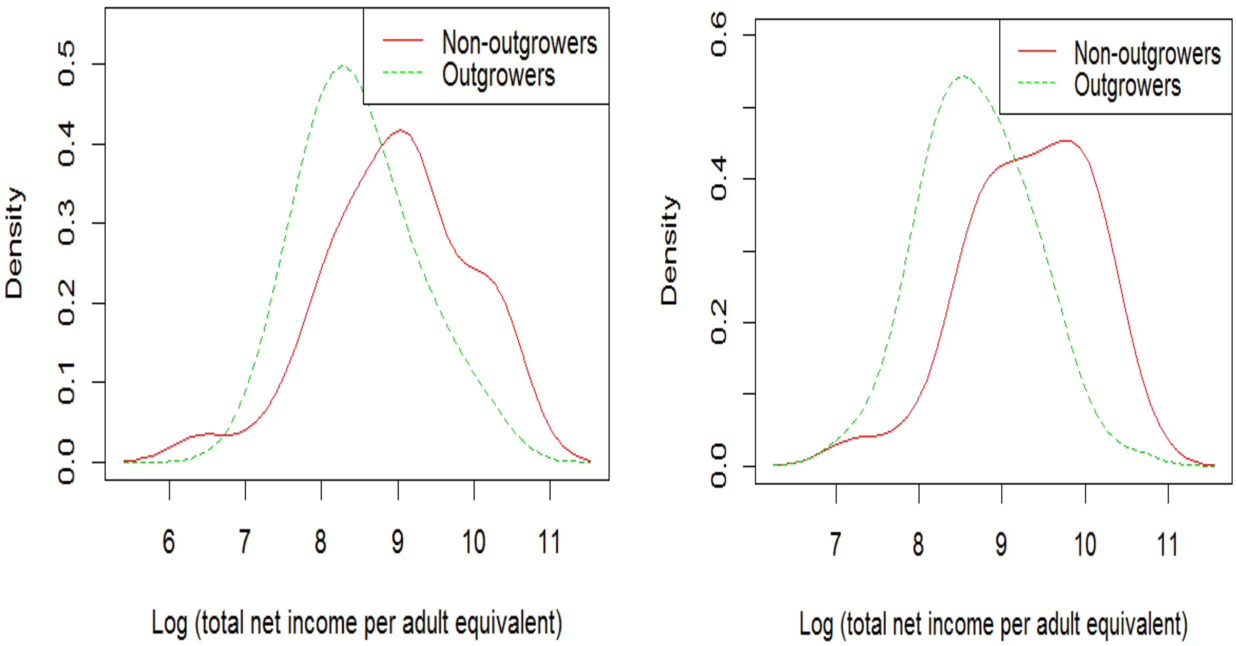

Figure A2. *Distribution of (hypothetical) net income per adult equivalent for the 1975 outgrowers when rain-fed land is contributed (figure on the left-hand side) and the 2008 outgrowers when irrigated land is contributed (figure on the right-hand side) compared to non-outgrowers (samples matched by one-to-one nearest neighbor matching with replacement).*

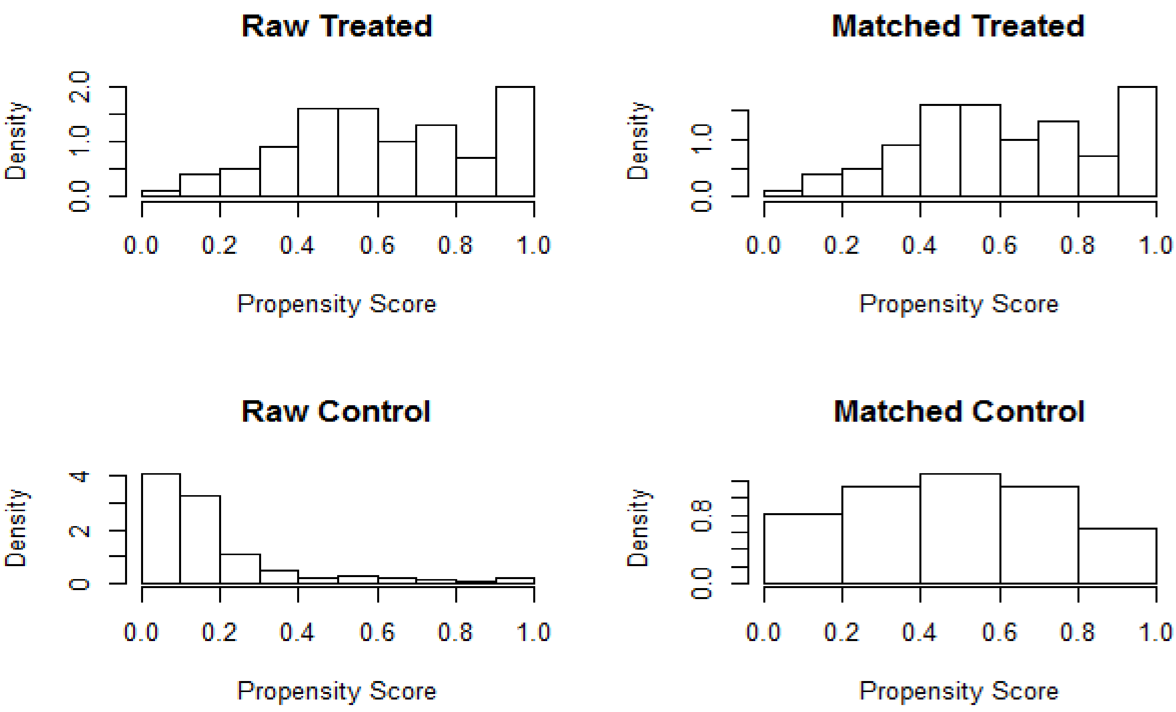

Figure A3. *Distribution of propensity scores for the outgrowers and non-outgrowers before and after matching using nearest neighbor matching with replacement (for the 1975 outgrowers).*

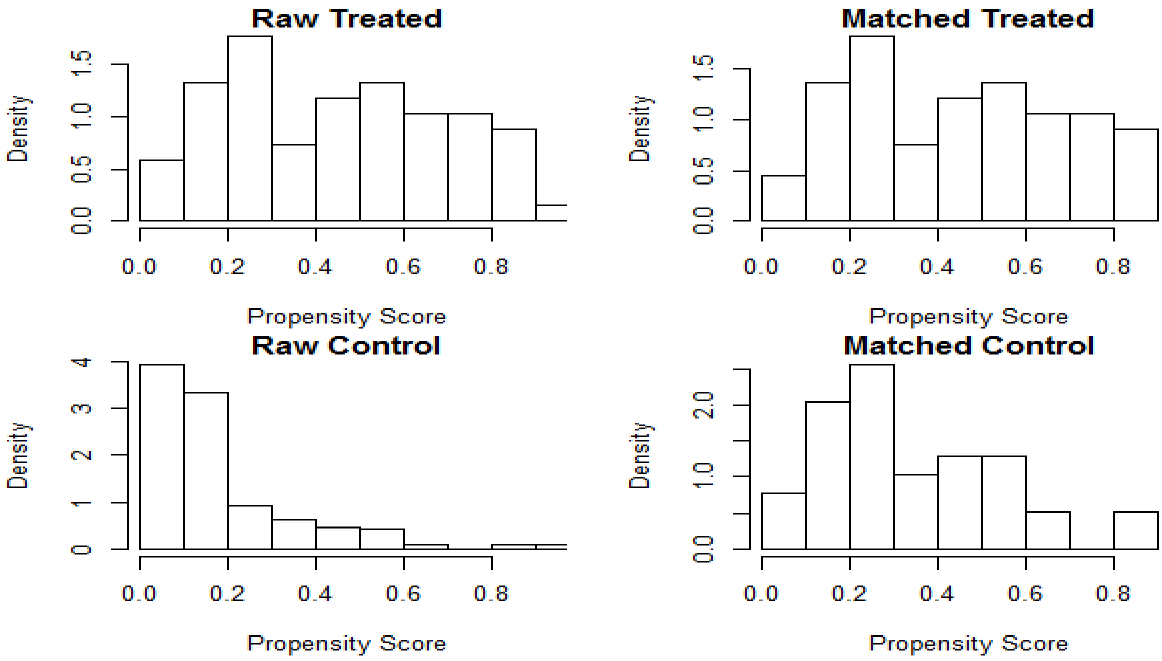

Figure A4. *Distribution of propensity scores for the outgrowers and non-outgrowers before and after matching using nearest neighbor matching with replacement (for the 2008 outgrowers).*

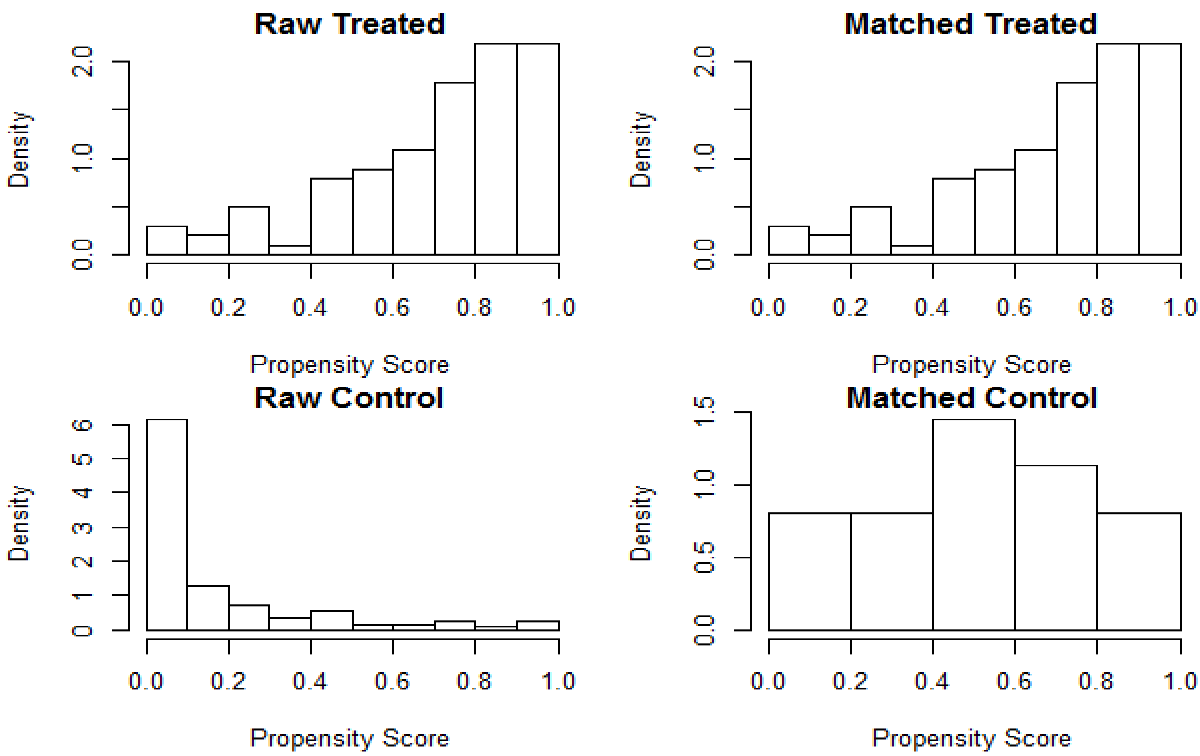

Figure A5. *Distribution of propensity scores (for estimating the "hypothetical" effects) for the outgrowers and non-outgrowers before and after matching using nearest neighbor matching with replacement (for the 1975 outgrowers).*

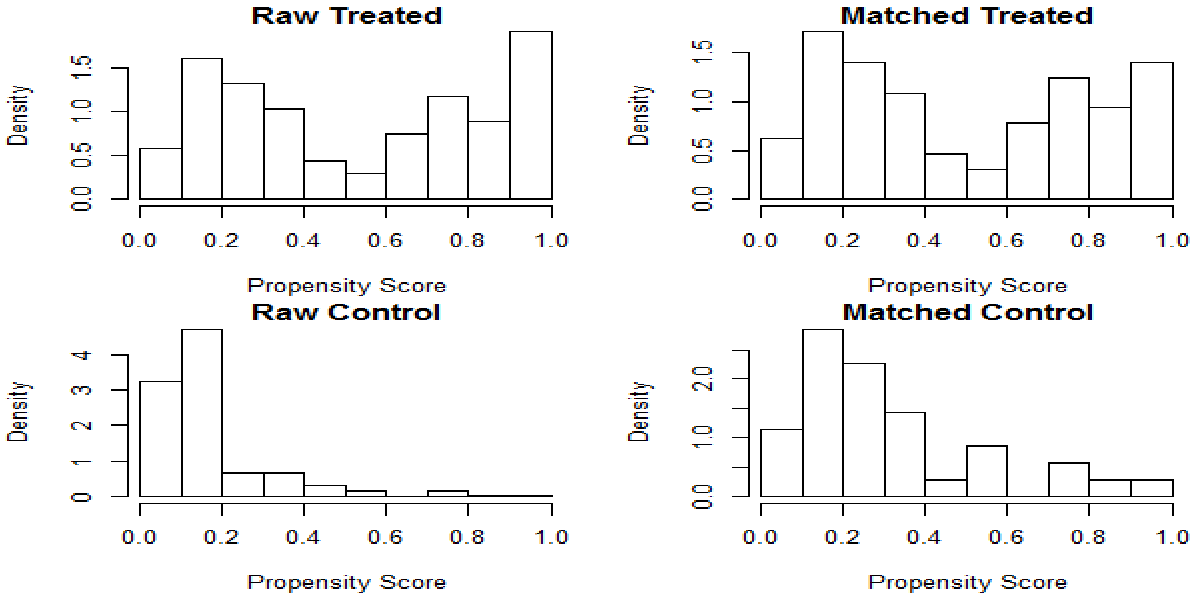

Figure A6. *Distribution of propensity scores (for estimating the "hypothetical" effects) for the outgrowers and non-outgrowers before and after matching using nearest neighbor matching with replacement (for the 2008 outgrowers).*

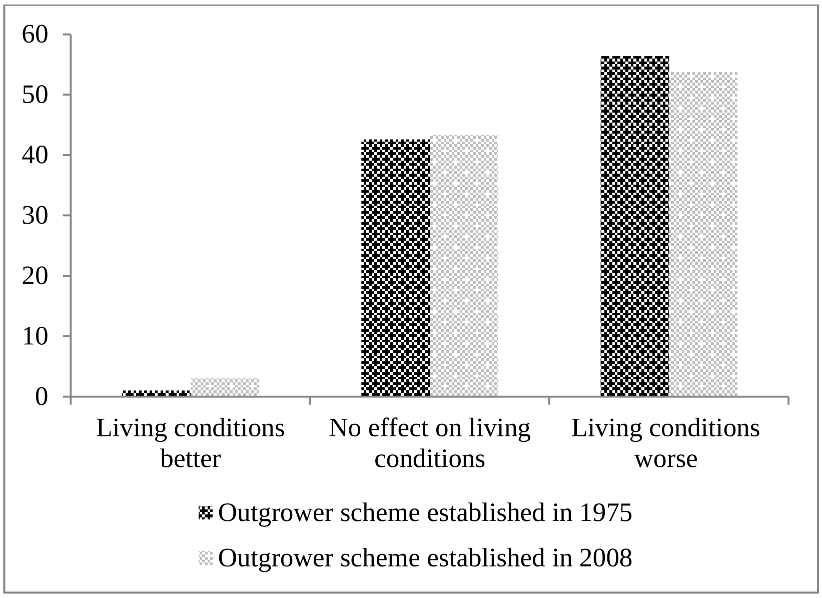

Figure A7. *Outgrowers' perceived effects of participation in the sugarcane outgrower scheme.*

APPENDIX B: SUPPLEMENTARY TABLES

Table B1. *Ecological and geographic characteristics of Adama and Bora districts.*

Geographic/ecological characteristics	Adama district	Bora district
Mean altitude	1550 m above sea level	1665 m above sea level
Mean annual rainfall	768 mm	815 mm
Mean annual minimum temperature	13°C	12.5°C
Mean annual maximum temperature	28.3 °C	28.5 °C
Dominant soil types	Sandy loam, loam and clay loam	Sandy loam, loam and clay loam
Distance from Addis Ababa	110 km	124 km
Access to tarmac road	Yes	Yes
Access to irrigation water	Yes	Yes

Table B2. *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*

	1975 Outgrowers		2008 outgrowers	
Variables	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 B3. *Balancing properties of covariates in the outgrower and non-outgrower 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
HH with primary education	Unmatched	0.50	0.49	0.807
	Matched	0.51	0.58	0.541
HH with secondary school education	Unmatched	0.06	0.12	0.148
	Matched	0.06	0.03	1
Working age household members	Unmatched	3.32	3.11	0.303
(15-65 years)	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
HH with primary education	Unmatched	0.37	0.49	0.092
	Matched	0.38	0.31	0.529
HH with secondary school education	Unmatched	0.06	0.12	0.245
	Matched	0.06	0.05	1
Working age household members	Unmatched	3.28	3.11	0.462
(15-65 years)	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 B4. *Balancing properties of covariates in the outgrower and non-outgrower 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
HH with primary education	Unmatched	0.50	0.49	0.807
	Matched	0.50	0.42	0.420
HH with secondary school education	Unmatched	0.06	0.12	0.148
	Matched	0.06	0.13	0.244
Working age household members	Unmatched	3.32	3.11	0.303
(15-65 years)	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
HH with primary education	Unmatched	0.37	0.49	0.092
	Matched	0.38	0.37	0.156
HH with secondary school education	Unmatched	0.06	0.12	0.245
	Matched	0.06	0.09	0.530
Working age household members	Unmatched	3.28	3.11	0.462
(15-65 years)	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 B5. *Balancing properties of covariates in the outgrower and non-outgrower samples before and after genetic matching (for estimating the 'hypothetical' effects)*

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	0.21	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
HH with primary education	Unmatched	0.50	0.49	3.54		0.773
	Matched	0.50	0.46	9.85	-300	0.398
HH with secondary school	Unmatched	0.06	0.12	-24.64		0.078
Education	Matched	0.06	0.02	16.67	-33	0.156
Working age household members	Unmatched	3.32	3.11	12.61		0.303
(15-65 years)	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
HH with primary education	Unmatched	0.37	0.49	-24.61		0.087
	Matched	0.37	0.31	13.72	-50	0.407
HH with secondary school	Unmatched	0.06	0.12	-24.94		0.111
Education	Matched	0.06	0.09	-14.48	-50	0.400
Working age household members	Unmatched	3.28	3.11	10.41		0.461
(15-65 years)	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 B6. *Balancing properties of covariates in the outgrower and non-outgrower 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
HH with primary education	Unmatched	0.50	0.49	3.54		0.773
	Matched	0.50	0.47	7.88	-200	0.044
HH 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
HH with primary education	Unmatched	0.37	0.49	-24.61		0.086
	Matched	0.37	0.37	0	100	0.835
HH 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 B7. *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	-1,471	-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).

Table B8. *Estimated average treatment effects of participation in sugarcane outgrower schemes on outgrowers' productive and consumer durable asset stocks (based on* Genetic Matching with replacement)

Dependent variable	Average treatment effects
When irrigated land is contributed (1975)	
Total productive asset stocks per adult equivalent	-3,286***
Total productive asset stocks per household	-6,826***
Total consumer durable asset stocks per adult equivalent	-1,051*
Total consumer durable asset stocks per household	-1,963**
When rain-fed land is contributed (2008)	
Total productive asset stocks per adult equivalent	547
Total productive asset stocks per household	1,660
Total consumer durable asset stocks per adult equivalent	131
Total consumer durable asset stocks per household	392

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