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IMPACT OF AGRICULTURAL COOPERATIVES ON SMALLHOLDERS' TECHNICAL EFFICIENCY: EVIDENCE FROM ETHIOPIA

Gashaw Tadesse Abate*, Gian Nicola Francesconi** and Kindie Getnet***

Abstract

Using household survey data from Ethiopia, this paper evaluates the impact of agricultural cooperatives on smallholders' technical efficiency. We utilize propensity score matching to compare the average difference in technical efficiency between cooperative farmers and similar independent farmers. The approach assumes exogenous cooperative formation and similar farm technology across households. The results show that agricultural cooperatives are effective in providing support services that significantly contribute to members' technical efficiency. These results are found to be insensitive to hidden bias and consistent with the idea that agricultural cooperatives enhance members' efficiency by easing access to productive inputs and facilitating extension linkages. Based on the findings, increased participation in agricultural cooperatives should further enhance efficiency gains among smallholder farmers.

Keywords

Agricultural cooperatives, smallholder farmers, technical efficiency, Ethiopia.

JEL classification

Q12, Q13, Q16.

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1. Introduction

Enhancing productivity and commercialization among smallholder farmers is widely perceived as a key strategy for rural development, poverty reduction, and food security in Sub-Saharan Africa (World Bank, 2008). For productivity gains to be achieved, smallholder farmers need to have better access to technology and improve their technical efficiency. It is important for smallholders to have easy access to extension services in order to optimize on-farm technical efficiency and productivity, given the limited resources available. While the private sector is gradually emerging as a contender, the public sector remains the major provider of extension services in most of these countries (Venkatesan and Kampen, 1998). A third option for providing services to smallholder farmers is agricultural cooperatives, which serve the dual purpose of aggregating smallholder farmers and linking them to input and output markets (Coulter et al., 1999; Davis, 2008).

Given that agricultural systems in Sub-Saharan Africa are typically fragmented into a myriad of small or micro farms over vast and remote rural areas, the role of agricultural cooperatives has become increasingly important (Wanyama et al., 2009). Despite the turbulent history sometimes associated with post independence and highly centralized governance regimes, agricultural cooperatives are nowadays omnipresent throughout the sub-continent. In recent days considerable public development programs or private initiatives are channeled through cooperatives in order to overcome prohibitive transaction and coordination costs (Pingali et al., 2005). However, it is still empirically unclear and highly contested whether these collective organizations can deliver and live up to their promises. Given the prominence of agricultural cooperatives, this is an important policy question for many African countries.

Since the downfall of the *Derg* regime in 1991, agricultural cooperatives in Ethiopia have become an integral part of the national strategy for agricultural transformation (Ministry of Finance and Economic Development, 2006). With varying degrees of success, agricultural cooperatives are longstanding and widespread throughout the country (Bernard et al., 2008; Bernard and Spielman, 2009; Francesconi and Heerink, 2010; Francesconi and Ruben, 2007; Getnet and Tsegaye, 2012; Tigist, 2008). The recently established Agricultural Transformation Agency (ATA) has also strongly asserted agricultural cooperatives as preferential institutions for moving smallholders out of subsistence agriculture and linking them to emerging input and output markets. In conjunction with promotional activities by the National Cooperative Agency, this effort has resulted in considerable growth both in number of agricultural cooperatives and the services they provide to their members. In June 2012, the majority of both the 400,000 primary cooperatives and the 200 cooperative unions in the country were agricultural cooperatives engaged in input and output marketing.

By 2005, agricultural cooperatives had commercialized more than 10 percent of the marketable surplus in Ethiopia (Bernard et al., 2008). In recent years they are the major suppliers of improved seeds and chemical fertilizer for all farm households (Ministry of Agriculture and Rural Development, 2010: unpublished). While their role in agricultural inputs adoption for productivity growth is widely recognized (Abebaw and Haile, 2013; Spielman et al., 2011), the impact of technical efficiency gains among their members remain unproven. Whether cooperative members are technically more efficient than non-members is an open question. Agricultural cooperatives, as producer organizations, are mandated to supply inputs together with providing embedded support services and for facilitating farmer linkage with extension service providers; hence, members are expected to be technically more efficient.

This paper aims to answer this question by comparing cooperative members and similar independent farmers within the same *kebeles*[1] (in order to reduce potential differences in technology and agro-ecology in which this procedure tempers possible diffusion effects). This approach, which compares members and non-members within the same *kebeles* in which the agricultural cooperatives operate, enables us to precisely capture the efficiency gains from membership, since members receive benefits from dividends, information, and extension services that are embedded in new technologies and have prior access to inputs, which are directly linked with technical efficiency gains.

We used the Stochastic Production Frontier (SPF) function model to measure the technical efficiency of sampled farm households, as it is effective in estimating the efficiency score of households that account for factors beyond the control of each individual producer (Coelli et al., 2005; Kumbhakar and Lovell, 2000). After estimating the technical efficiency score, we applied Propensity Score Matching (PSM) techniques to estimate the impact of membership in agricultural cooperatives on technical efficiency, drawing on the approaches of Bernard et al. (2008), Francesconi and Heerink (2010) and Godtland et al. (2004). Comparing them with the results obtained from parametric estimation using Ordinary Least Squares (OLS) further checked the robustness of the PSM estimations obtained from alternative matching algorithms. Moreover, in order to understand the sensitivity of our results to possible bias on unobservable covariates, we conducted Rosenbaum Bounds Sensitivity Analysis to detect the likelihood of hidden bias.

Our results consistently show a positive and statistically significant impact of membership in agricultural cooperatives on technical efficiency at the farm level. On average, we found about a five percent difference in technical efficiency between cooperative members and non-members. The results suggest that member households are in a better position to obtain maximum possible outputs from a given set of inputs. The results are insensitive for a hidden bias that would double the odds of participation in cooperatives and they are consistent with the idea that agricultural cooperatives enhance members' efficiency by providing easy access to inputs, information, and embedded support services.

The rest of paper is organized as follows: section 2 highlights the history and recent development of agricultural cooperatives in Ethiopia. Section 3 presents the data source and descriptive statistics of the variables used in the analysis. Section 4 presents the research methodology, including discussion of the empirical strategy, estimation procedure of the propensity scores and estimation of household technical

[1] *Kebele* is the smallest rural administrative unit in Ethiopia.

efficiency scores. Section 5 reports the results and section 6 concludes by discussing the main findings.

2. Agricultural cooperatives in Ethiopia

Historically, agricultural cooperatives have played an important role all over the world in providing market access, credit and information to producers. In particular, agricultural cooperatives in the United States and Western Europe have played an important economic role in providing competitive returns for independent farmers (Chaddad et al., 2005). Agricultural cooperatives in those countries were established as service providers and were primarily aimed at countervailing the market power of producers' trading partners, preservation of market options and reduction of risk through pooling. They have also been accorded with a range of public policy supports that has encouraged their market coordination role in agri-business (Staatz, 1987 and 1989).

In Ethiopia, however, the tradition of agricultural cooperatives was completely different from the western type of agricultural cooperatives from the initial days of establishment to the socialist regime. During the imperial regime (1960s-1974), a period during which cooperatives were started, agricultural cooperatives were setup in the form of cooperative production or agricultural collectives to jointly produce commercial and industrial crops (i.e., coffee, tea and spices). They were not in a position to operate efficiently due to unenforceability of efforts, inequitable incentives, higher agency costs, and slow and centralized decision-making, which are inherent problems of collective production[2] (Deininger, 1995).

During the socialist regime (1974-1990) as well agricultural cooperatives continued to be extended arms of the state and were used primarily as instruments of the government in order to control the agricultural sector and prevent the rise of capitalistic forms of organization (Rahmato, 1990). There were two types of agricultural cooperatives during this period: production cooperatives engaged in collective production and service cooperatives handling modern inputs, credit, milling services, selling of consumer goods, and purchasing of farmers produce. Production cooperatives were expected to operate over 50 per cent of the nation's cultivable land in the same fashion of joint production and were believed to be more cost-effective (Rahmato, 1994). However, ill-conceived policies coupled with shirking by coerced farmers resulted in lower output and underutilization of scale and deployed labors by cooperatives as compared to individual farmers. Besides, forced formation and routine intervention from the state agents are critical factors, which contributed to the poor record of agricultural cooperatives during this regime (Rahmato, 1993).

Subsequently, when the new mixed economic system was introduced in 1991 farmers were given the choice to work on commonly or individually owned land; the past negative experience led most of the farmers to reallocate common lands to individual

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[2] See Deininger (1995) for complete historical accounts on the inefficiencies of cooperative production systems as compared to agricultural cooperatives providing services (marketing, credit and information) to independent farmers in Cuba, Vietnam, Nicaragua, Peru and Ethiopia in terms of utilization of economies of scale, innovation, equity and provision of public goods.

holdings, which eventually led to the collapse of most production cooperatives (Abegaz, 1994). During the transition period, despite the efforts made to create an enabling environment for agricultural cooperatives through the issuing of new regulations[3], most of them continued to be burgled by individuals and others downsized due to competition from the private traders following trade liberalization (Kodama, 2007; Rahmato, 1994). In general, prior to 1990 agricultural cooperatives in Ethiopia were 'pseudo' cooperatives both in their undertakings and membership.

During the late 1990s, the government of Ethiopia revived its interest in cooperatives and they become part and parcel of the country's agriculture and rural development strategy (Getnet and Tsegaye, 2012; Ministry of Finance and Economic Development, 2006). In particular, the government strongly promoted agricultural cooperatives to encourage smallholders' participation in the market (Bernard et al., 2008). As proclaimed in the new legal framework, this new wave of cooperative organizations was thought to be different from previous cooperative movements. Although externally induced formation is still prevalent[4], in relative terms the new policy allows cooperatives to be diverse and independent participants in the free market economy.

As part of the government support for cooperative promotion, cooperative governance was also reinforced through the establishment of the Federal Cooperative Commission in 2002, a public body to promote cooperatives at the national level (Bernard et al., 2010; Francesconi and Heerink, 2010; Kodama, 2007). The commission was established with a plan of providing cooperative services to two-thirds of the rural populations and to increase the share of agricultural cooperatives in input and output marketing through the establishment of at least one primary cooperative in each *kebele.* While there is evidence that suggests a consequent growth in the cooperative movement in Ethiopia, its coverage remains 35 per cent of *kebeles,* and only 17 per cent of the households living in those *kebeles* are members (Bernard et al., 2008).

With regards to performance, the impacts of agricultural cooperatives are less studied. There have been only a few attempts made to understand their commercialization role in collecting and selling members' produces and the results are mixed. Francesconi and Heerink (2010) found a higher commercialization rate for the farmers that belong to agricultural marketing cooperatives, which suggest the importance of organizational form in cooperative inquiries. Bernard et al. (2008) conversely found a similar commercialization rate for the farmers that belong to cooperatives (i.e., cooperative members tend to sell an equivalent proportion of their output to market as compared to non-members), notwithstanding the higher price obtained by the cooperatives for members per unit of output. Their role in providing a better price through stabilizing and correcting local market in favor of the producer is also corroborated by Tigist (2008).

Other recent studies on impact of agricultural cooperatives by Abebaw and Haile (2013) and Getnet and Tsegaye (2012) respectively indicated better adoption of agricultural inputs and livelihood improvement among users of cooperatives as

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[3] Agricultural Cooperative Societies Proclamation No. 185/1994.

[4] In Ethiopia member initiated cooperatives account only for the 26 percent of the total. The remaining 74 percent of the cooperatives are externally initiated, mostly by government and donor agencies (Bernard et al., 2008).

compared to non-users. What is scarce in the literature is the impact of agricultural cooperatives on productivity and technical efficiency of members, despite the fact that they are mainly used as a preferential channel to access agricultural inputs (i.e., fertilizer and improved seeds) and services (i.e., financial, training and extension). In the technical efficiency literature there are empirical works that suggest the positive role of membership in producer organizations or cooperatives in reducing inefficiency (Binam et al., 2005; Chirwa, 2003; Idiong, 2007; Jaime and Salazar, 2011). However, those results are merely based on the analysis of inefficiency models without accounting for original differences among farm households and in countries other than Ethiopia. In an effort to address this gap, we made an attempt to go one step further and compare the difference in technical efficiency between members and non-members that are similar in their observable covariates or pre-membership characteristics in the specific context of rural Ethiopia.

3. Data and descriptive analysis

The key variables used in this study include household characteristics; inputs used for production; production value and village level characteristics (such as population density and availability of farmer training centers). The data used are from the 'Ethiopia Agricultural Marketing Household Survey', jointly carried out by the Ethiopian Development Research Institute (EDRI), Ethiopian Institute of Agricultural Research (EIAR) and International Food Policy Research Institute (IFPRI) between June and August 2008. This survey provided data on all the variables of interest except village level variables, which were then obtained separately from the Central Statistical Authority (CSA).

The 'Ethiopia Agricultural Marketing Household Survey' is focused on smallholders' production and marketing patterns and covers the four most populated regions of Ethiopia (Amhara, Oromia, SNNP[5] and Tigray). The sampling procedure employed was a three-stage stratified random sampling[6]. The original sample includes 1,707 households randomly drawn from 73 Peasant Associations (PAs). From the original sample we dropped households with missing observation on variables of interest[7]. The resulting sample used in this study includes 1,638 farm households, from which we drew a sub-sample (i.e., member and non-member farm households within cooperative *kebeles*) mainly used to address our research question.

Table 1 presents a summary of demographic and geographic characteristics of sample households used in the analysis. From the total sample households considered, 34 per cent are members of agricultural cooperatives (i.e., treatment group) and the

[5] Southern Nations, Nationalities, and Peoples Regional State.

[6] In the first stage, the *Woreda's* from each region were selected randomly from a list arranged by degree of commercialization as measured by the *Woreda*-level quantity of cereals marketed (i.e., the major focus of the survey). This ensured that that *Woreda's* were uniformly distributed across the range of level of marketed cereal outputs. In the second stage, farmers' or peasants' associations (FAs or PAs) were randomly selected from each *Woreda*. For the third stage of selection, households were randomly selected from the list provided by the PA office.

[7] For example, we dropped households that report production volume without amount of seed used or land cultivated.

remaining (66 per cent) is found to be independent farm households (i.e., comparison group). Farm households belonging to agricultural cooperatives are relatively more literate, older, more likely to have a male head and have higher household size both in numbers and adult equivalents. In addition, members are also more likely to own radios, televisions and mobile phones, as compared to the non-members.

Tab. 1 - Demographic characteristics of sample households

Indicators	Members (n = 564)		Non-members (n = 1074)		Pooled Sample (N = 1638)	
	Mean (Std. Dev.)	Min/Max	Mean (Std. Dev.)	Min/Max	Mean (Std. Dev.)	Min/Max
Household size	6.50(2.04)	1/14	6.18 (2.66)	1/26	6.29(2.47)	1/26
Sex of HH head	1.04(0.20)	1/2	1.10 (0.30)	1/2	1.08(0.27)	1/2
Age of HH head	45.76 (12.28)	20/86	44.09(13.35)	15/89	44.67(12.99)	15/89
HH head education level	0.45(0.49)	0/1	0.25(0.43)	0/1	0.32(0.46)	0/1
Number of plots	6.37(2.81)	1/22	5.14(2.72)	1/21	5.56(2.81)	1/22
Number of crops	2.75(1.04)	1/6	2.34(1.04)	1/7	2.48(1.06)	1/7
Off-farm income	0.55(0.49)	0/1	0.61(0.48)	0/1	0.59(0.49)	0/1
Radio and/or TV ownership	0.60(0.49)	0/1	0.39(0.48)	0/1	0.46(0.49)	0/1
Phone ownership	0.01(0.13)	0/1	0.006(0.08)	0/1	0.01(0.10)	0/1
Value of crop produced	3423.4(3149.9)	133/22750	2266.4(2437.8)	38/19380	26665.5(2758.8)	37.5/22750
Fertilizer used by HHs	96.39(136.32)	0/900	22.41(49.61)	0/650	47.88(96.13)	0/900
Improved seed used by HHs	7.46(23.86)	0/300	1.70(7.53)	0/100	3.68(15.51)	0/300
Cultivated land size	1.37(0.94)	0.08/7.06	1.14(0.90)	0.15/6.75	1.22(0.92)	0.015/7.06
Labor (adult equivalent)	5.43(1.77)	1/11.69	5.08(2.20)	0.74/22.12	5.20(2.07)	0.74/22.12
Oxen owned by HHs	1.71(1.11)	0/8	1.19(1.07)	0/8	1.37(1.11)	0/8
TLU[a] (excluding ox)	3.34(3.33)	0/31.04	3.22(5.29)	0/69.2	3.26(4.71)	0/69.2

[a] Tropical Livestock Unit.

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

As expected, members are using more productive inputs (i.e., fertilizer and improved seeds). This can be explained by ease of access, as agricultural cooperatives are the major last-mile distributers of fertilizers and seeds, and also by the fact that members need to compensate for relatively lower fertile land. Although not reported in the table to conserve space, the data indicates a mean difference within non-member farm households in input use by locations. Non-member farm households residing in cooperatives' *kebeles* use a higher amount of fertilizer and improved seeds as compared to non-members living in a *kebele* without agricultural cooperatives. This suggests the potential presence of a spillover effect in input use and the presence of similar technology among members and non-members to study efficiency gains in *kebeles* with agricultural cooperatives.

As shown in Table 2, farm households that belong to agricultural cooperatives are those located at comparatively accessible locations (closer to the nearest local markets, closer to the nearest whether roads and *Woreda* amenities). This can also suggest that most of the agricultural cooperatives in Ethiopia are found in locations that are relatively accessible. In terms of other village level characteristics, on average, members and non-members are located in Peasant Associations (PAs) with similar population density and have comparable access to irrigation and Farmer Training Centers (FTC).

Tab. 2 - Geographic characteristics of sample households

Indicators	Members (n = 564)		Non-members (n = 1074)		Pooled Sample (N = 1638)	
	Mean (Std. Dev.)	Min/Max	Mean (Std. Dev.)	Min/Max	Mean (Std. Dev.)	Min/Max
Distance to whether road	55.10(73.98)	0/810	76.63(89.57)	0/720	69.22(85.12)	0/810
Distance to nearest market	67.21(69.5)	5/1080	75.63 (72.71)	5/1080	72.73(71.71)	5/080
Distance to *Woreda* capital	141.60(111.86)	1/810	154.74(111.48)	2/810	150.22(11.75)	1/810
Population density	183.2(114.6)	27/652	187.4(144.4)	27/652	185.9(134.8)	27/652
Access to irrigation	0.10(0.30)	0/1	0.09(0.28)	0/1	0.09(0.29)	0/1
Soil quality						
Fertile	0.19(0.39)	0/1	0.34(0.47)	0/1	0.29(0.45)	0/1
Medium[b]	0.65(0.47)	0/1	0.49(0.50)	0/1	0.55(0.49)	0/1
Teuf	0.14(0.35)	0/1	0.15(0.36)	0/1	0.15(0.35)	0/1
Farmer training center	0.09(0.29)	0/1	0.12(0.33)	0/1	0.11(0.32)	0/1

[b] Medium signifies that the land owned by the household in question is a combination of both fertile and infertile soil qualities.

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

Table 3 reports the summary statistics of the impact indicator variable and the predicted probability of participation used for matching. The descriptive statistics show a higher level of technical efficiency among members. The average technical efficiency of members and non-members are 0.73 and 0.64 respectively. Farm households that belong to agricultural cooperatives were found to be more efficient by 8.9 percentage points as compared to non-members and the mean difference is statistically different from zero at P<0.000. However, at this point we cannot determine that membership results in efficiency gains, as this difference can be partially or totally emanated from original difference among households.

Tab. 3 - Technical efficiency score and estimated probability of participation in cooperatives

Indicators	Members (n = 564)		Non-members (n = 1074)		Pooled Sample (N = 1638)	
	Mean (Std. Dev.)	Min/Max	Mean (Std. Dev.)	Min/Max	Mean (Std. Dev.)	Min/Max
Technical efficiency score	0.73(0.12)	0.28/0.98	0.64(17.65)	0.07/0.97	0.67(0.16)	0.07/0.98
Estimated probability of participation (Pscore)	0.49(0.21)	0.02/0.95	0.26(0.18)	0/0.85	0.34(0.22)	0/0.95

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008

4. Analytical approach

This paper aims at measuring the average impact of membership in agricultural cooperatives on farm households' technical efficiency. In other words, we estimate the Average Treatment Effect on the Treated (ATT)[8], where the treatment is membership in agricultural cooperatives and the treated are member farmers. In such types of casual inference, the estimation of treatment effects in the absence of information on the counter-factual poses an important empirical problem. In impact evaluation literature this is known as the problem of filling in missing data on the counter-factual (Becker and Ichino, 2002; Dehejia and Wahba, 2002; Heckman et al., 1997; Rosenbaum and Rubin, 1985). The challenge is to find a suitable comparison group with similar covariates and whose outcomes provide a comparable estimate of outcomes in the absence of treatment.

The empirical approach in this study is twined to reduce three potential sources of biases in the selection of a comparison group of non-member or non-cooperative farmers. These potential biases are common in evaluations aimed at measuring ex-

[8] See Becker and Ichino (2002), Dehejia and Wahba (2002), Heckman et al. (1997), Rosenbaum and Rubin (1983), Smith and Todd (2005), and Todd (2006) for detailed methodological discussion on estimation of Average Treatment Effect on the Treated through matching procedures. We didn't include equations of ATT to conserve space.

post impact of projects that involve some degree of self-selection among participants. A point in case is given by this study, which aims to evaluate the impact of membership in agricultural cooperatives, given that participation is voluntary and based on the intrinsic preferences, ability and motivation of the farmers, as well as considering that no baseline (i.e., ex-ante) observations are available to assess the performance of member-farmers before they joined a cooperative.

The first potential source of bias is given by 'selection on observables', which may arise due to sampling bias, meaning that the selection of cooperative location was not-random but determined by spatial fixed effects (i.e., village level characteristics) and farm households characteristics. To control for selection bias associated with the fact that participation in cooperatives was not random, we draw from similar approaches by Bernard et al. (2008), Francesconi and Heerink (2010) and Godtland et al. (2004), and apply Propensity Score Matching (PSM) techniques to account for differences in observed covariates between members and non-members. Using PSM has a great importance in providing unbiased estimate through controlling for observable confounding factors and in reducing the dimensionality[9] of the matching problem (Becker and Ichino, 2002; Rosenbaum and Rubin, 1983).

With regards to placement bias, however, we argue that Ethiopia's past and current governance of cooperative organizations minimizes the importance of farmers' free will and locations resource endowments, since every *kebele* is expected to have at least one cooperative and participation in cooperatives means access to publicly subsidized inputs. Hence, in most cases the establishment of agricultural cooperatives is driven by neither location nor farm household characteristics residing in that location, but by centrally planned governance strategies. Further supporting our argument, Bernard et al. (2008) assume, as we do, that cooperatives are externally formed in its PSM analysis, and found that government and development agencies initiate 74 per cent of cooperatives in Ethiopia. Thus, in Ethiopia cooperative placement based on *kebeles* and/or households' characteristics is rather negligible.

The second source of bias in selecting a comparison group is spillover effects. In the presence of externalities, comparing users of cooperatives with non-users in the same *kebele* can increase the possibility of having spillover effects that underestimate the cooperative impact. On the other hand, considering a comparison group from *kebele* without cooperatives can increase differences at the *kebele* level (i.e., difference in agro-ecological conditions, infrastructure and institutions) by increasing the likelihood of selection bias. In our empirical analysis we tried to take care of both concerns. We first consider a sample that includes members and non-members from the "*kebeles* with cooperatives" and then we use the whole sample to match cooperative members with non-members from "*kebeles* without cooperatives" as well.

The third source of bias is 'selection on unobservable', which arises due to differences between members and non-members in the distribution of their unobserved characteristics (e.g., in their ability, desire, risk preference, aspiration etc.). Given the

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[9] Propensity score methods solve the dimensionality or separateness problem through creating a single composite score from all observed covariates $\boldsymbol{X}$, which will be used for matching (Becker and Ichino, 2002; Rosenbaum and Rubin, 1983; Steiner and Cook, 2012).

data available we cannot control for selection on unobservable referring to farmers' preferences, motivation or ability. Controlling for such biases requires a suitable instrument that explains the probability of participation in agricultural cooperatives but does not explain their outcome. In this case, however, since we employ matching and compared members and non-members whose propensity scores are sufficiently close or have the same distribution, we can assume that the distribution of unobservable characteristics is the same or at least not so different for both groups independent of membership to induce a bias (see Becker and Ichino, 2002, for a discussion). Further, we use Rosenbaum Bounds Sensitivity Analysis to test the sensitivity of our result to possible hidden biases due to unobservable household characteristics when this assumption is relaxed.

4.1 Estimation of the propensity score (P-score) and matching

As indicated in the previous section we deployed propensity scoring to match members of agricultural cooperatives with similar independent farm households. Hence, we first estimated the conditional probability of becoming a member in agricultural cooperatives (i.e., propensity score) given observed household characteristics using a flexible Probit model, where membership status in cooperatives is the dependent variable and covariates and their quadratic terms are introduced as independent variables.[10]

Although the probability of participation needs to be estimated only for households living in a *kebele* with cooperatives for better identification of the variables that determine participation, we also estimated the likelihood of participation for the whole sample to understand the existence of sufficient overlap of the covariates. At large, the coefficients and statistical significance of the covariates are similar, except for livestock ownership, telephone ownership and households that produce barley. We mainly used the propensity scores based on the reduced sample to estimate the average treatment effect on the treated for two reasons. One, the opportunity to participate exists in the restricted sample; and two, the restricted sample is the primary focus of the analysis as it better controls local level differences that can potentially bias the impact, tempering possible spillover effects that are found to be negligible.

The results from the Probit estimation are summarized in Table 4. From the results we understand that the propensity to become a member of agricultural cooperatives is high for households with large family size, experience in farming, number of farm plots, mobile ownership, wealth (i.e., number of ox and land), and crop types produced by household (i.e., *teff*, wheat and finger-melt). However, after certain threshold wealth, household size and age adversely affect probability of participation. On the other hand, farm households that have off-farm incomes, live closer to roads, and grow diverse crops are less likely to participate in cooperatives.

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[10] Quadratic terms are introduced in order to account for possible non-linear relationships and to maximize the predicting power of the model (see Godtland et al., 2004, for detailed discussion).

Tab. 4 - Determinates of participation in agricultural cooperatives

Indicators	Members and non-members from cooperatives' *kebeles* *(reduced sample)*		Members and non-members from *kebeles* with and without cooperatives *(full sample)*	
	Coefficient	Std.Err	Coefficient	Std.Err
Household size	0.201***	0.067	0.206***	0.064
Household size^2	-0.013***	0.004	-0.014***	0.004
Gender of household head	-0.182	0.153	-0.161	0.151
Age of household head	0.034*	0.019	0.040**	0.018
Household head age^2	-0.001*	0.000	-0.001**	0.000
Household head literacy	0.408***	0.078	0.404***	0.077
Distance to the nearest road	-0.001***	0.000	-0.001***	0.000
Distance to the nearest local market	0.001	0.000	0.001	0.000
Distance to *Woreda* capital	-0.001	0.000	-0.001	0.000
Number of farm plots	0.027*	0.016	0.038***	0.016
Number of crops	-0.165	0.109	-0.197*	0.105
Household access to irrigation	-0.060	0.126	-0.085	0.123
Household receives off-farm income	-0.157**	0.075	-0.139**	0.073
Household owns telephone	0.987**	0.441	0.521	0.342
Number of ox owned	0.2590***	0.073	0.252***	0.071
Number of ox owned^2	0.033**	0.015	-0.029*	0.015
Livestock owned other than ox (TLU)	-0.008	0.011	-0.017*	0.010
Hectare of land held	0.127***	0.041	0.162***	0.040
Hectare of land held^2	-0.004**	0.002	-0.006***	0.002
Household produces *Teff*	0.381***	0.136	0.444***	0.131
Household produces wheat	0.572***	0.140	0.662***	0.136
Household produces sorghum	-0.177	0.147	-0.180	0.141
Household produces barley	0.170	0.135	0.240*	0.131
Household produces maize	0.155	0.138	0.137	0.135
Household produces finger melt	0.643***	0.149	0.762***	0.145
Constant	-2.369***	0.488	-2.665***	0.477
Number of observations	1455		1638	
Pseudo R^2	0.1464		0.1861	
Sensitivity (in %)	50.00		48.58	
Specificity (in %)	83.73		87.52	
Total correctly classified (in %)	70.65		74.11	

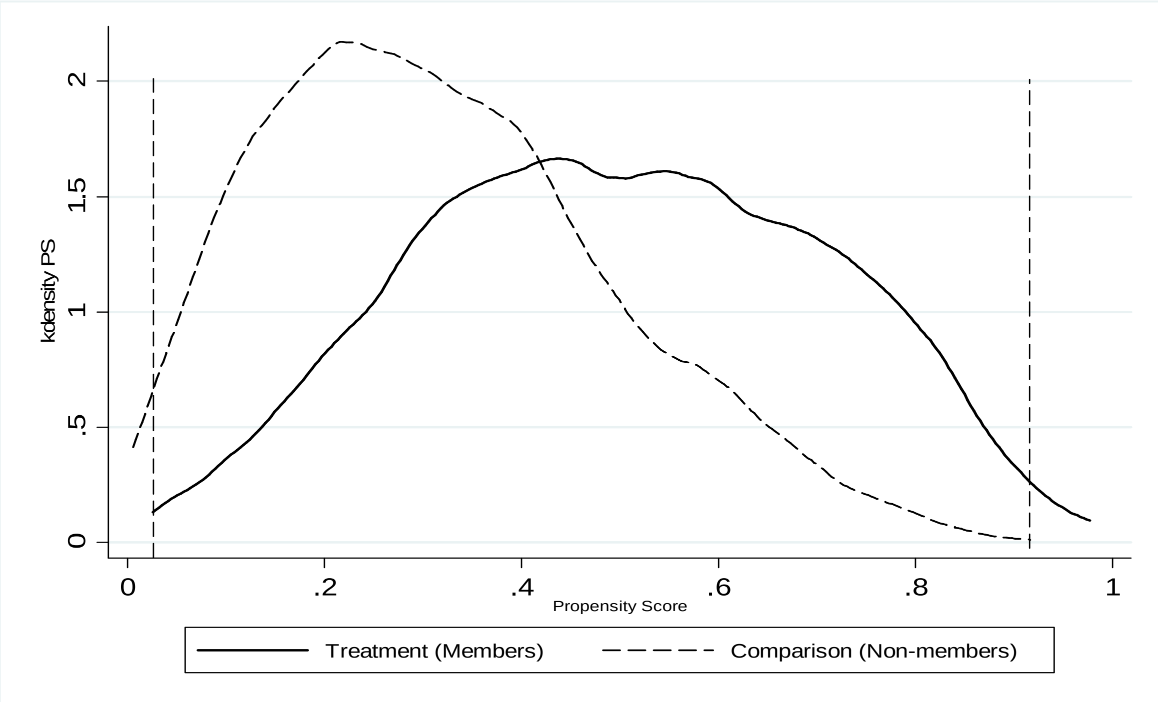
Note: *** Significant at 1% level, ** significant at 5% level and * significant at 10% level.

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

The results are more or less consistent with what has been found by Bernared et al., (2008) as predictors of participation in cooperatives. They suggest that poorer households without any resources (i.e., land, labor, oxen etc.) and households producing different crops than the common cereals marketed through agricultural

cooperatives are less likely to become members. They also show that wealthy households with sufficient experience in farming and excess owned labor will not tend to be involved in collective action, which is consistent with theoretical predications.
The density distribution of propensity scores for members and non-members are presented in Figure 1. In order to improve the robustness of the estimate the matches are restricted to members and non-members who have a common support[11] in the distribution of the propensity score. As it can be seen in the figure, the distributions appear with sufficient common support region that allows for matching. Besides, the difference between members and non-members in their propensity score distribution validates the use of matching techniques to ensure comparability. From several matching techniques applicable in impact evaluation, we use two extensively applied methods (i.e., non-parametric kernel based matching and five nearest neighbors matching).

Fig. 1 - Density distributions of the propensity scores for members (treated group) and non-members (comparison group)[12]



Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

The non-parametric kernel regression method is used to allow matching of members with the whole sample of non-members, since the technique uses the whole sample of the comparison with common support to construct a weighted average match for each treated (Heckman et al., 1997; Heckman et al., 1998). That is, the entire sample of non-members in the comparison group is used to construct a weighted average match

[11] Common support refers to the values of the propensity scores where both treatment (i.e., members) and comparison groups (i.e., non-members) are found. 8 to 13 observations that are off-support are dropped (Table A3 and A4).
[12] The reported density distribution is for the reduced sample (i.e., sample 1) that includes only members and non-members in a *kebele* with agricultural cooperatives.

to each member in the treatment group. On the other hand, the five nearest neighbors matching is used to match each member with the mean of the five non-members who have the closest propensity score. The imperative of nearest neighbors matching is that it compares non-members with scores that are closer to the scores of the members.

What is more, the validity of the matching procedure relies on the extent to which these techniques sample or construct a comparison group that resembles the treatment group. Besides, the balancing test within blocks that are satisfied in our estimation of the propensity score in case of both samples (see propensity score blocks in Table A3 and Table A4), we undertake a 'balancing test' that compares a simple mean (i.e., mean equality test) of household characteristics within the treatment group to the corresponding comparison groups created by the matching techniques before and after matching as a complement.

Tab. 5 - Balancing test of matched sample[13]

	Unmatched samples			Five nearest neighbors matching			Kernel-based matching		
	Members	Non-members	Diff: *P*-value	Members	Non-members	Diff: *P*-value	Members	Non-members	Diff: *P*-value
Household size	6.50	6.03	**0.000**	6.50	6.45	**0.676**	6.50	6.46	**0.775**
Gender of HH head (1= Male, 2= Female)	1.04	1.10	**0.000**	1.04	1.04	**0.834**	1.04	1.03	**0.799**
Household head literacy (1= Yes, 0= No)	0.45	0.25	**0.000**	0.45	0.48	**0.320**	0.45	0.46	**0.768**
Age of household head	45.76	44.80	**0.169**	45.81	44.95	**0.239**	45.81	45.41	**0.585**
Distance (minutes)									
To the nearest road	55.10	72.11	**0.000**	55.20	57.51	**0.590**	55.20	57.7	**0.562**
To the nearest market	67.21	68.26	**0.783**	67.16	71.43	**0.357**	67.16	69.95	**0.523**
To *Woreda* capital	141.6	148.58	**0.249**	142.2	140.75	**0.828**	142.2	143.56	**0.837**
Number of plots held	6.37	5.38	**0.000**	6.35	6.33	**0.942**	6.35	6.21	**0.432**
No. of crops planted	2.75	2.42	**0.000**	2.74	2.76	**0.764**	2.74	2.72	**0.741**
Access to irrigation (1= Yes, 0= No)	0.10	0.08	**0.367**	0.10	0.08	**0.328**	0.10	0.09	**0.481**
Off-farm income (1= Yes, 0= No)	0.55	0.61	**0.014**	0.55	0.57	**0.492**	0.55	0.56	**0.744**
Own telephone (1= Yes, 0= No)	0.019	0.002	**0.001**	0.014	0.011	**0.672**	0.014	.017	**0.627**
Number of ox owned	1.71	1.22	**0.000**	1.70	1.68	**0.711**	1.70	1.68	**0.693**
Livestock owned (TLU)[c]	3.34	2.80	**0.008**	3.32	3.14	**0.972**	3.32	3.43	**0.631**
Size of farm land (ha)	2.06	1.51	**0.000**	2.05	2.06	**0.929**	2.05	1.30	**0.869**

[c] Livestock owned (TLU) refers to livestock other than ox owned by the household.

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

[13] The reported balancing test is for the reduced sample (i.e., sample 1) that includes only members and non-members in a *kebele* with agricultural cooperatives. We did similar tests for the full sample and the balancing properties are satisfied.

As reported in Table 5, the unmatched sample fails to satisfy the balancing property. Although the groups are found to be comparable in terms of access to irrigation, age of household head and distance to market and district administration, it shows a systematic difference between members and non-members in the majority of their observed characteristics before matching. The balancing test results after matching that compares cooperative members to the sub-set of comparison non-members selected through five nearest neighbors matching and kernel-based matching shows no systematic or statistical difference in observed characteristics between the two groups. Hence, the results suggest that our comparison is valid from statistical point of view.

4.2 Measuring technical efficiency

The technical efficiency measure is intended to capture whether agricultural cooperatives enable their members in getting better access to productive inputs and services including training on better farming practices that enhance their productive efficiency. The stochastic frontier production model[14] is used to estimate the technical efficiency of sample households. It measures the ability of households to obtain maximum possible outputs from a given set of inputs (Coelli et al., 2005; Farrell, 1957; Kumbhakar and Lovell, 2000). Such a measure is of great importance in estimating the household efficiency score by accounting for factors beyond the control of each producer. Besides, it helps to understand the factors that determine technical inefficiency of farm households, since some of the factors can be influenced by policies.

Following this approach we first detected the presence of inefficiency in the production for sample households. Estimating the stochastic production frontier and conducting a likelihood-ratio test assuming the null hypothesis of no technical inefficiency on input-output data carried out the test. As reported in Table A.1, the result shows that the inefficiency component of the error term is significantly different from zero, which indicates the presence of a statistically significant inefficiency component. Besides, the value of gamma indicates that there is a 52 per cent variation in output due to technical inefficiency. In other words, the technical inefficiency component is likely to have an important effect in explaining output among farm households in the sample.

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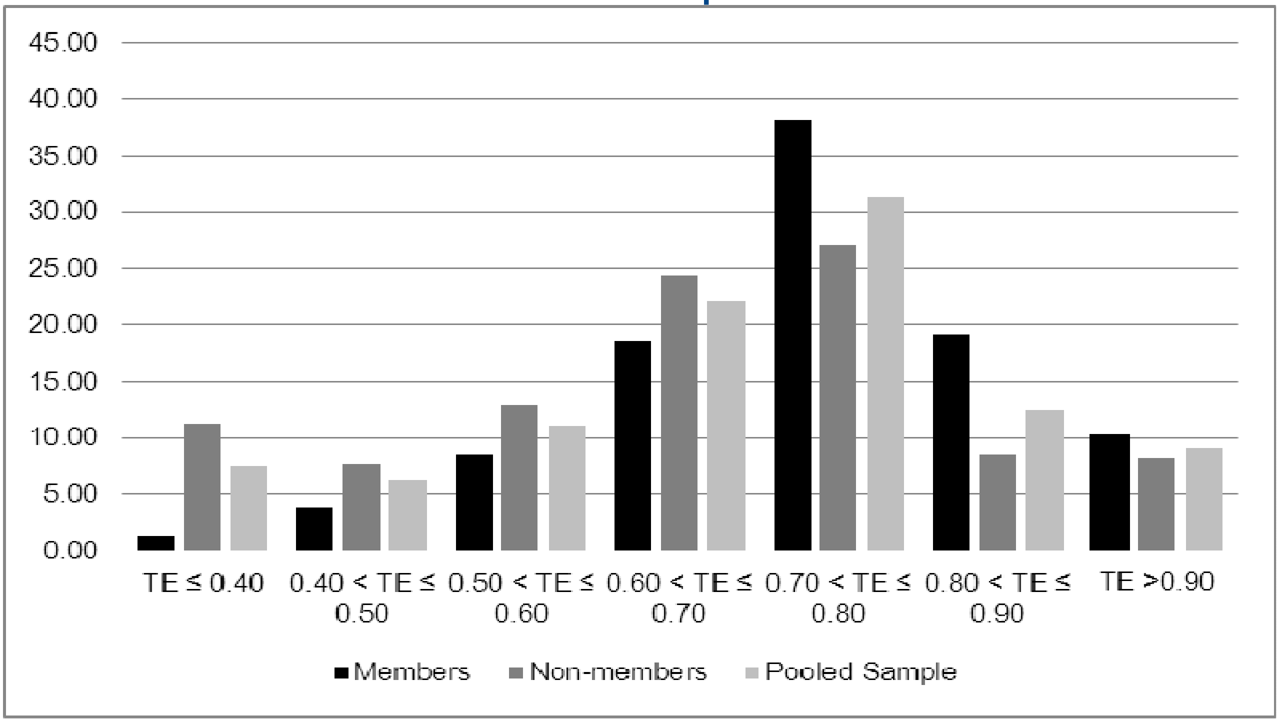
[14] Unlike the deterministic approach, it is a model that incorporates household-specific random shocks that represents statistical noises due to factors beyond the control of households, measurement errors and omission of relevant variables (Coelli et al., 2005; Kumbhakar and Lovell, 2000). In other words, in stochastic production frontier the error term is composed of the symmetric error component and the technical inefficiency component that measures shortfall of output from its maximum frontier or possible output. Hence, in this approach technical efficiency is measured as the ratio of observed output to maximum attainable output in a context characterized by household specific random shocks (i.e., $\exp\{V_j\}$):

$$TE_j = \frac{Y_j}{f(X_j, \beta).\exp\{V_j\}}$$

Where, TE_j refers to the technical efficiency of the jth producer, Y_j is the observed output, $f(X_j, \beta)$ indicates the deterministic part that is common to all producers or households, $\exp\{V_j\}$ is a producers specific part that captures the effect of random noises or shocks on each producer. See Aigner et al. (1977), Coelli et al. (2005), Jondrow et al. (1982), Kumbhakar and Lovell (2000), and Meeusen and Ven den Broeck (1977) for detailed methodological discussions.

Once we detected the presence of technical inefficiency, we estimate a one-stage simultaneous maximum likelihood estimate for the parameters of the Cobb-Douglas[15] stochastic frontier production function to predict households' technical efficiency scores and to understand determinants of inefficiency. As expected, all conventional inputs (land, labor, fertilizer, seed and number of oxen owned) are found to be significant determinates of household production (see Table A2). The inefficiency model suggests that inefficiency of farm households is significantly linked with number of plots, diversification of crops, gender of household head and membership in agricultural cooperatives[16]. The results are in line with the findings of Alemu et al. (2009), Idiong (2007), and Jaime and Salazar (2011).

Fig. 2 - Frequency distribution of technical efficiency scores by cooperative membership[17]



Note: TE refers to Technical Efficiency score of households.

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

With regard to membership in agricultural cooperatives, the result indicates that membership reduces technical inefficiency by about 5 per cent (see Table A2). Concurrently, from the descriptive statistics we understood that the mean technical efficiency of members is significantly higher than that of non-members and the majority of the members are above the mean efficiency (i.e., 67.91 per cent) of the

15 Cobb–Douglas stochastic frontiers are found to be adequate representations of our data as compared to the specifications of the translog stochastic frontiers.

16 The coefficient of membership in agricultural cooperatives obtained from the inefficiency model is comparable to the average impacts of cooperative membership on technical efficiency resulted from matching estimators.

17 The reported frequency distribution is for the reduced sample (i.e., sample 1) that includes only members and non-members in a *kebele* with agricultural cooperatives.

pooled sample (Figure. 2). Besides, as is clear from Figure. 2, the density of non-members is above that of the members on the distribution below the mean efficiency of the whole sample. However, we cannot draw any conclusion at this stage as this difference can be partially or totally due to original differences among households. Thus, we use matching that computes the average difference in technical efficiency scores between members and non-members in the common support region using the techniques described above and Ordinary Least Squares (OLS) estimation by including a number of household and village level variables as a robustness check.

5. Results and discussion

5.1. Average impact of agricultural cooperatives on technical efficiency

As described in the above sections, the average impact of cooperative membership on the technical efficiency of small farmers is analyzed using the reduced sample (i.e., sub-sample 1) that includes members and non-members from *kebeles* with agricultural cooperatives and the whole sample that aimed at accounting for possible spillover effects (i.e., sample 2). The resulting non-parametric estimate of the Average Treatment Effect on the Treated (ATT), average impact of membership in agricultural cooperatives on the technical efficiency of smallholder farmers, based on the Propensity Score Matching (PSM) methods, is reported in Table 6. The paper mainly used the analysis based on the reduced sample as it accounts for differences in technology and agro-ecology that can affect efficiency estimation. On the other hand, the impact estimate based on the whole sample aimed at examining the extent of spillover effects. As is clear from Table 6, the diffusion effect is found to be negligible. Meaning, the impact estimate based on the whole sample is lower[18] than the impact estimate based on the reduced sample where the possibility of diffusion effects exists.

Consistent with the results from the descriptive statistics and the inefficiency model of the stochastic frontier function, we found that, on average, farmers belonging to agricultural cooperatives are more efficient than independent farmers. The results suggest that member households are in a better position to obtain maximum possible outputs from a given set of inputs used, by about 5 percentage points, in line with the expectation that agricultural cooperatives likely make productive technologies accessible and provide embedded support services (i.e., training, information and extension linkages). The impact estimates are robust across different estimation methods and samples considered. We further checked the robustness of the estimates for a specific region (i.e., Amhara Region), where the size of the sample allows for using matching techniques. The results are comparable to the results from the reduced and the whole sample (i.e., about a 5.5 per cent and 4.5 percentage points difference for kernel based and five neighbors matching, respectively).

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[18] Lower average impact from the whole sample that include non-cooperative *kebeles* can also indicate the presence of technology difference between cooperative and non-cooperative *kebeles*, strengthening our decision to focus on cooperative *kebeles* in order to reduce potential differences in technology, as it should be accounted to compare differences in technical efficiency due to cooperative membership.

Tab. 6 - Effect of cooperative membership on technical efficiency of smallholders

	Kernel-based matching		Five nearest neighbors matching		Number of Obs.
	ATT	Std. Err.	ATT	Std. Err.	
Sample 1: (% Difference in TE)	5.59	0.008***	5.64	0.010***	1455
Sample 2: (% Difference in TE)	5.38	0.010***	4.45	0.009***	1638
Check for robustness: observations limited to Amhara region only					
Sample 1	6.07	0.011***	4.68	0.012***	431
Sample 2	5.55	0.013***	4.91	0.014***	385

Note: Sample 1 includes members and non-members only from kebeles with agricultural cooperatives; Sample 2 includes the whole sample (i.e., members and non-members from kebeles with and without agricultural cooperatives).
TE refers to households' Technical Efficiency score.
Bootstrap with 100 replications is used to estimate the standard errors.
*** Significant at 1% level.

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

Nonetheless, the above results rely heavily on the assumption of unconfoundedness or conditional independence[19] (i.e., once the factors affecting participation are taken into account, the condition of randomization restored) and are not robust against 'hidden bias'. If there are unobserved variables which affect participation in cooperatives and technical efficiency simultaneously, unobserved heterogeneity affecting the robustness of the estimates might arise (Becker and Caliendo, 2007; Keele, 2010; Rosenbaum, 2002; Rosenbaum and Rubin, 1983).

We assess the presence of this problem using Rosenbaum bounds sensitivity analysis when the key assumption is relaxed by a quantifiable increase in uncertainty. As reported in Table 7, the results are found to be insensitive to a bias that would double the odds of participation (self-selection) in agricultural cooperatives but sensitive to bias that would triple the odds. The magnitude of hidden bias, which would make our finding of a positive and significant effect of membership in agricultural cooperatives on technical efficiency questionable or spurious, should be higher than $\Gamma=2.4$ and $\Gamma=2.3$ for sub-sample 1 and sub-sample 2, respectively. Hence, we deduce that the strength of the hidden bias should be sufficiently high to undermine our conclusion of positive and significant impact of membership on agricultural cooperatives on technical efficiency based on the matching analysis.

[19] Unconfoundedness in our case means that participation in agricultural cooperatives does not depend on households' technical efficiency, after controlling for the variations in technical efficiency induced by differences in observable covariates. It is a strong assumption that implies that participation is based on observable characteristics and that variables simultaneously influencing participation and technical efficiency are observable.

Tab. 7 - Rosenbaum Bounds sensitivity analysis for hidden bias

Critical Value of Hidden Bias (Γ)	TE (Sample 1) Sig+ (max)	TE (Sample 2) Sig+ (max)
1	<0.0000001	<0.0000001
1.10	<0.0000001	<0.000001
1.20	<0.000001	<0.000001
1.30	<0.000001	<0.000001
1.40	<0.000001	<0.000001
1.50	<0.000001	<0.000001
1.60	<0.000001	<0.000001
1.70	<0.000001	0.000017
1.80	0.000053	0.000149
1.90	0.000368	0.000895
2	0.00184	0.003944
2.10	0.006992	0.013387
2.20	0.02102	0.036361
2.30	0.051713	**0.081666**
2.40	**0.107157**	0.156001
2.50	0.191758	0.259870
2.60	0.302942	0.385155
2.70	0.430901	0.518678
2.80	0.561708	0.64555
2.90	0.681954	0.754428
3	0.782422	0.839684

Note: Sample 1 includes members and non-members only from kebeles with agricultural cooperatives; Sample 2 includes the whole sample (i.e., members and non-members from *kebeles* with and without agricultural cooperatives).

TE refers to households' technical efficiency score.

The sensitivity analysis is for one-sided significance levels.

Γ measures the degree of departure from random assignment of treatment or a study free of bias (i.e., Γ=1).

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

Besides the average treatment effect on the treated (ATT), we estimated the impact based on a regression method using Ordinary Least Square (OLS) estimation controlling for household and *kebele* level characteristics expected to influence both participation in agricultural cooperatives and household level of technical efficiency to check for consistency. We employ a flexible specification that controls for agricultural inputs used, soil quality, household size, household head literacy, distance to the nearest local market, access to irrigation, off-farm income and *kebele* level variables like population density and availability of a farmer training center, allowing for a full set of interaction between cooperative membership and household covariates.

As reported in Table 8, we obtained consistent results with that of the non-parametric estimates. Further supporting the results of the ATT, membership in agricultural cooperatives has a significant positive impact on technical efficiency of households, by about 4 to 6 percentage points. From the interaction terms we also understand that technical efficiency gains from membership in a cooperative is significantly affected by household size and access to irrigation.

Tab. 8 - Cooperative membership and technical efficiency (OLS)

Independent variables	Dependent variable: level of technical efficiency (TE score)			
	Sample 1		Sample 2	
	(1)	(2)	(3)	(4)
HH size (Number)	0.009	0.008	0.008	0.007
	(5.32)***	(3.65)***	(5.80)***	(4.08)***
HH head literacy	0.023	0.021	0.026	0.028
(1= Yes, 0= No)	(3.18)***	(1.88)*	(3.89)***	(2.81)***
Distance to market (Minutes)	-0.000	-0.000	-0.000	-0.000
	(4.46)***	(3.10)***	(4.17)***	(3.03)***
Access to irrigation	0.268	0.291	0.268	0.290
(1= Yes, 0= No)	(42.79)***	(34.85)***	(48.51)***	(42.59)***
Receives off-farm income	-0.046	-0.049	-0.045	-0.047
(1= Yes, 0= No)	(6.78)***	(5.04)***	(7.03)***	(5.42)***
Improved seed (Kg)	0.000	0.000	0.000	0.000
	(1.69)*	(1.46)	(1.74)*	(1.51)
Fertilizer (Kg/ha)	0.000	0.000	0.000	0.000
	(2.22)**	(2.16)**	(2.28)**	(2.20)**
Land cultivated (ha)	0.016	0.016	0.016	0.016
	(3.65)***	(3.60)***	(3.78)***	(3.71)***
Number of ox owned	0.003	0.003	0.003	0.003
	(0.83)	(0.81)	(0.96)	(0.94)
Membership in cooperatives	**0.063**	**0.047**	**0.060**	**0.040**
	(9.26)* **	**(2.06)** **	**(9.32)*** **	**(1.91)* **
Population density	-0.000	-0.000	-0.000	-0.000
	(7.23)***	(7.13)***	(7.66)***	(7.55)***
FTC (Availability of farmers Training	0.060	0.059	0.043	0.042
center during 2008)	(5.88)***	(5.78)***	(4.45)***	(4.35)***
Soil quality				
Medium[d]	0.004	0.004	0.006	0.007
	(0.45)	(0.53)	(0.81)	(0.87)
Teuf	-0.036	-0.034	-0.025	-0.024
	(2.88)***	(2.69)***	(2.27)**	(2.14)**
(Interaction terms)				
Membership in cooperatives ×				
HH size		0.003		0.004
		(0.86)		(1.47)
HH head literacy		0.008		0.000
		(0.59)		(0.03)
Distance to Market		-0.000		-0.000
		(0.51)		(0.65)
Access to irrigation		-0.058		-.058
		(5.21)***		(5.91)***
Receives off-farm income		0.006		0.006
		(0.51)		(0.50)
Constant	0.622	0.625	0.623	0.628
	(37.01)***	(31.85)***	(41.62)***	(37.66)***
R^2	0.43	0.43	0.43	0.43
N	1452	1452	1634	1634

[d] Medium refers to households that own both fertile and infertile lands and *Teuf* refers to the households that own infertile lands. Households that own fertile lands are omitted for reference. t-statistics in parenthesis. *** Significant at 1% level, ** significant at 5% level and * significant at 10% level.

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

The impact of cooperative membership on households' technical efficiency increases with the number of family members and decreases with access to irrigation. On the other hand, we found that technical efficiency gains due to membership are not significantly affected by household head literacy, distance to market and off-farm income.

Other variables accounted for in the regression are also significant determinants of technical efficiency with expected signs. While household size, household head literacy and access to irrigation significantly increase households' level of technical efficiency; distance to market and obtaining off-farm income by households adversely affect efficiency. Although they positively affect efficiency, the economic significance of input variables (i.e., fertilizer use, use of improved seed and numbers of oxen owned) is found to be much lower. Among village level characteristics, households living in a *kebele* with a farmer-training center are found to be more efficient by about 4 percentage points.

In all, although the magnitude or economic significance is not as high as expected, the results obtained suggest participation in agricultural cooperatives resulted in technical efficiency gains among smallholder farmers. We consider that this efficiency difference can be due to greater benefit of agricultural cooperatives in farm technology/inputs adoption by lowering costs and improving members' access to productive inputs and services (Abebaw and Haile, 2013; Getnet and Tsegaye, 2012). As presented in Table A5, we also found considerable impact of cooperatives membership in use of farm inputs (i.e., fertilizer and improved seeds). Moreover, benefits of cooperatives in linking smallholders to extension services can be also the sources of this efficiency gaps between members and non-members, as recent study by Rodrigo (2012) found a positive effect of agricultural cooperatives in increasing farmers involvement in agricultural extension programs in Ethiopia that results in productivity growth among members.

5.2. Impact heterogeneity

The above results obtained from the matching estimates assume a homogenous treatment effects among cooperative member households. However, treatment impacts can vary within cooperative members, as households are distinct in their socio-economic realities. In order to understand potential impact heterogeneity within members, we graph the distribution of cooperatives' impact on members level of technical efficiency (i.e., the difference between actual observed technical efficiency and corresponding matched values obtained from the estimation of ATT) based on the results from Kernel matching estimates.

While the impacts are normally distributed, we observe some variations of membership impact on technical efficiency within members across the two samples (Figure. A1). For large proportion of members, involvement in cooperatives results in about 5-15 per cent efficiency gains as compared to non-members. For the remaining few member households we notice both efficiency gains and losses ranging from 20-40 per cent as compared to their counterparts. We further regress technical efficiency gains due to membership in cooperatives obtained from kernel matching estimates by household characteristics, with the purpose of understanding the determinates or correlates of observed impact variations within members.

The results from the regression suggests that the impact of membership in cooperatives on technical efficiency significantly increases with cultivated land size, application of improved seeds and access to irrigation and farmer training center and decreases with distance to market, off-farm income and sex of household head (Table A6). It implies that technical efficiency gains from cooperative membership is better responsive for member households with large and irrigated land holding and resides in villages with farmer training centers. The lower impact of cooperatives membership for members away from local market on the other hand can be due to higher costs of accessing the services provided by the cooperatives, as most of the cooperatives in Ethiopia are located closer to nearest markets. Conversely the results indicate that household head literacy, access to media, as measured by radio ownership and application of fertilizer does not explain variations in efficiency gains within members.

6. Conclusions

Over the past decade and a half, agricultural cooperatives in Ethiopia have strongly promoted as instrument to transform subsistence agriculture by preserving market options and increasing farmers' income, as they are believed to be efficient in internalizing transaction costs, reducing the variability of farmers' income through risk pooling and countervailing opportunistic behaviors (Hogeland, 2006; Staatz, 1987). Though many variations in the agricultural cooperatives model can be distinguished, typical agricultural cooperatives in Ethiopia combine both agricultural supply and marketing activities. Currently, agricultural cooperatives market more than 10 percent of farmers' produce and supply farm inputs for all farm households irrespective of membership. Although their share in input and output marketing shows how vibrant the cooperatives are in supporting agricultural transformation, empirical studies on their efficiency and productivity impacts are very limited.

Using household data drawn from the Ethiopia Agricultural Marketing Household Survey in 2008, this paper aims to understand the impact of membership in agricultural cooperatives on technical efficiency in a context where membership incentives can result in efficiency gains. We assume that the establishment of cooperatives in Ethiopia has been independent of community and household level characteristics due to negative experiences in the past and current policies on cooperative formation (i.e., one cooperative for each *kebele*). Moreover, we assume that difference in technology between members and non-members is insignificant, as agricultural cooperatives in Ethiopia are required to supply basic farm inputs for all farm households. In addition, the role of spillover effects cannot be underestimated. With these assumptions, we used Propensity Score Matching techniques to compare the average technical efficiency difference between cooperative member households and independent farm households living within the same *kebele* in which agricultural cooperatives operate.

Our results consistently indicate a positive and significant impact of agricultural cooperatives on members' levels of technical efficiency. On average members are better situated to get maximum possible output from a given set of inputs used, by at least five percent. These results are in line with the predicted role of agricultural cooperatives in improving efficiency by providing easy access to productive inputs and embedded support services such as training, information, and extension on input application. The robustness of the findings is demonstrated by similar results obtained from different approaches and techniques. However, as compared to the results of the descriptive statistics, the impact based on the average treatment effect is lower, which indicates the existence of variation or heterogeneity across households within members.

In general, the efficiency gains from membership in agricultural cooperatives emerged from the analysis has important policy implications. It suggests that besides their progressive role in input and output marketing, agricultural cooperatives in Ethiopia are effective in providing embedded supportive services, significantly contributing to members' technical efficiency. Therefore, promoting agricultural cooperatives as complementary institutions to public extensions services should further enhance smallholders' technical efficiency.

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APPENDIX

Tab. A1 - Detecting the presence of inefficiency component

	Dependent Variable: Production Value in Birr (logged)		
Input variables	Coefficient	Std. Err.	Z-ratio
ln (Land size held by household (ha))	1.356	0.062	(21.81)***
ln (Seed used (Kg))	0.105	0.017	(6.12) ***
ln (Fertilizer used (Kg))	0.041	0.009	(4.25)***
ln (Labor (owned in adult equivalent))	-0.036	0.056	(0.64)
ln (Labor (hired in number of days))	0.047	0.015	(3.04)***
ln (Number of ox owned)	0.537	0.043	(12.36)***
Constant	6.246	0.123	(50.48)***
Lambda	1.557	0.091	
Gamma ($\gamma = \lambda^2 / (1+\lambda^2)$)	0.52		
Number of observation	1638		
Wald chi2 (6)	1568.61		
Prob > chi2	0.0000		
Log likelihood function	-1871.602		
Log likelihood ratio test of sigma_u chibar2 (01)	24.96		

Note: *** Significant at 1% level, ** significant at 5% level and * significant at 10% level.

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

Tab. A2 - Maximum Likelihood (ML) estimates of the parameters for Stochastic Production Frontier (SPF) function and technical inefficiency determinants

Production function	Dependent variable: production value in Birr (logged)		
	Coefficient	Std. Err.	Z-ratio
ln (Land size held by household (ha))	1.161	0.637	(18.20)***
ln (Seed used (Kg))	0.073	0.017	(4.21)***
ln (Fertilizer used (Kg))	0.039	0.009	(4.05)***
ln (Labor (owned in adult equivalent))	-0.175	0.086	(2.03)**
ln (Labor (hired in number of days))	0.048	0.014	(3.34)***
ln (Number of oxen owned)	0.487	0.042	(11.34)***
Constant	6.576	0.167	(39.29)***
Technical inefficiency component			
Household size	-0.047	0.050	(0.95)
Gender of household head	0.712	0.215	(3.31)***
Age of household head	-0.006	0.005	(1.14)
Household head read and write	-0.238	0.164	(1.45)
Distance to local market	0.002	0.001	(1.73)*
Number of plots held	0.115	0.033	(3.48)***
Number of crops planted	-0.708	0.194	(3.64)***
Household access to irrigation	-4.193	3.212	(1.31)
Household receives off-farm income	0.186	0.163	(1.14)
Membership in cooperatives	**-0.539**	**0.194**	**(2.78)*** **
Household access to institutional credit	0.059	0.179	(0.33)
Constant	-0.118	0.521	(0.23)
Sigma V	0.618		
Number of observation	1638		
Wald chi2 (6)	947.13		
Prob > chi2	0.0000		
Log likelihood function	-1790.492		

Note: *** Significant at 1% level, ** significant at 5% level and * significant at 10% level.

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

Tab. A3 - Propensity scores blocks for members and non-members in *kebeles* with agricultural cooperatives (only observations within common support) –reduced sample

Block of Pscore	Members	Non-members	Total
0.026	43	248	291
0.2	60	196	256
0.3	96	174	270
0.4	37	73	110
0.45	46	47	93
0.5	92	76	168
0.6	82	46	128
0.7	67	19	86
0.8	41	4	45
Total	564	883	1447

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

Tab. A4 - Propensity scores blocks for members and non-members in *kebeles* with and without agricultural cooperatives (only observations within common support) – whole sample

Block of Pscore	Members	Non-members	Total
0.015	54	448	502
0.2	65	206	271
0.3	97	153	250
0.4	76	120	196
0.5	76	68	144
0.6	149	58	207
0.8	47	8	55
Total	564	1061	1625

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

Tab. A5 - Average impact of cooperative membership on agricultural input adoptions

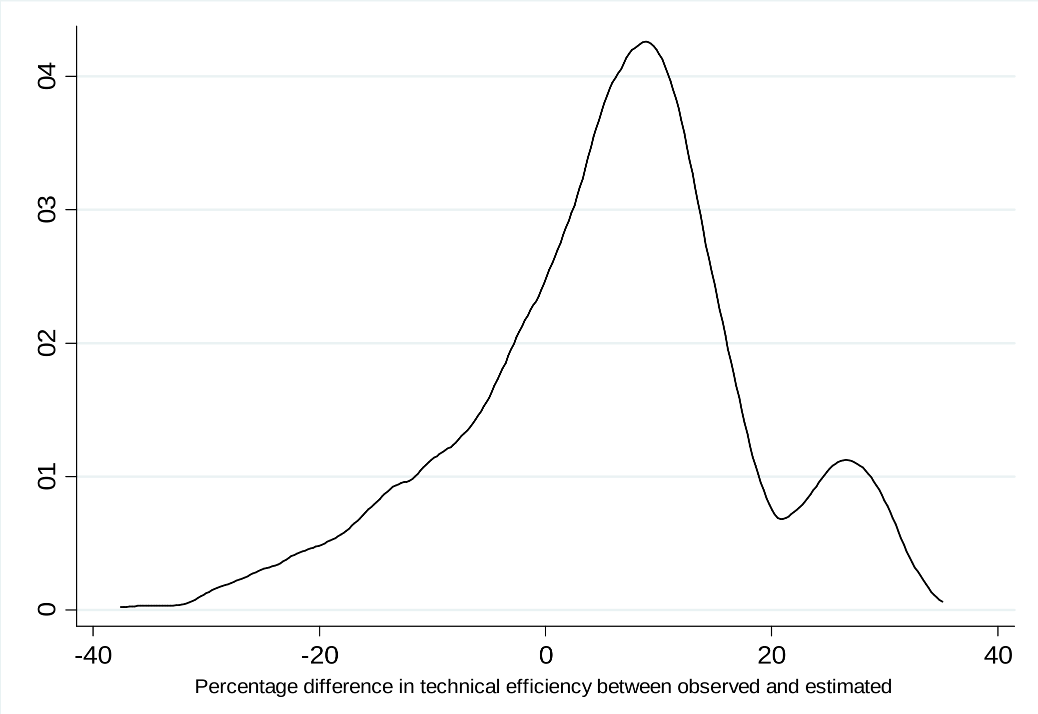
Indicator	Kernel-based matching		Five nearest neighbors matching		Number of Obs.
	ATT	Std. Err.	ATT	Std. Err.	
Sample 1					
Fertilizer (total amount in kg)	48.66	6.74***	49.55	7.73***	1455
Fertilizer (kg/ha)	31.32	4.88***	32.78	5.49***	1455
Improved seed (total amount in kg)	4.45	1.22***	4.40	1.39***	1455
Sample 2					
Fertilizer (total amount in kg)	46.13	6.81***	44.06	7.46***	1638
Fertilizer (kg/ha)	30.42	4.66***	29.67	6.26***	1638
Improved seed (total amount in kg)	4.52	1.18***	4.48	1.29***	1638

Note: Sample 1 includes members and non-members only from *kebeles* with agricultural cooperatives; Sample 2 includes the whole sample (i.e., members and non-members from *kebeles* with and without agricultural cooperatives).
Bootstrap with 100 replications is used to estimate the standard errors.
*** Significant at 1% level.

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

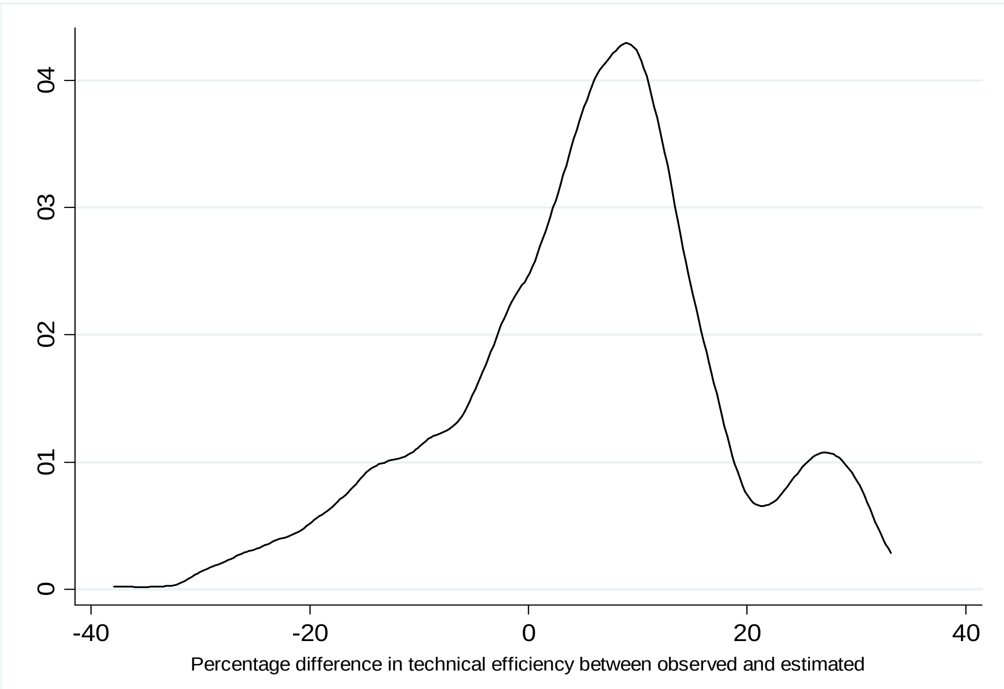
Fig. A1: Distribution of cooperative membership impacts based on the results from Kernel matching estimates

(a) Sample 1: members and non-members only from kebeles with agricultural cooperatives



Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

(b) Sample 2: members and non-members from kebeles with and without agricultural cooperatives



Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.

Tab. A6 - Correlates of variations in impact of cooperative membership on technical efficiency within members

Indicator	Dependent variable: Technical efficiency gain from membership	
	Sample 1	Sample 2
HH head age	0.000 (0.76)	0.000 (0.46)
HH head gender	-0.047 (2.19)**	-0.055 (2.58)**
HH head literacy (1= Yes, 0= No)	-0.002 (0.27)	0.004 (0.42)
Distance to market (Minutes)	-0.000 (1.68)*	-0.000 (1.51)
Access to irrigation (1= Yes, 0= No)	0.231 (25.18)***	0.238 (27.47)***
Receives off-farm income (1= Yes, 0= No)	-0.033 (4.01)***	-0.035 (4.21)***
Radio ownership	0.012 (1.26)	0.012 (1.25)
Land cultivated (ha)	0.015 (2.86)***	0.015 (2.92)***
Number of plots	-0.003 (1.56)	-0.003 (1.42)
Number of Oxen	-0.006 (1.24)	-0.004 (0.90)
Reside in village with FTC (1= Yes, 0= No)	0.037 (2.66)***	0.042 (2.86)***
Improved seed (Amount used in Kg)	0.000 (1.95)*	0.000 (1.88)*
Fertilizer (Amount used in Kg)	-0.000 (0.14)	-0.000 (0.26)
Constant	0.095 (2.77)***	0.099 (2.86)***
Number of Obs.	559	549
R-Squared	0.37	0.39

Note: *** Significant at 1% level, ** significant at 5% level and * significant at 10% level.
t-statistics in parenthesis.

Source: Authors' calculations, based on data from Ethiopia Agricultural Marketing Household Survey, 2008.