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Bioeconomics Working Paper Series

Working Paper 2013/6

An updated version of this working paper is published as:

Verhofstadt, E., Maertens, M. (2014). Smallholder cooperatives and agricultural performance in Rwanda: do organizational differences matter?. *Agricultural Economics*, 45 (S1), 39-52



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Cooperative membership and agricultural performance: Evidence from Rwanda

Ellen VERHOFSTADT¹ and Miet MAERTENS¹

Abstract

Agricultural policies in Rwanda focus on agricultural intensification and increased market orientation of the smallholder farm sector. Cooperatives are seen as key vehicles in this but little is known about their effectiveness to achieve these goals. In this paper we analyze the impact of cooperative membership on agricultural performance for rural households in Rwanda. Cross-sectional household data, collected in 2012, are used to analyze the impact of cooperative membership on different agricultural performance indicators. We specifically look at the diversity in cooperatives and distinguish different types of cooperatives in several ways. We use several econometric techniques to deal with potential selection bias in estimating the impact of cooperative membership, including a proxy variable method based on a willingness to pay measure and propensity score matching (PSM) methods. We find that cooperative membership in general has a positive impact on different farm performance indicators but that these effects are driven by specific types of cooperatives.

Keywords: agricultural cooperatives, technology adoption, institutional innovation, farm productivity, farm income, Rwanda

JEL codes: Q13, Q12, O13, D13

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Acknowledgement

The authors acknowledge funding from VLIR-UOS (Vlادoc scholarship program) and the KU Leuven Special Research Fund (OT program). The authors thank the National University of Rwanda in Butare for their support with field work. The authors thank conference and seminar participants in Leuven, Gent and Mekelle for comments on earlier versions of the paper.

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Cooperative membership and agricultural performance: Evidence from Rwanda

1. Introduction

Smallholder agriculture is argued to remain important for economic development and poverty reduction in developing countries but its development is challenged by the need for institutional innovations to overcome market failures (World Bank, 2008; Hazell et al., 2010). There is a renewed interest from donors, governments and researchers in cooperative producer organizations as an institutional vehicle to improve smallholder agricultural performance, particularly through improved market participation (Bernard and Spielman, 2009; Fisher and Qaim, 2012a; 2012b). While pre-structural- adjustment cooperatives in developing and centrally-planned economies have largely proven to be inefficient and unsustainable (see e.g. Deininger, 1995; Swinnen and Maertens, 2007), contemporaneous cooperative producer organizations are argued to be different from their predecessors and to benefit smallholder farmers by reducing transaction costs in input and output markets and improving bargaining power vis-à-vis buyers (Markelova et al., 2009; Bernard and Taffesse, 2012).

The literature documents successes and failures of contemporaneous agricultural cooperatives. There are recent examples from all over the world of a positive impact of cooperative membership on specific aspects of smallholder farm performance. Ito, Bao and Su (2012) show that membership in a cooperative has a strong positive effect on the income of watermelon farmers in China. Vandeplass, Minten and Swinnen (2013) find that dairy farmers in India are more efficient and have higher profits when organized in a cooperative. Abebaw and Haile (2013) and Francesconi and Heerink (2010) respectively show that cooperative membership in Ethiopia increases the adoption of improved agricultural technologies, especially mineral fertilizer, and the rate of commercialization. Holloway and co-authors (2000) show that cooperatives increase market participation among dairy farmers in Ethiopia. Fisher and Qaim (2012a) find that cooperative membership leads to higher prices and higher farm incomes among banana farmers in Kenya. Shiferaw, Obare, Muricho and

Silim (2009) show that membership in grain cooperatives in Kenya lead to increased adoption of improved varieties, higher producer prices and larger marketable surpluses. Wollni and Zeller (2007) indicate that cooperative membership facilitates access to more lucrative specialty markets in the coffee sector in Costa Rica. But, likewise, there is evidence of a lack of success of cooperatives to improve farm performance. Bernard, Taffesse and Gabre-Madhin (2008) and Bernard and Taffesse (2012) indicate that grain marketing cooperatives in Ethiopia, while offering higher prices, do not succeed in increasing commercialization. Mujawamariya, D'Haese and Speelman (2012) point to problems of double side-selling in coffee cooperatives in Rwanda. Hellin and co-authors (2009) conclude that producer organizations in the maize sector in Mexico are not successful because the cost of the organization is not compensated by an increased income from sales.

These impact studies focus on a single cooperative, on multiple cooperatives in a single sub-sector, or on various cooperatives but very few of them explicitly look at differences in impact across different cooperatives. Various authors distinguish and characterize different cooperatives; e.g. producer-owned versus investor-owned cooperatives, member-controlled versus state-controlled cooperatives, collective action versus government-initiated cooperatives, open versus closed cooperatives, marketing versus producer cooperatives, and single-purpose versus multipurpose cooperatives (Sykuta and Cook, 2001). Ito and co-authors (2012) argue that agricultural cooperatives in China include a wide range of producer organizations with important differences but they do not explore potential heterogeneous impacts. Review articles on different agricultural cooperatives in developing countries (Barham and Chitemi, 2009; Markelova et al., 2009) conclude that the success of cooperatives depends on the characteristics of the groups as well as on the type of products and markets. It has e.g. been suggested that cooperatives are more successful in higher-value products and less in grain and legume markets (Bernard and Spielman, 2009). While these studies point to an important heterogeneity among cooperatives, there is almost no

quantitative evidence on how this heterogeneity affects the impact cooperatives have on smallholder farm performance. An exception is the study by Fisher and Qaim (2012a) on cooperatives among banana farmers in Kenya; they do look at heterogeneity across cooperative groups and find that older groups perform better. They explain this finding by the fact that, when technology adoption and production of perennial crops are involved, the benefits of group membership do not occur instantly. There is a need to better understand what type of contemporaneous agricultural cooperatives are most successful in stimulating the development of the smallholder farm sector in developing countries.

In this paper, we analyze the impact of cooperative membership on farm performance in Rwanda. We specifically look at the diversity in cooperatives and distinguish different types of cooperatives in several ways, for example based on the sub-sector (maize or horticulture cooperatives), on who initiated the cooperative (collective-action or government-initiated cooperatives), or on the labor arrangements within the cooperative (communal or individual). We use several econometric techniques to deal with potential selection bias in estimating the impact of cooperative membership, including an innovative proxy variable method and propensity score matching methods. We find that cooperative membership in general has a positive impact on different farm performance indicators but that these effects are driven by specific types of cooperatives.

Rwanda is a particularly interesting case to study the impact of cooperative membership on farm performance. The agricultural sector is of particular economic importance in the country, making up more than one third of GDP and close to 90% of employment, and is seen as a key growth-engine for economic development and poverty reduction (Gor, 2011; World Bank, 2011). Strategies and policies for agricultural development in Rwanda focus on intensification and increased market orientation of the predominant smallholder farms. Cooperatives are seen as an important vehicle to achieve this and the number of agricultural cooperatives in the country has expanded very rapidly during

the past couple of years (GoR, 2011;USAID, 2013). There is however a wide diversity with respect to the type of cooperatives that emerge and the way they function, and likely also with respect to their success in promoting intensification, increasing market orientation, and stimulating agricultural growth. There is, however, very few quantitative evidence of the impact of cooperatives on the performance of the smallholder farm sector. Most studies on cooperatives in Rwanda are qualitative studies that focus on the functioning of and entry into cooperatives. Researchers have pointed out that cooperatives in Rwanda are top-down and exclusive, that they undermine land tenure security and investment in improved land management practices (Ansoms, 2009; 2010; Nabahungu and Visser, 2011; Pritchard, 2013). Quantitative evidence on the impact of cooperative membership on farm performance can complement these qualitative insights.

2. Case study and data collection

We use original household survey data collected between February and March 2012 in Muhanga, an administrative district in the Southern province of Rwanda (Figure 1). Explorative field visits in 2010 and 2011 revealed that the district of Muhanga hosts a variety of agricultural cooperatives, with a clear distinction between cooperatives involved in cereal (maize) production and marketing, and cooperatives involved in horticulture.

[Figure 1]

A three-stage stratified random sampling technique was used and resulted in the selection of 401 households. In the first stage, we selected 16 cooperatives. Based on government reports and personal communication with local government officials and the local cooperative support organizations, we identified 26 active cooperatives in the district. We stratified these according to where cooperatives sell their produce: cooperatives only selling at local wet markets and the urban market in Gittarama (the provincial capital); cooperatives also selling to traders from more distant markets; and cooperatives with experience in selling

to processing companies and exporters. We randomly selected cooperatives from these strata: 7 out of 12 from the first group, 5 out of 10 from the second group, and all 4 from the last group. In the second stage, we identified the villages where these 16 cooperatives are active and made a random selection of 40 villages (*umudugudu*'s) out of 61. In the third stage, we stratified households in these villages according to cooperative membership, and selected 263 cooperative member households, belonging to 16 different cooperatives, and 138 control households. Cooperative members were oversampled because of our specific interest in the different cooperatives. To correct for this oversampling, we use sampling weights in our descriptive analysis. These are calculated as the inverse of the probability of being selected in the sample, using information from the cooperatives and from detailed census data. While cooperative members account for 65% of the households in the sample, they make up 28,8% of the population when sampling weights are taken into account. For the analysis in this paper, we use 389 households. We dropped 12 cooperative member households from the sample because the cooperative they indicated to belong to, is not known and not included in the list of 26 cooperatives active in the district.

We developed and used a quantitative structured questionnaire, including different modules on household demographic characteristics, land and non-land asset holdings, agricultural production, cooperative membership, off-farm employment and income, non-labor income, food security, intra-household decision-making, and savings and credit. Some of these modules – e.g. on food security and intra-household decision making, were specifically directed to the spouse, who was interviewed separately. A final and specific module of the questionnaire includes a bidding game. With this game we elicited respondents' willingness to pay to become a cooperative member. The bidding game was implemented with both actual cooperative members and non-cooperative members. As there is a variety of cooperatives active in the area, we refer to a specific cooperative in the game. This is the cooperative they are member from for actual cooperative members and a selected cooperative

that is prevalent in the village for non-cooperative members. We use an iterative bidding game that involves a sequence of dichotomous choice questions, in which the highest bid is set at 200.000 RWF² and the lowest at 1.000 RWF. The highest bid corresponds to the highest actual membership fee among the cooperatives in the survey area. The iterative bidding game method has been widely used by other economists (e.g. Whittington et al., 1993; Frew, 2004) and has been proven to be a suitable and reliable technique in developing countries (Whittington 1998; Onwujekwe and Nwagbo, 2002; Dong et al., 2003).

The household survey data were complemented with data from a survey among the 16 selected cooperatives. This includes data on cooperative activities, investments, credit, sourcing and marketing strategies, and organizational set-up.

3. Cooperatives in Rwanda

3.1. Importance of cooperatives

As mentioned in the introduction, cooperatives are seen as an important vehicle to increase intensification and market orientation of the smallholder farm sector, and the number of cooperatives is expanding rapidly. In 2008, Rwanda had approximately 1.500 registered cooperatives³ of which 43% active in agriculture, and 186.000 cooperative members of which 54% in an agricultural cooperative. Agricultural cooperatives are most prevalent in the horticulture, coffee and maize subsectors (table 1). According to the latest (unofficial) estimations, the number of cooperatives has increased to 5.000, comprising about 2,5 million members (USAID, 2013) and about 2.400 agricultural cooperatives (MINECOFIN, 2007). The overall number of cooperatives is likely to further increase as all pre-cooperative associations are required by law to register as official cooperatives (ILO, 2010).

² 200.000 RWF corresponds to about 310 Euro; 1.000 RWF corresponds to about 1.55 Euro.

³ According to the Rwanda Cooperative Agency, “a cooperative is an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise, according to internationally recognized co-operative values and principles”. Cooperatives are expected to be “voluntary organizations; open to all persons able to use their services and willing to accept the responsibilities of membership, without gender, social, racial, political or religious discrimination”. Cooperative members in Rwanda have by law equal voting rights (one member, one vote) (RCA, 2011).

[Table 1]

The National Land Policy (GoR, 2004) has played a role in the founding of cooperatives. Specifically for the cultivation of the fertile and highly-productive marshlands, the regulation stipulates these areas as a special category of public, thus state-owned, land with usufruct rights in the form of concessions and with the allocation responsibility within the Ministry of Lands and Environment. Land consolidation projects have been introduced to avoid parceling of this valuable agricultural land. Cultivation of the marshlands is regulated by the government and only accessible for official cooperatives. The Government of Rwanda believes these measurements are necessary to move from “*a mediocre agriculture that has no future, characterized by tiny plots on which the prevailing crops are sweet potatoes, sorghum and beans for domestic consumption*” towards improved (mode of) production on marshlands with technical innovations (GoR, 2004). Besides access to productive marshland areas, cooperatives also play a role in distributing subsidized inputs, especially fertilizer (World Bank, 2010). With an average mineral fertilizer use of 4kg/ha, the government encourages increased fertilizer application, by distributing the input through rural cooperatives at subsidized prices.

3.2. Maize and horticulture cooperatives

There is a large diversity among agricultural cooperatives in Rwanda. Besides the focus on different crops, there are marketing cooperatives, producer cooperatives⁴ and intermediate forms of cooperatives. Cooperatives differ in size, with regard to the number of members and/or the area under cultivation. Cooperatives can be founded voluntarily by farmers’

4 In producer cooperatives members undertake joint agricultural production and some services and production inputs might be supplied by the cooperative. Often, labour is pooled on private plots. In marketing cooperative some services and production inputs might be supplied and the cooperative markets members’ produce and surpluses are shared based on a member’s volume sold through the cooperative. In these cooperatives, assets are commonly not pooled (Bratton, 1986; Onumah et al., 2007)

collective action or can be government-initiated. We focus on maize and horticulture cooperatives and first explore the difference between these two types of cooperatives, using cooperative and household survey data.

In table 2 we summarize some general cooperative characteristics of the 5 maize and 11 horticulture cooperatives, and the 134 maize and 117 horticulture cooperative members in our sample. Maize cooperatives are on average larger than horticulture cooperatives, with larger initial capital investments, more members, and larger cooperative field sizes. The membership fee in both types of cooperatives is similar but is now much higher than at start-up, which relates to the fact that members already have invested in the cooperative during the past years and that new members are expected to compensate for this. All maize cooperatives and 50% of the horticulture cooperatives are government-initiated while the other 50% of horticulture cooperatives emerged through collective action. Comparing cooperative members, we observe that on average, members of a horticultural cooperative joined more recently – 2,8 years ago compared to 5,8 years for maize cooperative members – and paid a lower initial membership fee – 2,8 thousand RWF compared to 6,1 thousand RWF.

[Table 2]

The production and marketing arrangements differ in some aspects across the cooperatives (table 3). In fact, all cooperatives under study act as ‘land cooperatives’, meaning that cooperative members collectively purchase or rent in land, either from private land-owners or from the state. For maize cooperatives, the cooperative land is completely rented in from the state. This mostly concerns marshlands that are state-owned since the new land policy of 2004. For horticulture cooperatives, about half of the cooperative land is rented from the state, 43% is rented from private land-owners and 6% is purchased and owned by the cooperative. Apart from the cooperative land, farmers usually also cultivate their own plots which they own or rent in individually. The way production on cooperative land and marketing of the produced crops is arranged differs across the cooperatives. In all maize

cooperatives, members are allocated a specific part of the cooperative land that they cultivate individually⁵. Maize cultivation is characterized by a synchronized planting and harvesting regime. Once harvested, the produce from cooperative plots is sold through the cooperative – 80% of the maize cooperatives explicitly do not allow side-selling. Post-harvest handling and storage is organized jointly and controlled by regional state-agronomists. In 3 out of the 5 maize cooperatives, the members are paid per kg maize they harvested and delivered to the cooperative. In the other cooperatives, farmers are either paid collectively in cash or in kind, equally divided over the cooperative members, or the revenues from selling maize are kept within the cooperative as savings. After the maize season, members are free to cultivate other crops on the collective plots allocated to them. They often grow vegetables during this second season and the revenues from selling these vegetables can mostly be kept by the farmers – in one case the cooperative collects a tax on these revenues. Given that land is obtained collectively, production organized individually, and marketing organized collectively, the maize cooperatives in the sample could be broadly categorized as ‘land and marketing cooperatives’.

In 82% of the horticulture cooperatives, the members cultivate the cooperative land collectively⁶. In this case, all produce is sold through the cooperative and members are either paid a collective share of the revenue, either in cash or in kind (respectively 27% and 18% of the cooperatives), or the revenues are kept within the cooperative as savings (36% of the cooperatives). As production on cooperative land is organized through communal labor, these cooperatives can be broadly categorized as ‘land and production cooperatives’. In the other 18% of the horticulture cooperatives, the members individually cultivate an allocated part of

⁵ Marshlands that are state-owned and cultivated by cooperatives used to be under private tenure before the new land policy of 2004. The specific plots allocated to and cultivated by individual cooperative members might correspond to the plot previously owned by that farmer.

⁶ The most common crops in these cooperatives are eggplant, onions, cabbages, carrot, green beans, pineapples and strawberries.

the cooperative land, there is no cooperative marketing for the horticultural products, and members keep individual revenues from marketing these products, either with or without paying taxes to the cooperative. These cooperatives act as 'land cooperatives' where only land acquisition is done jointly.

[Table 3]

Most cooperatives offer some services, especially the provision of agricultural inputs, to their members (table 4). About one fifth of the maize cooperatives and one fourth of horticulture cooperatives put agricultural equipment, such as hoes and shovels, at the disposal of their members. The majority of cooperatives, 60% for maize and 73% for horticulture cooperatives, give some form of credit to their members. Half of the horticulture cooperatives and 60% of maize cooperatives organize trainings for their members. All maize cooperatives provide improved seeds and mineral fertilizers, either at subsidized prices (80%) or for free (20%), while only 64% of horticulture cooperatives provide improved seeds and only 27% mineral fertilizer. The provision of pesticides by the cooperatives is less common. The high level of input provision in maize cooperatives is in line with the national policy in which cooperatives are given an important role for the distribution of improved seeds and mineral fertilizers.

[Table 4]

When asked about their overall satisfaction with the cooperative, 76% of maize cooperative members and 63% of horticulture cooperative members indicate to be satisfied. Reasons for that satisfaction include a internal good organisation, good cooperation among members, and the access to inputs and services. Reasons for dissatisfaction with the cooperative include the lack of (financial) transparency and delay in payments. Of the non-member households, 74% would like to be a member of a cooperative for varying reason such as to have access to land (46%), to be organised with friends (44%), to have access to information (42%) and to have

access to credit and modern inputs (29% and 24% respectively). Reasons for not being member of a cooperative for these households, include the lack of sensibilisation and awareness about cooperative formation (21%), high membership fees (17%), lack of land to contribute to the cooperative (31%), and lack of time (21%). Twenty percent of non-member households would not like to be a cooperative member and the most quoted reasons for that are a lack of advantages from cooperative membership (33%), lack of land (19%), and lack of time or labour to work in a cooperative (32%).

3.3. Cooperative members and non-members

Before turning to an econometric analysis of the impact of cooperative membership on farm performance, it is useful to compare household and farm characteristics between member and non-member farm-households and between maize and horticulture cooperative members. This is done in table 5. This comparison shows that cooperative member households have a relatively older household head and more household members that work in agriculture but there are no significant differences between member and non-member households with regard to the household size, the composition of the household, the gender composition of the labor force, the education of the household head, and the number of siblings close by (as a measure of social capital). When comparing maize and horticulture cooperative members, there is not much difference in demographic characteristics, apart from horticulture cooperative members having a higher share of female workers.

Land- and livestock holdings are quite small in the sample, on average households only own 0,27 ha of agricultural land and 1,1 tropical livestock units. Cooperative members own significantly more land and livestock than non-cooperative members while there is no difference in land and livestock ownership between members of maize and horticulture cooperatives. Households differ substantially with respect to total and per capita household income. The household income of cooperative members is 60% larger than that of non-

members, and the income of maize cooperative members 52% larger than that of horticultural cooperative members. The income from farming makes up on average 50% of total household income, and is a lot higher for cooperative members – 380.593 RWF compared to 169.693 RWF for non-members. Also farm income per worker and gross farm revenue are higher among cooperative members. There are no differences in farm income and revenue between maize and horticulture cooperative members. When looking at farm practices, we observe that cooperative members in general and maize cooperative members in specific, sell a larger share of farm produce, spend more on inputs and use more modern technologies such as improved seeds, mineral fertilizer, pesticides and irrigation.

Whether these observed differences in farm income, farm revenue, share of produce sold and use of modern inputs is the result of cooperative membership has to be revealed through a more in-depth econometric analysis.

[Table 5]

4. Econometric approach

To assess the impact of cooperative membership on farm performance in more detail, we estimate regression models of the following type:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_k X_{ik} + \epsilon_i \tag{1}$$

The dependent variable in the model, Y_i , measures the farm performance of household i . We think about farm performance in a broad way, including agricultural intensification, market orientation, farm revenue and income. We use different performance indicators and estimate the model separately and independently for each indicator: 1/ farm income (log specified), 2/ farm income per agricultural worker (log specified), 3/ gross revenue from farm production (log specified), 4/ the share of farm produce sold, 5/ total value of agro-inputs (including fertilizers, pesticides, seeds), 6/ use of improved seeds, 7/ use of mineral fertilizer, 8/ use of pesticides, and 9/ application of irrigation practices. The latter four indicators are

binary variables, for which probit models are used, while the former are continuous variables, for which linear regression models are used. Our main variable of interest in equation (1) is D_i , a binary treatment variable for cooperative membership. We first estimate the model for membership in a cooperative in general. As we are specifically interested in cooperative diversity, we then perform the analysis separately for membership in maize cooperatives and in horticultural cooperatives. We further distinguish between cooperatives with individual versus communal labor arrangements, and between cooperatives where revenues are paid to individual members per kg produce, where revenues are paid collectively in cash or in kind, or where revenues are saved and invested in the cooperative.

As cooperative membership is likely not randomly distributed in the population, we need to be aware of selection bias. We use four different methods and models to reduce potential bias and identify the impact of cooperative membership on farm performance as accurately as possible. First, as in equation (1) we include a large vector of control variables, X_i , in the regression to reduce potential bias arising from observed heterogeneity being correlated with the error term. These include household demographic characteristics, household asset ownership, a social capital indicator and a market access indicator – as described in table 9.

[Table 6]

Second, we use a proxy variable to capture some unobserved effects. Unobserved heterogeneity can cause the variable D_i to be arbitrarily correlated with the error term, leading to selection bias in estimated coefficients. There might be various sources of unobserved heterogeneity, like differences in entrepreneurship, ability, motivation and risk preferences between cooperative members and non-members. Inspired by the work of Bellemare (2012), we use the household's willingness to pay (WTP) to become a cooperative member as an additional control variable in the regression (see equation 2) to proxy for unobserved effects

and mitigate unobserved heterogeneity bias. Households' WTP was estimated through a bidding game, as explained above. The WTP measure is a reasonable proxy for unobserved factors like ability, motivation and entrepreneurship. It is likely redundant – meaning it is irrelevant for explaining farm performance if cooperative membership and unobserved ability, motivation and entrepreneurship would be controlled for (Wooldridge, 2002). In addition, WTP captures the variation in marginal utility derived from cooperative membership – or treatment in general (Bellemare, 2012) and is likely to be closely related to unobserved ability, motivation and entrepreneurship such that potential correlation between the X's and the error term is reduced in equation 2 (Wooldridge, 2002). As unobserved factors such as ability and motivation are likely positively correlated with both cooperative membership and farm performance, we expect this method to lead to more conservative estimations of the main effects.

$$= + + + + , \forall \quad (2)$$

Third, we consider the selection bias as a sample selection problem and apply propensity score matching (PSM) to estimate the average treatment effect (ATE) of cooperative membership. This involves matching cooperative members or treated households with non-members or control households that are similar in terms of observable characteristics (Angrist and Imbens; 1996; Imbens, 2004; Caliendo and Kopeinig, 2008). We estimate the propensity score (PS) as the probability of being a cooperative member, using the vector X as conditioning factors (see equation 3). We apply kernel matching⁷, using the default Gaussian kernel, and match treated units (cooperative members) to a construct that is the weighted average of all control units (non-members) with weights depending on the propensity score distance between treated and control units. Then the ATE is calculated as the

⁷ With kernel matching all information from all control units is used, which is an advantage because our sub-sample of control units is not very large.

average of the outcome differences between treated $Y(1)$ and matched controls $Y(0)$ (Dehejia and Wahba, 2002; Imbens, 2004) (see equation 3).

$$PS = P(D=1|X)$$

$$ATE = E[Y(1) - Y(0)] = E[Y(1)] - E[Y(0)] \quad (3)$$

The reliability of propensity score matching estimators depends on two crucial assumptions. First, the conditional independence assumption requires that given observable variables, potential outcomes are independent of treatment assignment (Imbens, 2004). This implies that selection into treatment is based entirely on observable covariates, which is a strong assumption. Second, the common support or overlap condition requires that treatment observations have comparison control observations nearby in the propensity score distribution (Caliendo and Kopeinig, 2008). We address these assumptions with robustness checks and the propensity score overlap and balancing properties in annex 2. As proposed by Heckman et al. (1997) only observations in the common support region – where the propensity score of the control units is not smaller than the minimum propensity score of the treated units and the propensity score of the treated units not larger than the maximum propensity score of the control units – are used in the analysis.

Fourth, we repeat the PSM approach, using both X_i and WTP as conditioning variables in estimating the propensity score (see equation 4). In this way, unobservable characteristics are to some extent taken into account in matching cooperative members with non-members. We use the same kernel matching method as above.

$$PS = P(D=1|X, WTP)$$

$$ATE = E[Y(1) - Y(0)] = E[Y(1)] - E[Y(0)] \quad (4)$$

In summary, we apply four different methods to estimate the impact of cooperative membership in general and membership in different types of cooperatives on farm performance, using different performance indicators.

5. Results and discussion

5.1. Maize and horticulture cooperatives

The estimated effects for the main variable of interest, cooperative membership, are given in table 10 for all cooperatives, and in tables 11 and 12 for maize and horticulture cooperatives respectively. The different estimation methods are referred to as model 1 (regression on X), model 2 (regression on X and WTP), model 3 (PSM with X as conditioning variables) and model 4 (PSM with X and WTP as conditioning variables). The full regression results for model 1 and 2 for selected outcome indicators and for maize and horticulture cooperatives are, for completeness, given in annex 1 but are not discussed in the text. The robustness checks for the PSM models 3 and 4 are given and discussed in annex 2. We need to note that, in most cases, the estimated coefficients of cooperative membership are lower in model 1 than in model 2, which indicates that including WTP as a proxy variable for differences in unobserved factors reduces selection bias somehow. Likewise, the estimated effects of the PSM methods in model 3 and 4 are mostly lower than the effects in regression models 1 and 2 respectively, which is in line with PSM methods generally giving more conservative estimates (Wooldridge, 2002).

The results in table 7 show that cooperative membership in general has a strong positive effect on farm performance. We find that participation in a cooperative improves market orientation; resulting in an increase in the share of farm produce sold of 10 to 16 percentage points. In addition, cooperative membership results in increased agricultural intensification. We find large and significant positive effects on the value of inputs – effects range between 6 and 8,6 thousand RWF and are significant at the 5 or 1% level – and on the likelihood of using improved seeds, mineral fertilizer, pesticides and irrigation – marginal

effects are between 21 and 31%, except for pesticides where effects are somewhat lower, and are all significant at the 5 or 1% level. Cooperative membership also has a positive effect on gross farm revenue, net farm income and farm income per worker. Taking the most conservative results, participation in cooperatives increases gross farm revenue with 37%, net farm income with 25% and farm income per worker with 27%, which are large effects.

[Table 7]

When analyzing the impact of maize and horticulture cooperatives on farm performance separately (table 8 and 9), it becomes clear that positive findings are mainly driven by maize cooperative membership. While membership in maize cooperatives increases agricultural intensification, commercialization and farm income; membership in horticulture cooperatives has a less pronounced effect on farm performance. The results in table 8 show that membership in a maize cooperative has a positive significant effect on all performance indicators. Taking the most conservative estimates, we find that participation in maize cooperatives increases farm income with 35%, farm income per worker with 33%, gross farm revenue with 36%, the share of produce sold with 14 percentage points, and the value of inputs with 7,7 thousand RWF. It also increases the likelihood of using improved seeds, mineral fertilizer, pesticides and irrigation with 35%, 39%, 15% and 35% respectively. These are large and important effects, indicating that in the case of maize cooperatives, cooperative membership contributes to improving the performance and wellbeing of smallholder farmers in Rwanda.

[Table 8]

Horticultural cooperatives are less successful in creating gains for their members. The results indicate that membership in horticulture cooperatives significantly increases intensification and commercialization but has no effect on returns and farm income. We find that participation in horticulture cooperatives increases the value of inputs with 3,6 thousand

RWF and the share of produce sold with 7,7 percentage points. These effects are substantially smaller than the effects found for maize cooperatives. In addition, based on model 2 which gives the most conservative results, we find that there is no effect on the likelihood of using modern inputs, on gross farm revenue and farm income.

[Table 9]

Our findings that maize cooperatives in Rwanda have a positive effect on different farm performance indicators, are in line with earlier results in the literature on a positive impact of cooperative membership (e.g. Holloway et al., 2000; Shiferaw et al., 2009; Francesconi and Heerinck, 2010; Fisher and Qaim, 2012a; Ito et al., 2012; Abebaw and Haile, 2013). Our finding that maize cooperatives have a much higher impact on farm performance than horticulture cooperatives does not correspond to the prevalent view in the literature that cooperatives are most successful for higher-value products (Barham et al., 2009; Bernard and Spielman, 2009). Most previous studies have indicated positive effects of cooperative membership for products such as fruits, dairy and coffee, and a lack of impact of cooperative membership for grain and legume crops (Bernard et al., 2008; Bernard and Taffesse, 2012); except for Shiferaw and co-authors (2009) who document positive effects of grain cooperatives on technology adoption in Kenya. It is not very likely that differences in findings are solely related to the type of crop and its characteristics in terms of value, perishability, quality differentiation, etc. Our results might be related to differences in the maize and horticultural markets in Rwanda. The market for maize is well established with a structured trading system, many traders and millers, and substantial government support. The market for horticultural crops is less developed and started to receive government support more recently.

But likely, also the characteristics of the cooperatives themselves matter to explain the observed heterogeneity in impact between maize and horticulture cooperatives. As discussed in section 3, there are important differences between the two types of cooperatives. Maize

cooperatives are larger and older (table 2). It has been argued that smaller (and more homogenous) groups function better because of more cohesion but that larger groups can achieve economies of scale (Markelova et al., 2009; Fisher and Qaim, 2012a); our results seem to support the latter argument. The longer experience (or maturity) of maize cooperatives might also partially explain their better outcome. In addition, maize cooperatives are all government-initiated while half of the horticulture cooperatives are initiated through collective action (table 2). It has been argued that the institutional arrangements in government-initiated cooperatives are problematic because rules and regulations are imposed rather than developed by the members themselves (Sykuta and Cook, 2001; Markelova et al., 2009). Previous research has criticized the top-down approach in Rwandan cooperatives (Ansoms, 2009 & 2010; Pritchard, 2013) but our results indicate that government-initiated cooperatives can have a strong positive impact. Our findings might be related to the fact that maize cooperatives receive more government support, e.g. through subsidized input programs. The provision of services, especially free or subsidized input provision, differs between the cooperatives and is more prevalent in maize cooperatives than in horticultural cooperatives. This likely partially explains the differences in estimated effects on intensification and input use between maize and horticulture cooperatives. Besides, also the way cooperatives function likely plays a role in explaining the heterogeneity in impact. As discussed in section 3, maize cooperatives function more as ‘land and marketing cooperatives’ – where land is obtained through the cooperative but where production is done individually – while horticulture cooperatives are more ‘land and production cooperatives’ – where land obtained through the cooperative is cultivated communally. Also the remuneration system differs, with maize cooperative members being more often paid individually per kg of produce delivered and horticulture cooperative members being more often remunerated through collective pays (table 3). These arrangements importantly affect farmers incentives and might contribute to

explaining the observed differences in impact of cooperatives membership. We explore this in more detail in the next subsection.

5.2. Differences in cooperative arrangements

We estimate models 1 and 2 with the same performance indicators but with a different classification of cooperatives⁸. We first distinguish between ‘land and marketing cooperatives’ with individual cultivation of cooperative fields (154 members), and ‘land and production cooperatives’ with communal cultivation of cooperative fields (97 members). All maize cooperatives and 2 of the 11 horticulture cooperatives belong to the first group. We then classify the cooperative in three groups according to the remuneration system: 1/ cooperatives with individual payment (85 members), 2/ cooperatives with collective payment (92 members), and 3/ cooperatives with saved revenues (74 members). The first group only includes maize cooperatives while the second and third group include both maize and horticulture cooperatives. The results of these analyses are given in table 10 and 11.

The results indicate that land and marketing cooperatives perform much better than land and production cooperatives (table 10). Not surprisingly, the estimated effects for land and marketing cooperatives are similar in magnitude and significance level than the effects found for maize cooperatives. This means that cooperatives in which land is cultivated individually, whether maize or horticulture cooperatives, produce benefits for their members in terms of increased intensification, increased commercialization and increased revenues and incomes. We find that membership in land and production cooperatives with communal labor on cooperative fields only increases the value of inputs and the rate of commercialization but not farm revenue or income.

[Table 10]

⁸ We restrict the analysis to regression methods only as PSM methods are not robust and balancing properties are not satisfied.

The results in table 11 point to differences in the impact of cooperative membership on farm performance, related to the remuneration system of the cooperatives. We find the largest and most significant effects on the likelihood of using modern inputs, on commercialization and on farm revenue for cooperatives where members are paid per kg of produce harvested and sold through the cooperatives. For cooperatives in which members are remunerated in a collective way, we find a significant positive effect of membership on the share of produce marketed but not on the value of inputs used, the likelihood of using modern inputs and irrigation, nor on farm revenue and income. For cooperatives in which revenues are saved, we find significant positive effects on gross farm revenue, the share of produce sold, the value of inputs, and the likelihood of input use but estimated effects are much smaller than for cooperative with individual payment. However, for cooperatives with saved revenues, we do find positive effects on farm income and income per worker (the latter is only significant in model 2).

[Table 11]

The findings from table 10 and 11 imply that – in addition to crop, market and other cooperative characteristics – the diversity in the way cooperatives arrange production and marketing is important in explaining differences in performance. Our results are in line with an incentive-compatibility explanation. We find the best farm performance effects for cooperatives in which farmers' incentives are least distorted, i.e. in cooperatives where production and remuneration is individually-based while land acquisition and marketing are joint.

6. Conclusion

In this paper, we analyze the effect of membership in different types of cooperatives on farm performance in Rwanda. We find that cooperative membership leads to adoption of modern inputs, increased intensification, increased commercialization of farm produce, and higher revenue and farm income. Maize cooperatives are found to perform better and to bring about more benefits for their members than horticulture cooperatives. This heterogeneity in effects can likely be attributed to differences in the characteristics of cooperative groups, differences in crops and markets, but also to differences in production and marketing arrangements in the cooperatives.

Our results support the idea that agricultural cooperatives can be an important institution to promote the transformation of the smallholder farm sector from a (semi-) subsistence farm sector to a commercial and intensified agricultural sector. Collective action is sometimes indicated as a prerequisite for cooperatives to be successful – likely as a reaction on the failure of government-controlled agricultural cooperatives in centrally-planned economic systems. However, we do not find evidence of this argument as government-initiated cooperatives in Rwanda do not perform worse than cooperatives that are initiated through collective action. Our results indicate that it is importance for cooperatives to function in a way that is compatible with famers' individual incentives.

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Figure 1 Research area in the Muhanga District of Rwanda

Source: Adapted from CGIS-NUR (2009)

Table 1 Registered cooperatives in 2008, by economic activity

	Cooperatives	Members
Total (#)	1.498	186.131
Agriculture	43%	54%
- horticulture cooperatives	26%	7%
- coffee cooperatives	19%	19%
- maize cooperatives	12%	15%

Source: own calculations based on ILO (2010)

Table 2 Characteristics of maize and horticulture cooperatives and cooperative members

	Maize cooperatives (N=5)	Horticulture cooperatives (N=11)
Average initial capital investment (RWF)	2.030.600 (2.717.570)	174.545 (237.175)
Amount of members in 2011 (#)	460 (296)	37 (31)
Total cooperative field size in 2011 (ha)	74,20 (67,23)	3,44 (2,82)
Membership fee at start-up (RWF)	4.400 (3.715)	2.958 (2.360)
Membership fee in 2011 (RWF)	29.750 (30.467)	24.000 (16.287)
Initiative to start-up cooperative		
- government-initiated	100%	50%
- collective action	0%	50%
Time of existence (years)	2,8 (1,5)	4,2 (1,7)
	Maize cooperative members (N=134)	Horticulture cooperative members ¹ (N= 117)
Member since (yrs)	5,8 (5,79)	2,8** (2,77)
Membership fee paid to coop. (RWF)	6.091 2.784*** (5.828)	(4.561)
Yearly contributions paid to coop, (RWF)	1.617 (1.893)	1.110 (2.586)
HH head is member (dummy)	66%	32%***

Notes: Mean values are shown, for continuous variables standard deviations are shown in parentheses

¹ Horticultural cooperative members are compared with maize cooperative members using t-test, *, ** and *** denote 10, 5 and 1% significance level

Source: calculations based on data from own cooperative survey (2012)

Table 3 Production and marketing arrangements in maize and horticulture cooperatives

	Maize cooperatives (N=5)	Horticulture cooperatives (N=11)
Production arrangements		
Access to cooperative land		
- Rented in from the state	100%	51%
- Rented in from individual	0%	43%
- Cooperative owned land	0%	6%
Field labor arrangements		
- individual field labor	100%	18%
- communal field	0%	82%
Marketing arrangements		
Side-selling not allowed (selling produce from cooperative fields outside the cooperative)	80%	82%
(selling own prod		
Marketing of maize		
- members are paid per kg	60%	0%
- collective pay in cash	20%	9%
- savings for cooperative	20%	18%
Marketing of horticultural products		
No cooperative marketing of horticulture products		
- income from own sales	80%	9%
- tax	20%	9%
Cooperative marketing of horticultural products		
- collective pay in cash	NA	27%
- collective pay in kind	NA	18%
- savings for cooperative	NA	36%

Source: calculations based on data from own cooperative survey (2012)

Table 4 Service and input provision by maize and horticulture cooperatives

	Maize cooperatives (N=5)	Horticulture cooperatives (N=11)
Agricultural equipment	20%	27%
Credit	60%	73%
Training	60%	50%
Improved seeds		
- no provision of improved seeds	0%	36%
- improved seeds for free	20%	64%
- improved seeds at low price	80%	0%
Mineral fertilizer		
- no provision of mineral fertilizer	0%	73%
- provision of mineral fertilizer for free	20%	18%
- provision of mineral fertilizer at low price	80%	9%
Pesticides		
- no provision of pesticides	60%	73%
- provision of pesticides for free	20%	27%
- provision of pesticides at low price	20%	0%

Source: calculations based on data from own cooperative survey (2012)

Table 5 Household and farm characteristics. according to cooperative membership

	Total sample (N=389)	Non-member households (N=138)	Member households ¹ (N=251)	Maize cooperative (N=134)	Horticulture cooperative ² (N=117)
Demographic characteristics					
Female single headed (dummy)	0,22 (0,41)	0,25 (0,43)	0,13 (0,34)	0,11 (0,31)	0,23 (0,42)
HH head age (years)	45,61 (13,3)	44,34 (13,86)	48,76** (11,33)	49,02 (11,8)	47,73 (9,33)
HH head education (yrs)	4,86 (2,9)	4,73 (2,71)	5,16 (3,31)	5,39 (3,2)	4,28 (3,6)
HH size (#)	5,03 (2,06)	4,93 (1,99)	5,29 (2,19)	5,22 (2,33)	5,56 (1,53)
HH size children (#)	2,53 (1,74)	2,57 (1,74)	2,44 (1,74)	2,35 (1,81)	2,80 (1,41)
HH size agricultural workers (#)	1,92 (0,98)	1,73 (0,85)	2,38*** (1,13)	2,38 (1,17)	2,41 (0,95)
% female workers	54% (20)	53% (20)	55% (19)	53% (18)	61%** (21)
Siblings (in law) living close by(#)	2,1 (2,5)	2,0 (2,5)	2,4 (2,4)	2,5 (2,5)	2,4 (2,0)
Household assets and income					
Land individually owned (ha)	0,27 (0,50)	0,22 (0,44)	0,38** (0,60)	0,35 (0,54)	0,54 (0,80)
Livestock (TLU)	1,1 (1,1)	0,8 (0,8)	1,8*** (1,4)	1,8 (1,5)	1,4 (1,0)
Total income (RWF)	465.650 (446.434)	398.636 (297.308)	630.319** (659.728)	677.741 (668.568)	443.690* (594.133)
Income per adult equivalent (RWF)	107.344 (95.170)	94.938 (67.643)	137.827*** (137.257)	150.143 (134.908)	89.357*** (136.880)
Farm characteristics					
Farm income	230.695 (307.925)	169.693 (179.353)	380.593*** (466.643)	401.821 (498.073)	297.053 (305.789)
Farm income per worker	122.874 (166.581)	100.205 (93.913)	178.578** (264.744)	190.775 (287.410)	130.578 (138.447)
Gross farm revenue	220.409 (270.454)	158.636 (152.059)	372.202*** (405.052)	396.221 (431.988)	277.675 (258.806)
Land cultivated individually (ha)	0,30 (0,50)	0,25 (0,36)	0,43** (0,71)	0,39 (0,64)	0,57 (0,93)
Cooperative land cultivated (ha)	0,030 (0,09)	0,00 (0,00)	0,10*** (0,14)	0,10 (0,16)	0,09 (0,07)
share of produce sold	25,7% (26)	20,3% (24)	39,1%*** (25)	43,5% (24)	21,7%*** (21)
input use (RWF)	13.252 (23.407)	7.648 (8.245)	27.114*** (38.157)	31.263 (41.583)	10.839*** (11.717)
use of improved seeds	57% (50)	43% (50)	90%*** (30)	97% (17)	64%*** (48)
use of mineral fertilizer	52% (50)	37% (48)	89%*** (32)	97% (18)	58%*** (50)
use of pesticides	36% (48)	23% (42)	67%*** (47)	76% (43)	36%*** (48)
use of irrigation	33% (47)	21% (40)	62%*** (49)	70% (46)	35%*** (48)

Notes: Mean values are shown, standard deviations are shown in parentheses

¹ Cooperative members are compared with non-members using t-test, *, ** and *** denote 10, 5 and 1% significance level

² Horticultural cooperative members are compared with maize cooperative members using t-test, *, ** and *** denote 10, 5 and 1% significance level

Source: calculations based on data from own household survey (2012)

Table 6 Control variables

Variable	Description
Demographic characteristics	
Female single HH	Dummy for single, female-headed households
HH head age (yrs)	Age of the household head in years
Square of HH head age	
HH head education (yrs)	Years of education of the household head
HH agricultural workers (#)	Number of agricultural workers in the household
HH children (#)	Number of children (age < 18 years) in the household
Asset ownership	
Land owned (ha)	The total area owned by the household, expressed in hectares
Square of land owned	
TLU	The number of tropical livestock units (TLU) possessed by the household
Social capital	
siblings close by (#)	The number of brothers and sisters of the household head and his/her partner living close by
Market access	
Distance to the market (min)	The mean distance to the market, expressed in minutes of walking distance, of the plots under cultivation

Table 7 Estimated effects of cooperative membership on farm performance

Dependent variables	Model 1	Model 2	Model 3	Model 4
log (farm income)	0,34** (0,13)	0,33** (0,15)	0,25** (0,11)	0,29** (0,12)
log (farm income/worker)	0,30** (0,13)	0,28* (0,14)	0,27** (0,12)	0,27* (0,15)
log (gross farm revenue)	0,52*** (0,11)	0,43*** (0,12)	0,37*** (0,11)	0,38*** (0,13)
share of farm produce sold	0,16*** (0,03)	0,14*** (0,03)	0,15*** (0,03)	0,10** (0,04)
Value of inputs used (RWF)	8.682*** (3.070)	7.138** (3.310)	8.672*** (1.765)	6.033*** (1.785)
Use of improved seeds (dummy)	0,26*** (0,04)	0,21*** (0,05)	0,23*** (0,05)	0,21*** (0,05)
Use of mineral fertilizer (dummy)	0,29*** (0,05)	0,25*** (0,05)	0,23*** (0,06)	0,24*** (0,07)
Use of pesticides (dummy)	0,21*** (0,05)	0,19*** (0,06)	0,13** (0,05)	0,16** (0,06)
Use of irrigation (dummy)	0,27*** (0,05)	0,22*** (0,06)	0,31*** (0,06)	0,29*** (0,06)

Notes: Estimated coefficients are reported for continuous outcome variable and marginal effects for binary outcome variables. Standard errors are shown in parentheses. Significant effects are indicated with * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$. Total number of observations is 389, of which 251 cooperative member and 138 control households.

Source: calculations based on data from own household survey (2012)

Table 8 Estimated effects of membership in maize cooperatives on farm performance

Dependent variables	Model 1	Model 2	Model 3	Model 4
log (farm income)	0,68*** (0,18)	0,62*** (0,20)	0,50*** (0,15)	0,35** (0,17)
log (farm income/worker)	0,65*** (0,18)	0,60*** (0,20)	0,49*** (0,14)	0,33** (0,14)
log (gross farm revenue)	0,73*** (0,15)	0,58*** (0,17)	0,47*** (0,12)	0,36*** (0,13)
share of farm produce sold	0,20*** (0,04)	0,17*** (0,04)	0,22*** (0,04)	0,14*** (0,05)
Value of inputs used (RWF)	12.670*** (4.723)	9.247* (5.268)	12.568*** (3.872)	7.787** (3.621)
Use of improved seeds (dummy) ^a	0,44*** (0,06)	0,40*** (0,06)	0,35*** (0,07)	0,38*** (0,08)
Use of mineral fertilizer (dummy) ^a	0,54*** (0,06)	0,47*** (0,06)	0,39*** (0,07)	0,41*** (0,08)
Use of pesticides (dummy) ^a	0,26*** (0,06)	0,26*** (0,07)	0,15** (0,07)	0,17** (0,09)
Use of irrigation (dummy) ^a	0,42*** (0,06)	0,35*** (0,07)	0,45*** (0,08)	0,46*** (0,07)

Notes: Estimated coefficients are reported for continuous outcome variable and marginal effects for binary outcome variables. Standard errors are shown in parentheses. Significant effects are indicated with * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$. Total number of observations is, of which 133 cooperative member and 138 control households

Source: calculations based on data from own household survey (2012)

Table 9 Estimated effects of membership in horticulture cooperatives on farm performance

Dependent variables	Model 1	Model 2	Model 3	Model 4
log (farm income)	0,030 (0,172)	0,0394 (0,182)	0,226 (0,174)	0,195 (0,205)
log (farm income/worker)	-0,0206 (0,171)	-0,0180 (0,181)	0,174 (0,202)	0,131 (0,244)
log (gross farm revenue)	0,328** (0,140)	0,237 (0,147)	0,466*** (0,132)	0,365** (0,148)
share of farm produce sold	0,117*** (0,0328)	0,0928*** (0,0344)	0,108*** (0,0378)	0,0770* (0,0429)
Value of inputs used (RWF)	4.419*** (1.486)	3.693** (1.569)	5.195*** (1.879)	4.123** (1.863)
Use of improved seeds (dummy)	0,133** (0,0629)	0,0899 (0,0667)	0,207*** (0,0762)	0,158* (0,0888)
Use of mineral fertilizer (dummy)	0,116* (0,0661)	0,0830 (0,0704)	0,143* (0,0813)	0,112 (0,0804)
Use of pesticides (dummy)	0,102* (0,0559)	0,0813 (0,0591)	0,114* (0,0651)	0,114* (0,0649)
Use of irrigation (dummy)	0,116* (0,0647)	0,0829 (0,0694)	0,183*** (0,0604)	0,193*** (0,0632)

Notes: Estimated coefficients are reported for continuous outcome variable and marginal effects for binary outcome variables. Standard errors are shown in parentheses. Significant effects are indicated with * * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$. Total number of observations is, of which 118 cooperative member and 138 control households

Source: calculations based on data from own household survey (2012)

Table 10 Estimated effect of membership in production and marketing cooperatives on farm performance

Dependent variables	land and marketing cooperatives with individual cultivation		land and production cooperatives with communal cultivation	
	Model 1	Model 2	Model 1	Model 2
log (farm income)	0,40*** (0,15)	0,46*** (0,17)	0,031 (0,18)	0,044 (0,18)
log (farm income/worker)	0,36** (0,16)	0,42** (0,17)	-0,029 (0,18)	-0,026 (0,18)
log (gross farm revenue)	0,49*** (0,13)	0,49*** (0,15)	0,21 (0,15)	0,19 (0,15)
share of farm produce sold	0,26** (0,13)	0,16*** (0,04)	-0,14 (0,15)	0,058* (0,035)
Value of inputs used (RWF)	9.793** (3.955)	5.566 (4.447)	4.093*** (1.574)	3.887** (1.594)
Use of improved seeds (dummy)	0,34*** (0,05)	0,33*** (0,05)	0,11 (0,07)	0,094 (0,070)
Use of mineral fertilizer (dummy)	0,39*** (0,04)	0,38*** (0,05)	0,024 (0,07)	0,023 (0,073)
Use of pesticides (dummy) ^a	0,22*** (0,06)	0,20*** (0,06)	0,050 (0,052)	0,046 (0,052)
Use of irrigation (dummy)	0,40*** (0,05)	0,38*** (0,06)	0,078 (0,07)	0,063 (0,10)

Notes: Estimated coefficients are reported for continuous outcome variable and marginal effects for binary outcome variables. Standard errors are shown in parentheses. Significant effects are indicated with * * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$. For land and marketing cooperatives with individual cultivation 154 cooperative members and 138 control households are included in the analysis. For land and production cooperatives with communal cultivation 97 cooperative members and 138 control households are included in the analysis.

Source: calculations based on data from own household survey (2012)

Table 11 Estimated effects of membership in cooperatives with individual remuneration, collective remuneration or saved revenues on farm performance

Dependent variables	cooperatives with individual payment		cooperatives with collective payment		cooperatives with saved revenues	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
log (farm income)	0,23 (0,20)	0,17 (0,24)	0,06 (0,18)	0,08 (0,19)	0,32* (0,18)	0,37** (0,18)
log (farm income/worker)	0,23 (0,20)	0,16 (0,24)	-0,006 (0,18)	0,008 (0,19)	0,27 (0,18)	0,31* (0,18)
log (gross farm revenue)	0,52*** (0,16)	0,42** (0,19)	0,21 (0,16)	0,19 (0,16)	0,35** (0,16)	0,37** (0,17)
share of farm produce sold	0,27*** (0,04)	0,19*** (0,05)	0,08** (0,04)	0,07* (0,04)	0,09** (0,04)	0,07** (0,04)
Value of inputs used (RWF)	17.409*** (5.298)	12.051* (6.308)	2.311 (1.610)	2.250 (1.653)	4.922*** (1.688)	3.963** (1.728)
Use of improved seeds (dummy)	0,44*** (0,07)	0,38*** (0,09)	0,08 (0,08)	0,08 (0,08)	0,29*** (0,07)	0,28*** (0,07)
Use of mineral fertilizer (dummy)	0,48*** (0,06)	0,45*** (0,07)	0,006 (0,08)	-0,004 (0,08)	0,29*** (0,07)	0,30*** (0,07)
Use of pesticides (dummy)	0,36*** (0,06)	0,35*** (0,07)	0,08 (0,05)	0,09 (0,06)	0,16*** (0,06)	0,16*** (0,06)
Use of irrigation (dummy)	0,46*** (0,05)	0,42*** (0,07)	0,08 (0,07)	0,04 (0,07)	0,30*** (0,06)	0,31*** (0,06)

Notes: Estimated coefficients are reported for continuous outcome variable and marginal effects for binary outcome variables. Standard errors are shown in parentheses. Significant effects are indicated with * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$. For cooperatives with individual payment 85 cooperative members and 138 control households are included in the analysis. For cooperatives with collective payment 92 cooperative members and for cooperatives with saved revenues 74 cooperative members are included in the analysis.

Source: calculations based on data from own household survey (2012)

Annex 1: Full regression results

Table A1.1 Estimated effects of membership in maize cooperative and other covariates on farm income, share of produce sold and value of inputs used, full regression results

Outcome variable	log (farm income)		share of farm produce sold		Value of inputs used (RWF)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
HH coop.member (dummy)	0,68*** (0,18)	0,62*** (0,20)	0,20*** (0,037)	0,17*** (0,041)	12.670*** (4.723)	9.246* (5.268)
Female single HH	-0,24 (0,30)	-0,22 (0,20)	-0,080* (0,042)	-0,072* (0,042)	-6.526 (5.423)	-5.517 (5.455)
HH head age (yrs)	0,052 (0,037)	0,054 (0,037)	-0,0058 (0,0077)	-0,0047 (0,0077)	-123 (989)	6 (991)
Square of HH head age	-0,0003 (0,0004)	-0,0004 (0,0004)	0,00 (0,0001)	0,00 (0,0001)	-1,76 (9,76)	-2,8 (9,76)
HH head education (yrs)	0,056** (0,024)	0,054** (0,024)	0,0029 (0,005)	0,0021 (0,005)	484 (642)	384,38 (645)
HH agricultural workers (#)	0,052 (0,070)	0,052 (0,0703)	-0,0009 (0,015)	-0,0007 (0,015)	3.231* (1.941)	3.255* (1.937)
HH children (#)	0,0079 (0,043)	0,0093 (0,043)	-0,0035 (0,0091)	-0,003 (0,009)	-1.646 (1.171)	-1.582 (1.169)
Land owned (ha)	0,013*** (0,0028)	0,013*** (0,0028)	0,0004 (0,0006)	0,0003 (0,0006)	62 (77)	48 (78)
Square of land owned	-0,00*** (0,00)	-0,00*** (0,00)	0,00 (0,00)	0,00 (0,00)	-0,082 (0,18)	-0,04 (0,18)
TLU	0,10 (0,067)	0,11 (0,067)	0,0097 (0,014)	0,011 (0,014)	5.953*** (1.816)	6.122*** (1.816)
Distance to the market (min)	0,0033 (0,0026)	0,0032 (0,0027)	0,0003 (0,0006)	0,0002 (0,0006)	-27 (72)	-30 (71)
siblings close by (#)	0,072** (0,032)	0,071** (0,032)	-0,0002 (0,0068)	-0,0006 (0,0068)	-427 (876)	-475 (874)
log (WP)		0,020 (0,030)		0,0097* (0,0063)		1.179* (811)
_cons	10*** (1,3)	9,8*** (1,3)	0,40 (0,24)	0,22 (0,23)	10.400 (31.352)	-11.391 (29.918)
Prob > F	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
R-squared	0,4317	0,4328	0,3426	0,3490	0,2449	0,2515

Notes: Estimated coefficients are reported for continuous outcome variable and marginal effects for binary outcome variables. Standard errors are shown in parentheses. Significant effects are indicated with * * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$

Source: calculations based on data from own household survey (2012)

Table A1.2 Estimated effects of membership in horticulture cooperatives and other covariates on farm income, share of produce sold and value of inputs used, full regression results

Outcome variable	log (farm income)		share of farm produce sold		Value of inputs used (RWF)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
HH coop.member (dummy)	0,026 (0,17)	0,039 (0,18)	0,12*** (0,033)	0,093*** (0,034)	4.419*** (1.486)	3.693** (1.569)
Female single HH	-0,36* (0,20)	-0,37* (0,20)	-0,019 (0,039)	-0,0082 (0,039)	-1.831 (1.749)	-1.499 (1.761)
HH head age (yrs)	0,079* (0,042)	0,079* (0,042)	-0,0013 (0,008)	-0,0012 (0,0079)	-292 (362)	-290 (361)
Square of HH head age	-0,0006 (0,0004)	-0,0006 (0,0004)	0,00 (0,0001)	0,00 (0,0001)	1,74 (3,66)	1,80 (3,65)
HH head education (yrs)	0,047** (0,023)	0,048** (0,023)	0,0077* (0,0044)	0,0065 (0,0044)	551*** (201)	515** (202)
HH agricultural workers (#)	0,097 (0,090)	0,098 (0,090)	-0,012 (0,017)	-0,013 (0,017)	233 (789)	195 (787)
HH children (#)	-0,036 (0,049)	-0,037 (0,049)	-0,020** (0,0093)	-0,018** (0,0093)	194 (423)	231 (424)
Land owned (ha)	0,013*** (0,0031)	0,013*** (0,0031)	0,0010* (0,0006)	0,0009 (0,0006)	37 (28)	33 (28)
Square of land owned	-0,00*** (0, 00)	-0,00*** (0,00)	0,00 (0,00)	0,00 (0,00)	-0,055 (0,072)	-0,040 (0,072)
TLU	0,26*** (0,083)	0,26*** (0,083)	0,0032 (0,0159)	0,0027 (0,016)	928 (722)	913 (721)
Distance to the market (min)	0,0011 (0,0029)	0,001 (0,0029)	-0,0009 (0,0006)	-0,0009 (0,0006)	56** (25)	58** (25)
siblings close by (#)	0,032 (0,035)	0,032 (0,035)	0,0037 (0,0067)	0,0032 (0,0066)	141 (302)	126 (301)
log (WP)		-0,0068 (0,029)		0,012** (0,0055)		354 (249)
_cons	9,4*** 1,5	9,5*** 1,5	0,31 0,28	0,23 0,28	8.260 12.811	5812 12.899
Prob > F	0,00	0,00	0,00	0,00	0,0001	0,0001
R-squared	0,4087	0,4088	0,2782	0,2924	0,2447	0,2514

Notes: Estimated coefficients are reported for continuous outcome variable and marginal effects for binary outcome variables. Standard errors are shown in parentheses. Significant effects are indicated with * * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$.

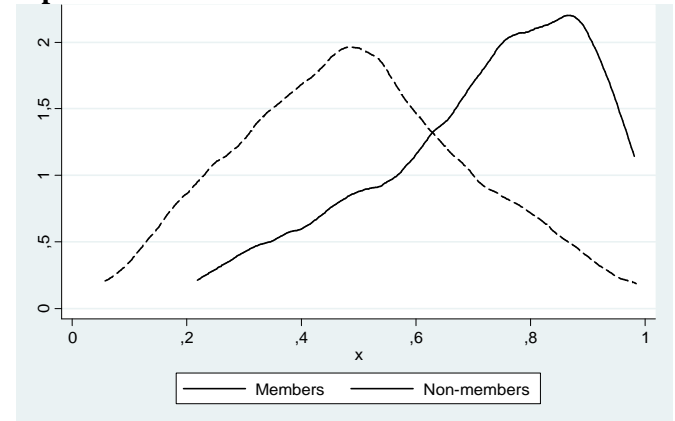
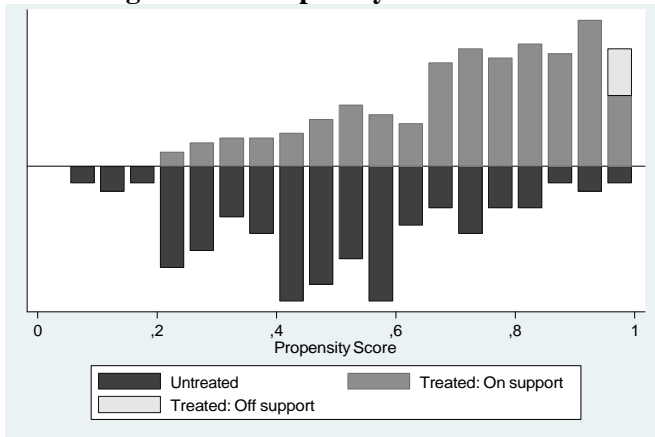
Source: calculations based on data from own household survey (2012)

Annex 2: Robustness checks for PSM estimations

Overlap and distribution of estimated propensity scores

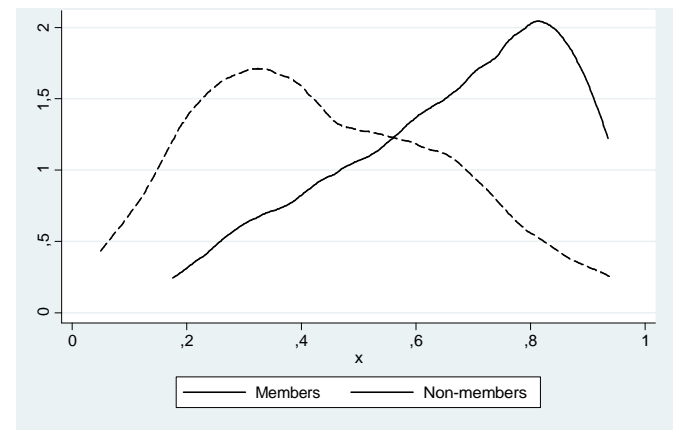
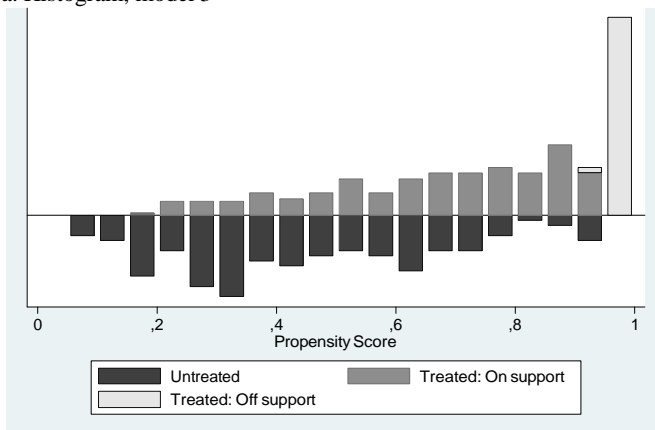
In the figures below, the propensity score distribution for member (treated) and non-member (control) households is displayed in histograms and kernel density plots for the different cooperatives and models. A visual inspection of these graphs, shows that there is sufficient overlap in the distributions between treated and untreated observations.

Figure A2.1 Propensity score distribution for all cooperatives



a. Histogram, model 3

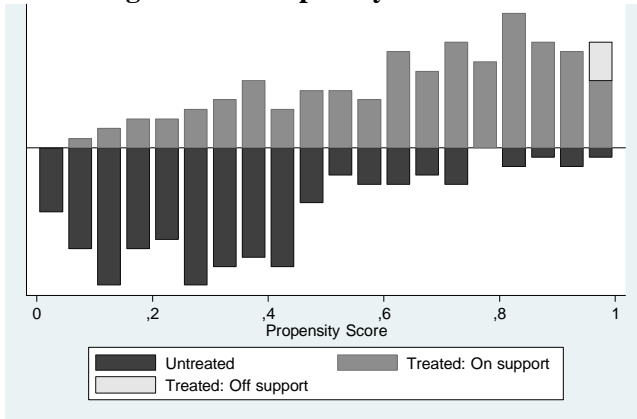
b. Kernel density plot, model 3



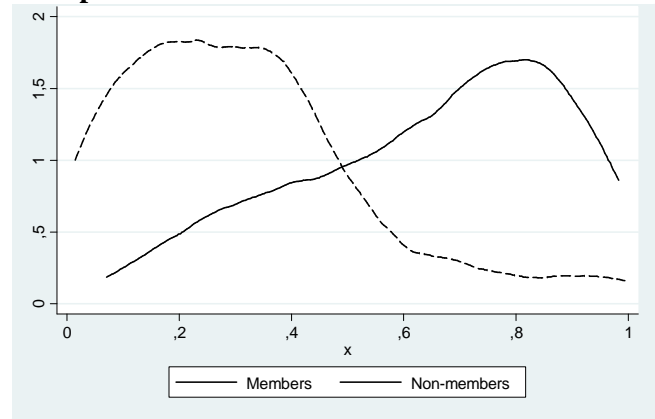
c. Histogram, model 4

d. Kernel density plot, model 4

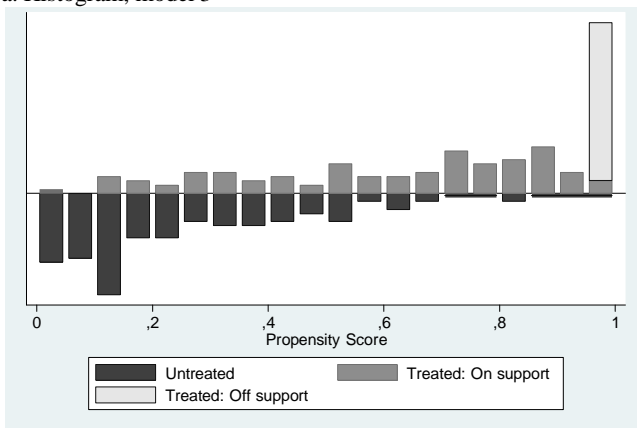
Figure A2.2 Propensity score distribution for maize cooperatives



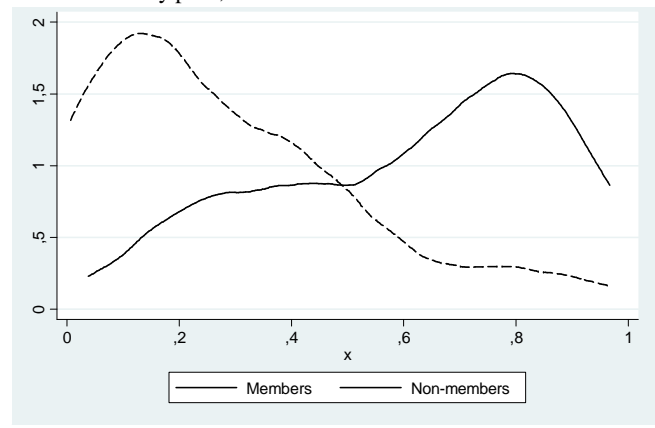
a. Histogram, model 3



b. Kernel density plot , model 3

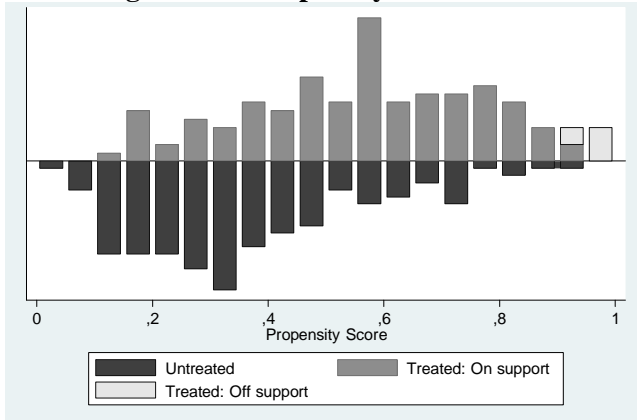


c. Histogram, model 4

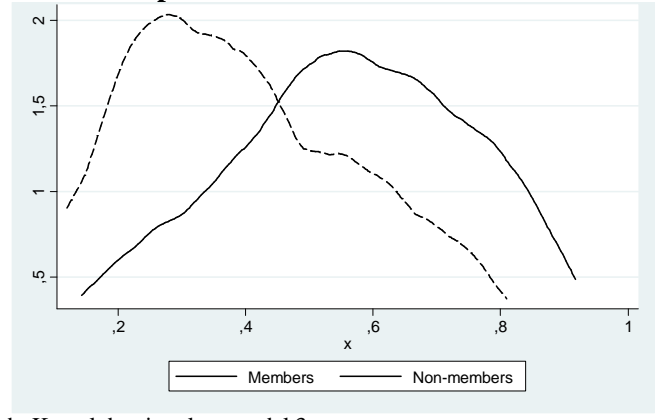


d. Kernel density plot , model 4

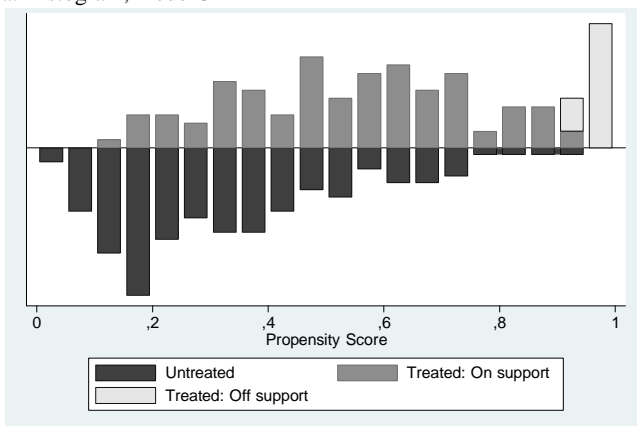
Figure A2.3 Propensity score distribution for horticulture cooperatives



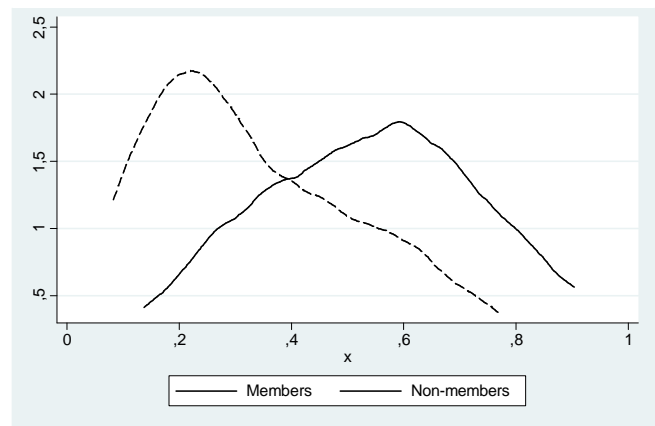
a. Histogram, model 3



b. Kernel density plot , model 3



c. Histogram, model 4



d. Kernel density plot , model 4

Balancing properties

In table A2.1. we summarize the balancing properties by presenting absolute mean and median bias, the probit pseudo-R² and the likelihood-ratio test of joint significance results before and after matching. Additionally, for all models, the balancing properties of all covariates are checked by means of standardised percentage biases before and after matching and the achieved percentage reduction post-matching and by means of t-tests to test for the equality of means in the samples before and after matching (results not shown).

Table A2.1 Balancing properties of covariates in member and non-member (control) households for kernel matching on propensity scores

Model		Mean bias	Median bias	Pseudo-R ²	LR
Total sample - Model 3	Unmatched	30,7	18,8	0,200	99,86***
	Matched	7,1	3,8	0,013	8,65
Total sample - Model 4	Unmatched	33,2	24,4	0,292	146,04***
	Matched	3,3	2,8	0,007	3,37
Maize cooperatives - Model 3	Unmatched	33,8	20,5	0,288	83,56***
	Matched	12,6	10,4	0,058	18,83
Maize cooperatives - Model 4	Unmatched	36,3	25,7	0,392	145,09***
	Matched	12,3	10,0	0,053	13,73
Horticulture cooperatives - Model 3	Unmatched	28,4	35,5	0,178	62,00***
	Matched	5,1	4,1	0,009	2,60
Horticulture cooperatives - Model 4	Unmatched	30,3	35,9	0,241	84,25***
	Matched	5,3	5,4	0,019	4,98

Source: calculations based on data from own household survey (2012)

From the absolute mean and median biases we clearly see that after the matching a large part of these biases are removed for all models. In our analysis, none of the standardized differences, after matching, have absolute values above the cut-off of 20, a standardized difference that is considered as too large (Rosenbaum and Rubin, 1985). The pseudo-R² is obtained from the probit estimation of the conditional treatment probability (propensity score) on all covariates used in matching both on the unmatched (before matching) and on the matched sample (after matching). If the propensity scores balance covariates well in a matched sample, then there should be no systematic differences in the distribution of covariates between both groups. Thus, the covariates should be similarly distributed and the pseudo-R² should be low (Caliendo and Kopeinig, 2008). In our analysis, the pseudo-R² substantially decreased after matching for all models. Further, the likelihood-ratio test of joint significance is insignificant in all models for the matched samples, which confirms the results of the previous two tests.

Conditional independence

To test the robustness of our matching estimators to failure of the conditional independence assumption, we perform a simulation-based sensitivity analysis, a method proposed by Ichino et al. (2008) and recently used in the studies of Ito et al. (2012) and Maertens et al. (2011). The results of these analyses are presented in table A2.2. Suppose that the conditional independence assumption is not satisfied given the observable covariates included in the analysis but that it would be satisfied if we would be able to observe one additional binary variable. The idea behind the method is to simulate a potential confounder in the data and use it as an additional covariate in the PSM. A comparison of the estimates obtained with and without the simulated confounder gives an indication of the extent to which the baseline estimation results are robust to specific sources of violation of the conditional independence assumption (Nannicini, 2007). We use a neutral confounder and a confounder calibrated to mimic the observable binary covariate female-headed household, as additional matching factors. The results indicate that the estimates with binary confounder differ less than 13% from the baseline matching estimators which indicates that the PSM yield robust estimates.

Table A2.2. Simulation-based sensitivity analysis

Dependent variables	Neutral Confounder			Confounder calibrated to mimic dummy for female headed households		
	Estimator effect ^a	Outcome effect ^b	Selection effect ^c	Estimator effect ^a	Outcome effect ^b	Selection effect ^c
Maize cooperatives						
log (farm income)	-1,2%	1,18	1,15	-1,2%	1,477	1,078
log (farm income/worker)	-1,4%	1,22	1,06	6,8%	1,271	1,208
log (gross farm revenue)	-1,4%	1,04	1,03	-1,4%	1,069	0,984
share of farm produce sold	0,6%	1,02	1,09	0,0%	0,292	1,195
Value of inputs used (RWF)	0,8%	1,16	1,09	-0,5%	0,367	1,310
Use of improved seeds (dummy)	0,3%	1,23	0,94	-1,2%	1,447	1,003
Use of mineral fertilizer (dummy)	-2,8%	1,12	1,09	0,5%	1,234	1,091
Use of pesticides (dummy)	1,6%	1,13	1,01	0,0%	0,968	0,986
Use of irrigation (dummy)	0,7%	1,22	1,08	0,5%	0,808	1,007
Horticulture cooperatives						
log (farm income)	-3,0%	1,248	1,06	-5,9%	1,117	2,258
log (farm income/worker)	-1,2%	1,21	1,08	1,2%	1,206	2,243
log (gross farm revenue)	2,7%	1,11	1,14	-5,4%	1,212	2,252
share of farm produce sold	2,3%	1,10	1,02	-15,9%	0,308	2,260
Value of inputs used (RWF)	-0,2%	1,07	0,96	-5,4%	0,466	1,983
Use of improved seeds (dummy)	-0,3%	1,09	1,10	7,6%	1,655	2,135
Use of mineral fertilizer (dummy)	-2,7%	1,15	1,06	12,3%	1,011	2,172
Use of pesticides (dummy)	-3,5%	1,27	1,05	8,7%	0,995	2,180
Use of irrigation (dummy)	0,4%	1,15	1,01	0,0%	0,793	1,942

^a The estimator effect indicates to what extent the baseline estimation result would change if we could observe an additional binary confounder

^b The outcome effect measures the estimated effect of the simulated binary confounder on the dependent

^c The selection effect measures the estimated effect of the simulated binary confounder on the selection into treatment, this is the propensity of being a member in a maize and horticulture cooperative, respectively.

Source: calculations based on data from own household survey (2012)