Are Farmer based organizations Effective Channels for Impacting Input Use and Income? Evidence from Smallholder Dairy East Africa

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Abstract

This survey used data from the East Africa Dairy Development project which utilizes farmer based organizations to evaluate whether producer organizations have been efficiently used by the project to impact on inputs use and income. Propensity score matching results show that project participants generated higher dairy revenues than non-participants. They also spent more on hired labour and animal breeding and had a higher probability of having improved breeds. The findings have important implications for development agents and policy makers seeking productivity improvement and increased market participation of poor smallholder dairy farmers as establishment and growth of producer organizations.

Key words: Producer organizations, dairy revenue, inputs use, propensity score matching

1. Introduction

Smallholder dairy play a critical role in poverty alleviation in developing world; studies (Mwebaze 2002; Muraguri et al 2004; Omiti et al 2006; Rutamu, 2009; Kugonza et al 2011) have highlighted the increasing importance of dairy farming as a source of livelihoods in rural East Africa. As a result dairy development projects have been established in this region, their main objective is to impact on the livelihoods of the poor farmers through availing improved technologies, increasing farmers' access to inputs and linking the farmers to output markets. Governments across East Africa have been working to encourage farmers to form dairy cooperatives to drive productivity and growth of the industry (FAO 2011).

Growth of smallholder dairy in East Africa have been impeded by challenges which includes inadequate access to productive breeds, lack of technical information, poor access to inputs and services despite the growing demand for milk (Makoni et al 2014). Innovative approaches like formation of farmer based organizations are therefore necessary to enable farmers benefit from collective action (Heltberg and Tarp 2000). This will assist farmers in collectively accessing inputs (economies of scale in bulk purchasing) as well as output bulking and marketing, guaranteeing farmer access to market as well as enhancing farmers' bargaining power. Processors on the other hand are guaranteed consistent supply of quality raw produce from the farmers and therefore a drastic reduction in transaction costs. Collective action is one vehicle which a majority of development projects have been employing to enhance productivity and increase market participation through producer organizations (POs) (Salifu et al 2012). They have also elicited interest from governments in developing countries and are forming part of policy interventions (Bernard et al 2008). Such forms

of vertical coordination have been yielding mixed results to the participants (Dorward et al 2005; Salifu et al 2012).

Studies have attempted to provide empirical evidence on the outcomes of externally supported producer organizations, for instance Salifu et al. (2012) used a qualitative approach to analyse the extent at which these organizations have achieved their objectives while Getachew (2011) used a more rigorous approach to look at the impact of inputs and products market development on households' income and inputs use in bee, poultry and crop farming in Ethiopia. Closely related to this study, are Rao et al. (2016) and Omondi et al. (2017), which explored processor linkages and its effect on household income and farm performance in Kenya and Uganda. From this analogy, it is evident that there are few studies that have applied rigorous quantitative analysis of the on-farm impact of externally supported POs in dairy sector. Our paper uses a more rigorous quantitative approach to provide such empirical evidence of both on-farm impact and input use in dairy sector from three East African countries, Kenya, Uganda and Rwanda.

We analyse data collected from dairy farm households in milk-shed areas of Kenya, Uganda and Rwanda where the East Africa Dairy Development Project (EADD) Phase 1 supported the development of dairy hubs using a market facilitative approach through POs. The dairy hub concept as applied by EADD is a mechanism that is geared towards upgrading dairy value chains via linkages to input and output markets mainly through collective action (Rao et al., 2016)[1].

In this study we analyse the impacts of participation in producer organizations on household revenues. In particular, we evaluate whether farmers who participated in the project through producer organizations generated more revenues and used more yield enhancing inputs in their enterprises than non-participants. Net profits were not computed due to data limitations. Using descriptive analyses and propensity score matching approaches, we provide evidence on the differences in revenues and expenditure on inputs as well as the likelihood of practicing improved production technologies. In the next section we present the analytical framework guiding this study. We then present data and descriptive statistics, followed by a presentation and discussion of the results before providing concluding remarks on possible policy implications and strategic action for development agents.

2. Analytical Framework

Application of the OLS in impact evaluation to measure direct effect of participation in agricultural projects has a likelihood of generating biased estimates due to potential endogenity in participation as a result of self-selection in programs (Ochieng et al 2014). This survey employs matching method

[1] More information about the dairy hubs can be found in Mutinda et al., 2015 and Omondi et al. (forthcoming)

where Propensity Score Matching (PSM) is used to correct for potential self-selection. Similar approach has been applied by Rao et al (2016) to assess whether participation in dairy hubs have a positive impact on household incomes. The approach gives an unbiased estimation of treatment effects, further it does not depend on functional forms and distributional assumptions (Heckman, Ichimura, & Todd, 1997). Rosenbaum and Rubin (1983) define propensity score as the conditional probability of receiving a treatment given pre-treatment characteristics. Any discrete choice model like logit or probit can be used to generate the scores (Caliendo and Kopeinig, 2008)

$$p(X) \equiv \Pr(D = 1|X) = E(D|X) \quad (1)$$

Where $\boldsymbol{D}$ indicates of exposure to treatment (1, 0) and $\boldsymbol{X}$ is a vector of pre-treatment characteristics. They further show that if treatment exposure within $\boldsymbol{X}$ is random, then it is also random within $\boldsymbol{p(X)}$, implying that if propensity score is known, then the Average Effect of treatment on the treated (ATT) can be estimated. They define the average treatment effect in a counterfactual framework as below

$$\Delta_i = Y_1 - Y_0 \quad (2)$$

Y_1 denotes the outcome of a household i that participates in the EADD project and Y_0 otherwise. Since there is no baseline for comparison, and therefore only either of the outcomes is observed for a single household not both, and this can be expressed as follows.

$$Y_i = D_i Y_i + (1 - D_i) Y_o \quad (3)$$

The average treatment effect is written as below

$$ATT = E(Y_1 - Y_0|D = 1) = E(Y_1|D = 1) - E(Y_0|D = 1) \quad (4)$$

When undertaking impact evaluation the parameter of interest is $E(Y_0|D = 1)$. PSM works under two assumptions; balancing and conditional independence assumptions. The former hypothesizes that participation in a project is shaped by pre-participation characteristics while the latter hypothesizes that covariates must be independent of participation. With these assumptions, the average treatment effect is given as below

$$ATT = E[E\{Y_i|D = 1, p(X)\} - E\{Y_0|D = 0, p(X)\}|D = 1] \quad (5)$$

To evaluate the effect of participation, four methods have been proposed Nearest-Neighbour Matching, Radius Matching, Kernel Matching and Stratification Matching. In stratification matching, propensity scores are divided in intervals where intervals consist of treated and control units with on average the similar propensity score. The blocks consisting of treated and control units that are

identified by algorithm that calculates the propensity score are used to compute the difference between mean outcomes of treated and control subjects (Becker and Ichino, 2002).

Nearest neighbour matching matches a treated with a control unit and computes the difference in outcomes. The ATT is computed by averaging the differences. In radius matching, a radius is set where treated units are matched with control units falling within propensity score of the treated units. Kernel Matching uses weighting where treated units are matched with weighted average of all controls. (Caliendo and Kopeinig, 2008; Stuart 2010). Since none of the four approaches is better than the other, a combination of some approaches will offer the best solution when looking for robustness of the estimates (Becker and Ichino, 2002).This paper used Nearest Neighbour, Radius Matching and Kernell Matching.

3. Data and Descriptive statistics

a) Data and data source

Data used was drawn from the survey conducted at the end of the first phase of the project in 2014 for evaluation and a multi-stage sampling procedure was used where four producer organizations were first purposively selected in each country. In Kenya the four producer organizations that were selected included Kabiyet, Metkei, Siongiroi and Olenguruone. Kinyogoga, Nabitanga, Mitala Maria and Mukono were selected in Uganda while Gasi, Kabarore, Mbare and Isnagano were identified in Rwanda. The second stage involved stratification of the populations of smallholder farmers within the catchment areas of these organizations into project participants (those benefiting from sale of milk and/or accessing services) and non-participants (those not benefiting from any of the services but located within the PO's catchment area). A suitable control group was also identified within 20-30 kilometres radius from the location of the POs' area of operation (either a milk bulking centre or a chilling plant) to control for spillover effects. A random sample was then selected from each strata and a total of 2407 farmers were selected comprising of 840, 684 and 883 from Kenya, Uganda and Rwanda respectively the breakdown by category is was per table 1 below.

Table 1: Distribution of the sampled households by country

	Kenya	Uganda	Rwanda
Participants	404	282	374
Non-participants	141	163	189
Control	295	239	320

b) Socio-economic Characteristics

Majority of the sampled households (over 70%) across the three study countries were male-headed. (Table 2) Farmers from Rwanda had higher average age than those from Uganda and Kenya. Uganda farmers generated higher revenues (US$ 172.7) from dairy compared to those from Kenya (US$ 116) and Rwanda (US$ 124.6). Single lactation day production was used to estimate mean cow production irrespective of the cattle breeds and on average cows from Rwanda were producing more milk (4.7 litres) than those from Kenya (3.5 litres), and Uganda (3.7 litres). Kenya had a significant higher number of farmers owning improved breeds (81%) and practicing improved feeding (86%) compared to Uganda and Rwanda.

Table2: Summary statistics of variables across countries

	Kenya (N=840)		Uganda (N =684)		Rwanda (N =883)		
	Mean	SD	Mean	SD	Mean	SD	F
Sex (1 =male, 0=female)	0.72_a	0.45	0.78_a	0.42	0.77_a	0.42	5.18***
Age of household head	47.6_a	14.2	47.0_b	13.1	50.1_{ab}	14.2	10.02***
Monthly revenue (US$)	116_a	139.6	172.7_{ab}	419.5	124.4_b	260.9	8.94***
Lactation day production per cow (litres)	3.5_a	3.6	3.0_b	3.7	4.7_{ab}	5.3	25.31***
Improved breeds (1=Yes 0=No)	0.81_a	0.39	0.45_a	0.50	0.60_a	0.49	124.01***
Improved feeds (1=Yes 0=No)	0.83_a	0.37	0.43_a	0.49	0.40_a	0.49	246.3***

****, ** denote statistical significance at 1% and 5% levels.Same subscript across the row denotes statistical difference at 1% level*

c) Revenues and costs

Table 3 below summarizes the overall revenue and costs between the participants, non-participants and control groups. On average project participants were making more revenue from dairy than non-participants and the control groups, there was however no difference in revenue between the non-participants and the control groups. Similarly the participants spent more on supplements and hired labour than the other groups, but there was no difference in these expenditures between non-participants and control groups. The participants spent more on breeding services than control group, non-participants also spent more on breeding than the control group but there was no significant difference between the participants and non-participants. The higher expenditure on yield enhancing technologies seems to have positively impacted productivity as project participants recorded significantly higher yield per cow than non-participants and the control group.

Table 3: Average difference in revenue and costs by participation status across all countries

	Participants (N=1060)		Non-participants (N =493)		Control (N =854)		F
Monthly revenue and cost	Mean	SD	Mean	SD	Mean	SD	
Dairy Revenue (US$)	168.8_{ab}	353.0	91.0_{a}	157.0	119.1_{b}	245.8	14.63***
Supplements cost (US$)	12.4_{ab}	36.2	6.2_{a}	25.4	9.1_{b}	31.4	6.68***
Hired labour (US$)	22.3_{ab}	62.5	11.2_{a}	28.1	13.2_{b}	25.5	13.85***
Animal health (US$)	15.4	38.9	11.8	32.3	14.1	48.6	1.15
Breeding services (US$)	2_{a}	6.8	2.3_{b}	22.8	0.8_{ab}	2.2	4.16**
Lactation day production per cow (litres)	4.2_{ab}	4.7	3.3_{a}	4.0	3.5_{b}	4.0	8.66***

****, ** denote statistical significance at 1% and 5% levels.Same subscript across the row denotes statistical difference at 1% level*

In Kenya project participants were making more revenue from dairy than non-participants but there was no difference with the control group Table 4. In terms of supplements and animal health costs there was no difference in terms of expenditure between the participants and non-participants. There was also no significant difference between any of the groups in milk production per day.

Table 4: Average difference in revenue and costs by participation status in Kenya

	Participants (N=404)		Non-participants (N =141)		Control (N =295)		F
Monthly revenue and cost	Mean	SD	Mean	SD	Mean	SD	
Dairy Revenue (US$)	124.1_{a}	143.6	86.9_{ab}	93.8	119.0_{b}	150.5	3.83**
Supplements cost(US$)	17.1_{a}	29.0	9.0_{ab}	15.9	17.3_{b}	42.7	3.57**
Hired labour (US$)	10.8	30.2	5.4	12.4	10.7	27.2	2.3
Animal health(US$)	4.1	6.5	2.9	3.6	4.1	4.6	2.59
Breeding(US$)	1.4	2.5	1.0	1.6	1.0	3.0	3.44
Lactation day production per cow (litres)	3.6	3.8	3.2	3.0	3.5	3.8	0.69

*** denote statistical significance at 5% levels. Same subscript across the row denotes statistical difference at 5% level*

The results in Table 5 below shows that project participants in Uganda were generating more revenue from dairy enterprise than non-participants and the control group. The project participants were also spending more on supplements and hired labour than either of the groups. Nevertheless, there was no difference between the groups in terms of breeding cost and daily milk production.

Table 5: Average difference in revenue and costs by participation status in Uganda

	Participants (N=282)		Non-participants (N =163)		Control (N =239)		F
Monthly revenue and cost	Mean	SD	Mean	SD	Mean	SD	
Dairy Revenue (US$)	245.4_{ab}	552.0	116.2_{a}	227.8	125.2_{b}	312.9	7.38***
Supplements cost	13.1_{ab}	50.0	4.6_{a}	13.8	2.2_{b}	11.4	7.85***
Hired labour	36.0_{ab}	105.7	11.8_{a}	41.4	14.9_{b}	30.2	7.87***
Animal health	34.5	68.8	24.6	52.4	25.7	75.8	1.43
Breeding	1.7	5.9	4.4	39.1	1.0	2.0	1.82
Lactation day production per cow	3.5_{a}	3.8	2.4_{b}	4.1	2.8	3.0	3.89**

****, ** denote statistical significance at 1% and 5% levels.Same subscript across the row denotes statistical difference at 5% level*

In Rwanda project participants were making more revenue from dairy than non-participants as shown in Table 6 below. Similarly, the participants were spending more on hired labour than the other two groups. The non-participants spent more on animal health then the control group. Project participants also spent more on breeding than the control group. Daily production per animal was significantly higher for project participants when compared to the control group.

Table 6: Average difference in revenue and costs by participation status in Rwanda

	Participants (N=374)		Non-participants (N =189)		Control (N =320)		F
Monthly revenue and cost	Mean	SD	Mean	SD	Mean	SD	
Dairy Revenue (US$)	159.2_{a}	307.2	72.2_{a}	110.4	114.6	259.8	7.44***
Supplements cost	6.8	31.0	5.4	36.4	6.7	27.6	0.17
Hired labour	24.3_{ab}	37.2	15_{a}	21	14.1_{b}	19	12.9***
Animal health	13.4	19.0	7.5_{a}	12.1	14.8_{a}	43.6	3.55**
Breeding	2.9_{a}	9.8	1.5	5.7	0.4_{a}	1.2	10.76***
Lactation day production per cow	5.4_{a}	5.9	4.3	4.4	3.9_{a}	4.8	5.86***

****, ** denote statistical significance at 1% and 5% levels.Same subscript across the row denotes statistical difference at 5% level*

4. Empirical Results and Discussion

Results from descriptive statistics reveal significant difference in dairy revenue and some costs between project participants, non-participants and the control group. To determine whether these differences are due to household participation in producer organisations i.e. to attribute these differences to hub participation, we conduct statistical matching as described in the analytical framework. The results of these analyses are shown in Table 8 (average treatment effects) and Table 7 (the results of the logit model used to predict propensity scores that form the basis for our matching).

Table 7: Propensity score matching logit model results

	Participation in producer organization	
Variables	Coefficient	SE
Gender(Dummy)	-0.2289**	0.1121
Age	0.0762***	0.0210
Age squared	-0.0007***	0.0002
Level of education	0.0574**	0.0291
Occupation	0.1617	0.0999
Constant	-1.628***	0.5596

****, ** denote statistical significance at 1% and 5% levels.*

The results of the average effect of treatment on the treated (ATT) are presented in Table 8 and they reveal a positive project impact on dairy revenue. All the three statistical matching algorithms (the nearest neighbour matching, radius and kernel matching) show that the project participants earned over US$ 50 more per month compared to the control group ($p \leq 0.01$). Similarly, participants are seen as having higher probability (over 16% and significant at $p \leq 0.01$ from all the three matching algorithms) of rearing improved breeds. With regards to input use, we analysed the use of hired labour, animal health services (curative and preventive measures) and breeding services (artificial insemination and bull services). The results (Table 8) reveal that project participants spent significantly more on hired labour than the control group. This shows that participation in the project is associated with more demand for labour and has positive implications on contribution to rural poverty eradication as program participants had higher number of cows than non-participants. Equally, the participants spent more on breeding (over US$ 16 and significant at $p \leq 0.01$ from all the three matching algorithms), There was however no difference in the cost of animal health services between the participants and the control group.

Table 8: Impact of project participation on revenue and input usage

Matching methodology	Nearest neighbour matching		Radius matching		Kernell matching	
Outcome	ATT	T	ATT	T	ATT	T
Revenue (US$)	55.7	2.734***	53.6	2.504**	51.1	3.294***
Improved breeds	0.16	5.392***	0.20	8.502***	0.19	9.291***
Hired labour	8	3.377***	6.9	2.494**	9.206	4.425***
Animal health	0.5	0.180	2	0.504	0.9	0.446
Breeding	17.2	6.639***	16.3	5.122***	16.2	5.591***

**** and ** denote statistical significance at 1% and 5% levels.*

These results have important implications on technology uptake and farmer based organizations are seen to play a critical role in breeds improvement which is a necessary condition to productivity improvement. Similar findings on positive impact on income have been reported by Rao et al (2016) who showed that overall, farmers participating in EADD supported producer organizations in Kenya and Uganda generated higher revenues from dairy enterprise than non-participants. When comparing

input use in potato farming, González et al (2014) also found out that farmers who participated in the project spent more on purchased inputs and had a higher probability of hiring labour than the non-participants.

5. Conclusion and policy implications

Smallholder dairy is a crucial sub-sector in East Africa when it comes to strategies for reducing poverty. Avenues to reach out to farmers need to be designed if meaningful progress is to be made regarding productivity and income improvements. Farmer based organizations will increasingly provide avenues for development agents in their efforts to reach out to farmers and reduce poverty. This survey used data from the East Africa Dairy Development project sites which utilizes farmer based organizations to evaluate whether these avenues have been efficiently used by the project to impact on inputs use and consequently income. Propensity score matching technique was applied to control for self-selection bias problem.

The findings indicate that farmers who participated in the project made more revenue from dairy than the control group. They earned between US$ 51 and US$ 55 more per month than their counterparts who did not participate in the project. The results also show that the participants spent more on hired labour and animal breeding. They also had a higher probability (between 16% and 20%) of having improved breeds.

In this light producer organizations could be appropriate avenues to spur smallholder dairy growth in East Africa and contribute greatly in poverty reduction efforts as dairy income is a source of employment and a major contributor to total household income in smallholder dairy regions (Rao el al. 2016). Further, they provide an avenue for cash constrained farmers to access inputs, services and training under flexible payment schedule which leads to improved on-farm production. Judging from the evidence provided from this survey, policies that would incentivize establishment of context specific producer organizations across different commodities value chains should be championed by development agents as this will drive productivity and increase market participation of poor smallholder dairy farmers. In addition, strengthening of producer organizations should be emphasized as this will enhance their stability and continuous service delivery to their members. The survey did not attempt to look at whether the inputs mix is optimal between the different groups and therefore future work should focus on this to inform on efficiency.

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