Impact of Community based breeding program on performance of and income from small ruminants in Ethiopia

Application of Doubly Robust Difference in Differences

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Abstract

This report presents effects of community based breeding program (CBBP) on small ruminant fertility, mortality, offtake, earnings per head of animal, and consumption expenditure. We used a two-wave panel dataset on 555 households in four different livestock production systems and estimated Doubly Robust Difference in Differences models. The results show that CBBP has improved fertility of small ruminants, offtake [market supply], and income from small ruminants. The effects reported here are broader and larger in magnitude than an earlier report on the same data but using different formulations of the difference in differences estimator. This report is part of a continuous effort that aims at comprehensively quantifying the different impacts of CBBP in Ethiopia. A separate set of analysis on a bigger dataset will follow before consolidating the national level report.

Introduction

Sheep and goats serve as an important store of value in Ethiopia and serve as one of the most liquid households assets (Dercon & Christiaensen, 2011; Kassie et al., 2021). They are also the go-to investments for female headed vulnerable households because they are relatively affordable, and incur lower risk of loss (Awgichew et al., 1991). Additionally, small ruminants are known to adapt to harsh environments and have a shorter gestation period which implies quicker return on investment (Armson et al., 2021).

Despite their importance and versatility to sustain livelihoods in most of rural Ethiopia, small ruminants have not received enough attention in the livestock development plans of the country until very recently (Gizaw, Abegaz, et al., 2013; Aynalem Haile et al., 2018). Small ruminant production is constrained by, inter alia, pests and diseases, poor genetic potential in consumable products, limited access to feed, and lack of market orientation (Kassie et al., 2019).

There have been several efforts to improve the genetics of the indigenous sheep and goat populations (Ayalew et al., 2003; Gizaw, Getachew, et al., 2013; A Haile et al., 2020). Nonetheless, sheep and goat breeding strategies in Ethiopia focused on importing exotic breeds. Different governmental (research and academic) and non-governmental institutions have implemented these introductions and crossbreeding (Aynalem Haile et al., 2019). These programs generated no significant effects on sheep and goat productivity or on farmers and pastoralists' livelihoods and the national economy at large. The major limitations faced have been the lack of a clear breeding and distribution strategy, little

consideration for the needs of the farmers and pastoralists, limited or no participation in the design and implementation of the breeding programs, and the lack of schemes to sustain crossbreeds at the village level (Aynalem Haile et al., 2019; Solomon et al., 2013).

Cross-breeding programs, and nucleus based selective breeding and distribution both lacked a sustainable strategy. As a result, these programs mostly failed to initiate uptake, commitment, and subsequent increase in productivity and resilience of livestock (Aynalem Haile et al., 2019). Data intensive advanced breeding programs or introduction of live animals for cross breeding could hardly be implemented in Ethiopia with the required level of complexity or expected level of success (A Haile et al., 2020; Marshall et al., 2019). This observation gave rise to a different approach for small ruminant breeding.

Community based breeding program (CBBP) is a novel approach to improve the productivity and resilience of small ruminants. It relies on the high genetic variation of small ruminants in Ethiopia (Kebede et al., 2012). This rich and diverse gene pool can be exploited to engineer small ruminant varieties with higher resilience and increased productivity. The introduction of CBBP to Ethiopia goes back to the 1980s by the Institute of Agricultural Research on Afar and Horro sheep. However, this early initiative did not see the light of day. More recently, CBBP was rolled out on Menz, Horro, Bonga, Washera, Doyogena and Atsbi sheep and for Konso, Arsi and Abergelle local goats. These initiatives were financed mainly through short term projects. Sustained long term investment interests have not been observed so far, neither from the government nor the private sector.

The intervention

CBBP was started in 2009 with four sheep breeds (*Afar, Bonga, Horro* and *Menz*) representing different production systems and involving eight communities in Ethiopia (A Haile et al., 2020). These pilot CBBPs have since expanded to include more than forty communities and have also been introduced to other countries including, Burkina Faso, Iran, Liberia, Malawi, South Africa, Sudan, Tanzania, and Uganda. CBBP is a better option compared to the conventional nucleus schemes or importation of exotic breeds in that it is inherently sustainable as it supports local-level decision making, focuses on locally adapted indigenous breeds, and considers the constraints that smallholder farmers face (A Haile et al., 2020; Mueller et al., 2015). CBBP involves collective action, participatory breeding goal definition and trait identification, breeding male selection, distribution of selected sires and introducing mating management, culling of unselected males, training of farmers, and data collection and management (Table 1).

The breeding interventions were undertaken across locations in various parts of the country. Sheep breeding programs have been implemented in *Menz*, *Horro* and *Doyo gena* districts. Goat genetic improvement interventions were undertaken in *Abergelle* district. *Doyo gena, Horro* and *Menz* represent sheep-dominated production systems. *Abergelle* represents goat dominated production systems. We combined the two species and hence we will refer to the interventions as small ruminant breeding practices. In each of the districts, there are intervention and control *Kebeles*[1]. We considered farmers who were

[1] Kebele [pl. Kebeles] is the smallest administrative unit in Ethiopia.

trained, understood, and practiced the different components of the breeding programs in the intervention sites as participants of the improved breeding program.

Table 1: Description of the components of the community based breeding program

Component	Description
• Breeders' cooperatives and controlled small-ruminant mating groups	○ In each site, breeders' cooperative and different mating groups were organized. Cooperatives facilitate regular animal identification, data collection and recording, sire use, management and rotation among mating groups.
• Definition of breeding objectives and selection traits	○ Identification of the reasons why farmers/ pastoralists keep their animals and the attributes they value most is crucial in breeding programs.
• Ranking and selection of best breeding males	○ At the beginning, sires were ranked based on their genetic worth (estimated breeding values) for agreed breeding objective traits and farmers selection criteria.
• Transfer/dissemination of improved sires to the participants and arrange mating system	○ Culling of older/unfit sires and dissemination of new as replacement done once [in the other sites] per year focusing on replacing older sires. This ensures that all flocks have enough and good quality breeding sires to mate their breeding females.
• Awareness creation, field day and training on small ruminant breeding techniques and capacity development	○ This involves workshop and field days aiming at sharing experiences, and training of participating breeders, extension workers, and researchers. ○ Pregnancy test using ultrasound, fresh semen collection and artificial insemination started in some of the sites. Field artificial insemination facilities put in place in all CBBP sites.

• Culling and selling of non-selected males	○ Older sires have been culled, fattened and sold in good price for meat.
• Monitoring and evaluation	○ Data collection and animal identification has been checked and evaluated. Data collected on performances has been analyzed and used to check the genetic progress for traits of interest.
• Certification of improved genetics	○ Breeding sires need to be certified for genetic merit, reproductive performance and for reproductive diseases. This enables dissemination of improved genetics to the base population.
• Establishment of reproductive platforms	○ Establishing reproductive platform was identified to be key for fertility improvement and dissemination. The platform assists in mass estrus synchronization, artificial insemination and pregnancy diagnosis using ultrasound.
• Development of suitability maps for sheep and goats	○ Mapping breeds/population to suitable environments is important in planning livestock breeding and scaling activities due to its efficiency in allocating improved and new breeds to appropriate habitats for optimal production. In the context of predicting suitable habitats for selected breeds of indigenous Ethiopian sheep and goats, we used geo-informatics based spatial analytic tools to develop breed-specific suitability index maps.

Source: (Kassie et al., 2021)

Methodology

We started this study by hypothesizing that CBBP affects small ruminant fertility, mortality, offtake and then improve returns per head of animal, and consumption expenditure per capita. To assess these impacts, two rounds of comprehensive surveys were conducted in 2014 and 2018. This report builds on the analysis reported in (Kassie et al., 2021) and therefore we refer the reader to this paper for description of the sample, data generation process, and the dataset.

This paper extends the analysis in Kassie et al (2021)) by using doubly robust difference in differences (DR-DiD) models to estimate the effects. According to Sant'Anna & Zhao (2020) DR-DID estimators, compared to other DiD estimators, are consistent if either (but not necessarily both) a propensity score or outcome regression working models are correctly specified. We estimated DiD with propensity score weighting with first difference of the dependent variable regressed on carefully selected pre-treatment level covariates (Abadie & Imbens, 2016).

Results and Discussion

The doubly robust treatment effects models showed similar but more pronounced effects of community based breeding program compared to the conventional difference in difference estimators reported in Kassie et al (2021). Participation in the CBBP has also significantly improved the fertility rate of small ruminants. Fertility is measured in

percentage, and the DR-DiD model shows that members have observed 9.7% increase in the fertility rate of their sheep and goats in a period of 12 months (Table 2).

Kassie et al (2021), using conventional DiD, reported insignificant effect on fertility rate of small ruminants. The more flexible specification to estimate average treatment effect on the treated by propensity-score matching, on the other hand, showed a significant increase in fertility rate of the participants' small ruminants.

The other parameter of interest is off-take in a 12 month period before the end-line survey. Participants of CBBP supplied 4 more animals to the market in one year period compared to non-participants. This is a big number by itself but it is slightly less than what was previously reported. Kassie et al (2021), using propensity score weighted difference-in-differences, reported that the CBBP members have supplied 18 more animals per year compared to non-participants in the same period.

Annual earnings from small ruminant production have significantly increased because of the community based breeding program (Table 2). Considering the income generated over a period of 12 months in 2018/19, CBBP participants have earned 83.2% more income per head of small ruminant. DiD and PSM combinations reported by Kassie et al (2021) did not show any significant treatment effect, whereas our DR-DiD has resulted in such a high treatment effect. We argue that the flexibility of the doubly robust specification has made the treatment effect more consistent and efficient compared to the conventional DiD estimators. This is in line with the empirical evidence presented by (Sant'Anna & Zhao, 2020).

The income gain is expected to be higher because of the value attached to the comprehensive documentation of the upbringing of the animals and their different conditions and appearances. Discussions with participating and non-participating farmers have clearly shown that being a member the community based breeding program boosts the confidence of farmers in the markets. This confidence is translated into higher bargaining power, and hence better income. Non-participating farmers are also very keen to be members of CBBP and the main benefit they anticipate from membership is better marketability of their small ruminants.

As shown above, the specification of the model we are reporting here has revealed some strong and positive impacts of CBBP. There are some parameters which were not statistically significant as well. We checked whether participating in CBBP has influenced the sheep and goat mortality rate. Although, the coefficient has the expected negative sign, it was not statistically different from zero. Consumption expenditure per adult equivalent was also considered an indicator of poverty level in the sample population. The DR-DiD model result in positive but insignificant treatment effects.

This is part of an ongoing work that is aiming at establishing a clear impact pathway for community based breeding programs in Ethiopia. In line with the positive and strong impact reported by Kassie et al (2021), our analysis of the same dataset showed that there are quite considerable changes in the small ruminant population owned by members of CBBP.

Table 2: Impact of CBBP on selected outcomes

	Fertility	Mortality	Offtake	Ln(return/head)	Ln(expenditure/AE)
ATET	9.715*	-3.149	3.706*	0.832***	0.044
	[5.898]	[3.415]	[2.237]	[0.262]	[0.091]
ATE	6.306	-2.638	2.996	0.857***	0.011
	[5.589]	[3.287]	[2.161]	[0.259]	[0.088]
N	489	466	520	555	555

Note: ATET denotes average treatment effect on the treated. ATE denotes average effect on the treated. Standard errors are in bracket. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All models estimated using Stata©.

Conclusion

This report has expanded the analysis reported by Kassie et al (2021) and showed that CBBP has significant effect on fertility, offtake, and earnings per head of small ruminant in the intervention sites. A more flexible specification has therefore enabled to carve out the impact on fertility that was not reported by Kassie et al (2021). In fact, as discussed in the intervention section above, CBBP is not meant for increasing fertility per se. However, it intends to improve the genetic quality of the animals through selection from within the germplasm. One of the genetic qualities the program focuses on is fertility in terms of, for instance, twinning ability.

We generally agree with the statement made by Kassie et al (2021) that the community-based breeding programs designed and implemented by and with the small ruminant keeping community are rewarding in many ways.

We plan to build on the analyses so far and expand the spatial and temporal dimensions of the data we are considering in estimating the impact of CBBP. This report will be followed by a pooled cross sectional data analysis of two datasets collected over a period of 9 months on nearly 2000 households. We will consolidate the treatment effects of CBBP and present it in a more accessible manner.

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