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Impact of improved bean adoption on commercialization in Southern Tanzania: Why women are excluded?

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Abstract
Improved technology adoption is well recognized as an important route to improving agricultural productivity and transformation of small subsistence farms into economic farm units in developing countries. Motivated by this notion and the fact that many households depend on bean for food and income, substantial efforts have been invested in bean improvement research in Tanzania in the past years, with a goal of accelerating farmer integration into markets. Using survey data from 625 households from southern highlands of Tanzania and an inverse probability weighted regression adjustment approaches within a multivalued treatment effect framework, this study evaluates the impacts of improved bean adoption on marketed surplus. Then the study analyses the gender patterns of bean commercialization, identifying the underlying causes of women exclusion. The study found positive effect of improved bean adoption on marketed surplus but a growing masculinisation of market participation among full adopters, meaning that higher productivity gains propel bean commercialisation. However, there are indirect negative effects on gender that exclude women from bean output market participation. The exclusion of women as bean commercializes is linked to both the functioning of markets themselves and factors inherent to the household.

Keyword: Improved bean, commercialisation, gender, Tanzania

1.0. INTRODUCTION

Agriculture is a back bone and the engine of economic growth for many countries in sub-Saharan Africa. In Tanzania, agriculture contributes about 30 % of the GDP and employs nearly 80% of the labour force (AFDB 2011). In recognition of its importance, the government of Tanzania and its development partners have been investing in agricultural research and development to increase agricultural productivity and stimulate growth in the country. Common bean (Phaseolus vulgaris) is a food security and income crop for smallholder farmers, ranked third after maize[1] and cassava in terms of area cultivated in Tanzania. Per capita bean consumption in the country is about 19.3kg, and the crop contributes 16.9% protein and 7.3% calorie in human nutrition (Rugambisa, 1990). Approximately 48 percent of bean production is sold mainly to her neighbouring countries (such as Zambia, Mozambique, Rwanda and Kenya), but the quantity exported has been growing at an average annual rate of 10% since 2005 (FAO data 2017).

There is a strong association between common bean and women in Sub-Saharan Africa, where the crop is often referred to as a 'women's crop'. This is because of the low productivity of bean that was traditionally grown by women as a food security crop. Following urbanization and population growth in sub-Saharan Africa, common bean has been transforming from subsistence to commercial oriented production, but integration into market systems remains low. For example, production continues to rely on family labour and minimal use of purchased inputs, while a bigger proportion of production is consumed on the farm.

To accelerate the bean commercialization process, the national bean research organization of Tanzania together with the Centro International de Agricultural Tropical (CIAT) under the umbrella of the Pan-African bean Research alliance have been developing higher yielding and better adapted varieties using a demand-led breeding strategy to ensure that released varieties are competitive on the market. Additional efforts are invested in developing sustainable pro-poor seed systems and supporting interventions for linking smallholder bean producers into profitable output markets. Higher productivity and disease resilience advantage of improved varieties relative to the traditional one can lower per unit average cost of production and increase marketable surplus, which raises the incomes of producers that adopt. In the long run, greater interaction and engagement with markets or the market system is expected to lead into development and poverty reduction among smallholder farmers (von Braun, 1995; Coles and Mitchell, 2011; Holmes and Slater, 2008).

A number of studies have analysed the impacts of improved bean variety adoption (Larochelle et al. 2015, Katungi et al. 2018) and other new legume varieties (e.g Asfaw et al. 2012; Amare et al. 2012, Verkaart et al. 2017) on household welfare in selected countries of sub-Saharan Africa. These studies underline positive impacts of improved crop varieties adoption on crop productivity, food security and poverty reduction. Relatively few studies have also examined the impact of improved legume variety adoption on probability and intensity of farmer participation in output markets in the context of sub-Saharan Africa. Examples include the studies done on the chickpea in Ethiopia, first by Asfaw et al (2011) and later by Tabe-Ojong and Mauch (2017). However, there is no study, we know of, that has assessed the impacts of bean improvement research on farmer integration into output markets in sub-Saharan Africa. Moreover, the few studies conducted in the context of chickpea in Ethiopia did not examine the gendered patterns of farmer integration in output markets.

Generally, and as noted by Djurfeldt (2017), much of the gender aspects in agriculture has focused on the production side, while less attention has been given to the gender dimensions in

[1] Maize contributes 60% of dietary calories and is an important source of income, except in areas where cash crops such as tobacco are well established (Urassa 2015).

agricultural commercialisation. Yet, such information would inform the design of interventions to enhance gender equality in bean improvement research programs. In recent years, there has been recognition that greater gender equality can enhance productivity and improve development outcomes for the next generation (World Bank, 2012). This realization has influenced donors and policy makers to prioritize gender equality and women empowerment as one of the important sustainable development goals. Accordingly, researchers and development practitioners are expected to promote gender equality as an integral part of poverty reduction and development initiatives but there is scanty information on how this can be achieved.

This paper examines causal relationship between improved bean variety adoption and farmer integration into markets, measured by marketed surplus. The study uses an inverse weighted probability adjusted regression (IPWRA) approach in a multivalued treatment framework to account for partial adoption of varieties when estimating the impact of improved bean variety adoption on market surplus. Using the same estimation approach, the study analyses the gendered patterns of smallholder bean producer integration into output markets. In the analysis, we seek to answer questions like; to what extent did the adoption of improved technologies contribute to marketed surplus and what are gendered patterns of farmer integration into output market. If women are being excluded, what are the underlying causes and what factors would facilitate inclusion?

The rest of the paper is organized as follows. The next section discusses the analytical framework followed by the description of the data sources, measurement and definition of key variables in section 3. Section four reports and discusses the results while section five concludes.

Analytical framework

The impacts of improved bean variety adoption on marketed surplus and gender is estimated in two stages. In the first stage, we estimate the adoption of improved bean and derive the latent propensity to adopt. We measure adoption as a variety choice and examine factors that influence farmers' choice of varieties. Smallholder farmers' choice of varieties is conceptualized within an agriculture household model (Singh et al., 1986), in which a household's production decisions are assumed to be driven by the need to maximise their utility over an agricultural good, leisure and purchased good given a set of constraints. Common constraints faced by bean growers in Tanzania include those on the budget, access to information, credit and the availability of improved seed and other inputs. In view of these constraints, farmers can choose to adopt fully by replacing local or with a new variety. Alternatively, the farmer has the option of growing a new variety alongside his/her local variety, in which case the new varieties would compete for limited land pre allocated to bean production, with existing bean varieties.

If adopted, improved variety should provide increment on the total harvest per unit area, which, in turn, raises the quantity of marketed surplus. We assume that the level of effect from the variety would depend on the newness of the variety. Over the years, there has been improvement in bean variety development processes of CIAT and her NARS partners that aim to generate new variety releases that are superior to old ones in terms of yielding capacity and/or market attributes (Mukankusi et al., 2018), also mirrored in trial data (PABRA database 2016). Moreover, older releases have been reused several times, which could have reduced their efficacy. Therefore, it is important to understand how adoption category influences yield in order to draw lessons and inform allocation of funding. The study uses a multinomial logit model since variety use is a categorical multivalued variable defined as 1= only improved seed of varieties released after 2001 are grown and thus full adopter, 2= grows a mixture of local and improved varieties whether new or old, therefore being a partial adopter and 3= non-adopters of new variety

In the second stage of our analysis, we identify the causal effects of new improved bean variety adoption on outcome variables: bean sales and women & men market integration measured as the share of marketed surplus transacted by each group during the study season. The fundamental challenge, however is that we only observe outcomes of beneficiaries, but we do not observe the outcomes of the same beneficiaries if they did not adopt the variety—thus, we face a problem of missing data (Imbens & Angrist 1997; heckman, Ichimura & Todd 1997). Randomised experimental designs have been applauded as the "gold standard" for addressing this challenge given that individuals in treated and those in the control groups are identical except that one of them receives the treatment. In the context of this study, randomized experiment approach was less likely to succeed given that the interest of the project implementers was to reach a wide population, which they pursued via multiple public-private partnerships. In the absence of randomization, which is common with cross sectional survey data used in this study, matching techniques can be used to restore randomness by mimicking experiment ex-post. According to Rosenbaum and Rubin (1983), conditioning on the propensity score –the probability of receiving the treatment given the covariates, rather than on the full set of covariates, is sufficient to balance treatment and comparison groups. This literature was extended to multivalued treatment by Imbens (2000).

As is in the binary case, multivalued treatment effects are estimated conditional on observable characteristics. We apply inverse probability weighted regression adjustment (IPWRA) method developed by Robins and Rotnitzky (1995). IPWRA combines Propensity score matching and regression adjustment techniques to consistently estimate the treatment effects parameters.

$$\text{Outcome model: } Y_{ijk}; f(\beta_i, X_i) + \varepsilon_i \quad (1)$$

$$\text{Treatment model: } pr(T = 1,2,--j) = h(\alpha\ Z_i) + \omega_i \quad (2)$$

Where T is the indicator for adoption status, defined as a multivalued treatment in which, each subject could receive one of the several different treatments or else not receive treatment at all. Y_{ijk} is the potential outcome k of a household (or individual) i that receives treatment level j, i.e. adopter category j. Then X is a vector of covariates that influence the outcome Y_{ik}, whereas Z is a vector of covariates that explain treatment assignment T; Vectors X and Z may overlap. Vectors ε, ω consist of random components of respective equations and are assumed to be correlated.

Now, let Y_{i0k} denote the potential outcome of a household (or individual) i that did not receive any treatment (i.e. grew local varieties). In the context of a multivalued treatment, the individual household (individual) treatment effects can be expressed as: $Y_{ijk} - Y_{i0k}$ for $t \in (1,......j)$. Then, the average treatment on the treated is estimated as:

$$ATET_{ipwra} = N_j^{-1} \sum_{i=1}^{N^j} (\hat{Y}_{ijk} - Y_{i0k}) \quad (3)$$

According to Woodridge (2010), IPWRA can achieve some robustness to misspecification in the parametric models (propensity score or regression adjustment model) as long as one of them is correctly specified. Because of this property, IPWRA is called is a double robust estimator. The IPWRA technique has been applied in estimating impacts of crop variety adoption by Smale et al. 2018; Bonilla et al. 2018).

IPWRA is implemented as a three steps estimation procedure. In the first step, the probability that the individual is treated (i.e. belong to adoption level j) is estimated and the propensity scores predicted. The inverse of the probability that each observation is in the treatment or control group is used to re-weight the sample in the second step. This creates a sample in which the distribution of covariates is independent of the treatment—thereby ensuring that the requirement of weak confoundedness is satisfied. In the third step, the expected outcome is estimated for each observation using a weighted outcome model that includes some of the observable characteristics used to estimate the treatment model and additional information. In our case, linear outcome functions were used--the inverse probability weighted least squares.

The IPWRA, however can only address self-selection that is based on observables, but does not control for biases that may stem from unobservable heterogeneity between the treated (adopters) and untreated individual (non-adopters). For example, if farmers who choose to adopt are systematically different from those who do not in a way that is unobserved to the research, the estimates from IPWRA will be biased. In order to ensure the robustness of our results, we included in the treatment model, variables that control for intrinsic unobservable factors related with plot characteristics and plot management, following a similar strategy that was used by Smale et al. 2018 in their estimation of sorghum variety adoption impacts on household welfare in Sudan. The application of the inverse propensity scores also requires that the propensity score is non-zero and less than one for all observations (i.e. this is a condition for common support). To assess for this property in our data, propensity scores for treated and control observations were plotted on graphs to examine the overlap of the distributions. Figure 5.4 shows that these distributions do, in fact, overlap.

Correcting for censoring in market participation intensity

Besides the challenge of lack of randomness in adoption decisions addressed in the previous section, the estimation of casual impacts of improved variety adoption on bean marketed surplus is challenged by the potential censoring of market participation intensity. This is because bean market participation intensity is measured as the quantity of bean that is sold. There are households who decided to sell part or all their bean harvest and a few who did not sell any part of their harvest. If we assume that the amount of bean sold is a linear function of the bean variety type cultivated and other explanatory factors, then a bean marketed surplus model can be expressed as:

$$M_i^* = \lambda H_i + \pi T + \mu_i$$
$$M_i = \begin{cases} M_i = M_i^* > 0 \\ 0 \quad M_i^* \leq 0 \end{cases} \qquad (4)$$

Where M_i^* is the latent unobserved variable denoting the total volume of bean household i supplies to the market. The variable M is the observed amount of bean sales and equal to the latent variable when the household decides to sell and observed as zero for non-market participation. Then, H is a vector of variables that explain the variations in the amount of observed bean sales. The variable T_{ij} denotes the adoption decisions expressed as a function of explanatory factors in vectors $Z_i \,\&\, \omega_i$ (eq.2), some of which also influence market participation.

To account for potential censoring bias, a selection model characterizing the decision on whether or not to sell beans in equation 4 is estimated first using a probit model

$$\Pr obit(dsale = 1) \qquad if = \Pr ob(\mathrm{M}>0)$$

$$= d(s_i\eta_i) + v_i,\ v_i \,\mathrm{N}(0,1) \quad (5)$$

The variable "dsale" is a qualitative indicator of whether a household sold any beans in the study season, s is a vector of variables that explain the decision on whether or not a household sells bean, η_i is a vector of parameters to be estimated. The mills ratio (λ) is then calculated as $\phi(\eta_i K_i) / \Phi(\eta_i K_i)$ [2] and included in the main model of market participation intensity alongside other potential explanatory variables in vector (H) of the quantity of bean sold (M) in order to correct for potential selection bias.

$$M_i = \psi_j H + \iota\lambda_i + \pi_j T_j + \mu \quad (6)$$

Equation 6 is then estimated with Inverse weighted probability regression to account for potential endogeneity of adoption in market participation intensity as specified in equation 2.

3.0 Data sources, definition of outcome variables and descriptive statistics

3.1 Data sources

The study was conducted between August and December 2016 in the southern highlands of Tanzania (SHZ) by the socioeconomics team of the Southern Tanzania Agricultural Research Institute (ARI) Centre at Uyole in collaboration with the International Centre for Tropical Agriculture (CIAT). The SHZ is covered by the Southern and Western agro-ecological zones of Tanzania, located between 1,200–1,500m and 1,400–2,300m altitudes above sea level and is characterized by highlands with undulating plains that are separated by hills and mountains (URT 2006). The zone contains the most fertile land in Tanzania and a unimodal type of rainfall that starts from the month of October and goes on up to April, on an average of 100–200mm per month (Luhunga 2017). The SHZ is considered the grain basket for Tanzania and account for 24.3 percent of the total national bean area, equivalent to 194,021 ha of beans (NBS 2013). The zone is divided into five sub agro-ecological zones that support a wide range of crops and livestock production. Bean production occurs in all the five agro ecological zones (FAO calendar:http://www.fao.org/agriculture/seed/cropcalendar); mainly planted in the months of February and March after maize has been planted in December-January.

The data was collected from a sample of 625 households that were part of the first survey conducted in 2012/2013 for monitoring adoption of improved bean varieties. Thus, the sample was designed in 2013 by first developing a sampling frame, selecting 20 rural based districts from a list of 28 districts compiled from the 2012 National agricultural census of Tanzania report, developing probability weights for each region using village population & land area under beans and using the weights to select 75 villages for the survey. The final step was the selection of actual villages and households for the interviews. A list of wards and villages was obtained from the district extension office in the selected districts and random numbers used to select the villages. Then households were selected following a systematic random sampling procedure based on the village register in each of the selected village numbering households on the list sequentially. The first household was selected at random from this list, and the remaining 9 households were chosen at fixed intervals x = N/10 (where N = number of households on the village list) until the target number of bean farmers was reached.

[2] ϕ, Φ are the respective probability density and cumulative density functions.

Data were collected using two pre-tested structured questionnaires: household questionnaire and community questionnaire. The household questionnaire was designed to elicit information on bean production, varieties grown, bean harvests & its utilisation including household members' participation in bean market transaction. The household questionnaire was administered through direct interviews of household heads or spouse that were conducted by trained and experienced enumerators. The community questionnaire was used to gather information on village level variables that could explain varietal adoption patterns.

Trained enumerators collected the data using Computer assisted personal interviewing technique. Numerous quality checks were built into the programming that identified inconsistencies and prevented enumerators from moving forward with the survey until errors were corrected. Before actual interviews with households, the survey tool was pre-tested, and adjustments were made to the tool following reviews to reduce errors, interview duration, and address ambiguities.

3.2 Variety identification and measures of adoption

In the context of informal seed systems, measuring variety adoption can be challenged by misclassification of varieties as improved or local. To overcome this challenge, the study used DNA finger printing for robust variety identification. A handful *of* seed samples of each bean variety grown on each plot by sampled households were collected and stored in a plastic bag identified with a combination of household id and plot id automatically generated by ODK application. Enumerators recorded the seed sample id on a sticker which was posted on the transparent plastic seed sample bag. The seed samples were then transferred and stored temporarily at the national bean research program laboratory at Uyole research center. After the completion of the survey, seed samples were received by the breeders for further processing in preparation of laboratory analysis.

Adoption was measured as a multivalued categorical variable. A farmer was defined as an adopter if he/she allocate any land to the production a variety that was released in 2001 and afterwards. There were households that planted only new varieties and those that planted new varieties on a proportion of the land pre-allocated to beans and yet others did not allocated any land to the new variety. Thus, household level adoption data can be distinguished at three levels: 1) full adopters (i.e. 100% of the land pre-allocated to bean was planted with new variety), 2= partial adopters (combined new with either local or old improved variety) and 3) non-adopters of new variety.

3.3 Measuring marketed surplus and gendered pattern

The paper focuses on farmer integration into output market as the typical indicator for the process of agricultural commercialization (Wooldridge 2005). Farmer integration in bean output market is measured at farm level through volume of bean sold while gender patterns in market participation was represented by the share of the marketed surplus that was sold by men and women separately. During data collection, respondents were asked about the volumes sold in each transaction that was made and the sex of the household member that made the transaction. This information was used to compute the volume sold by men and volumes sold by women within the same household, which we use to calculate the share of marketed surplus handled by sex of the seller.

3.4 Descriptive characteristics of the sample

About 41 % of the bean growing households grew new improved varieties in 2016; 15% planted only new varieties and 26% planted new varieties alongside other varieties 9local or old improved)—thus being partial adopters. The adoption rates for new improved varieties (i.e. released after 2001) was higher in districts that are located in the borders with countries that import beans from Tanzania. These were the districts (Namtumbo, Songea & Mbozi) that border with Mozambique, Malawi and Zambia. This perhaps reflects the power of weak ties that provide micro-macro bridges to facilitate information flow (Granovetter 2005). On average, households cultivate about 0.6 ha of beans, which constitutes 23-27 percent of the total land owned. Bean area is significantly larger among partial adopters (Table 1).

--------------------------------Table 1-------------------------------

Adopting and non-adopting households are similar in terms of demographic characteristics such as age, household size, sex of household headship, dependency ratio and endowments in wealth assets and landholding. A typical household consists of 5.1 people, with 0.55 dependents (are either aged below 14 or above 64years) per one active member, which implies that each active member works for 1.5 consumers in the household. Majority of the households are headed by individuals aged about 50 years, have an average of 7 years of schooling and 83% of them are males (Table 1). For livestock ownership, partial adopters fare better. This group of households tend to have more livestock units and live closer to the regional town compared with non-adopters. Adopters and non-adopters have similar amount of land holding, which is about 4 Ha per households.

The majority of the adopters reside in villages that have participated seed distribution programs. Farmers in villages without such programs can possibly obtain improved seed from inputs market centers or seed distribution centers which are respectively available within in a distance of 12 km from the villages and approximately 85 minutes walking time (Table 1) Long distance to seed sources can potentially constrain adoption of improved bean varieties in early stages of technology diffusion as has been reported in case of fertilizers in Ethiopia (Minten et al. 2013).

Table 1 also shows that the adopter categories fare better than non-adopters in terms of the total bean sales. Approximately 68=75% of the adopters sell part of their bean production and for those who participate in bean market, the marketed surplus is about 65% of the harvest. This is about 331 kg of bean per household per cropping season among adopters and 221kg for non-adopters. While women dominate the production chain as contributors of labour and decision makers in bean production, they appear to participate less in postharvest marketing activities. The share of the marketed surplus that was transacted by women in 2016 season was between 20 and 40% depending on the adoption status (Table 1).

4.0 Results from estimation

In this section, results from econometric estimation are presented, beginning with the determinants of bean variety adoption.

4.1 Determinants of IV adoption

Estimates from the Multinomial logit (MNL) revealed the determinants of the adoption behavior towards improved bean variety, with non-adoption as the baseline. The results reported in table 2 are the marginal effects. The likelihood ratio test statistic from MNL as shown by the chi-square value (91.1) was highly significant ($p < 0.001$), which indicates that the model adequately explains the variation in the adoption data.

----------------Table 2---------

The highlights of the results indicate that the adoption of improved varieties in 2016 was mainly influenced by the access to the technology and a less extent the characteristics of the physical production environment. To adopt a new variety, the farmer needs to be aware of its existence and be able to obtain its seed at planting time. Variables included in the model as proxies for access to seed were significant with the expected signs, which suggests presence of technology access constraints. For example, a 10 units increase in the percentage of new bean variety adopters in a district above the 2013 average of 27% (three years prior to the survey) was found to increase the probability that a household from that district was a full adopter in 2016 by 0.3% (Table 2). The effect was significant at less than 1% level, but the coefficients are of smaller magnitude which probably reflects the shorter time the seed has had to diffuse through informal dissemination pathways. Since district level adoption rate of 2013 was used as an instrument to control for possible endogeneity of new improved variety adoption in market participation intensity, i.e. the outcome variable, these results lend credence to the validity of our instruments. Distance from the residence to the nearest cooperative office, also a proxy for seed access, had a significant and positive influence on the probability that a bean growing household was a partial adopter in 2016. These results are consistent with the literature, which have reported that adoption of new legume varieties is sometimes hampered by lack of access to seed (Shiferaw et al. 2008; Asfaw et al. 2011).

Controlling for the two proxies for technology supply, we see that regional variations in the new variety adoption remains. Compared with Mbeya region, the probability of adopting new bean varieties was lower in Iringa, Rukwa and Ruvuma (Table 2). The patterns in regional adoption of improved bean suggests that the seed dissemination activities by actors in seed value chain has been relatively more intense in Mbeya region that is in close proximity of the research station and hosts the biggest urban center in the SHZ.

The demand side factors linked to information access constraints re-enforce the seed supply constraints. The education level of the household head included as proxy for access to information had a positive effect on the likelihood that a household allocated all land pre-allocated to bean production to new varieties—thus being a full adopter. Finally, the attributes of physical production context was represented by soil pH and elevation in the analysis. Results reveal that the probability of planting improved bean varieties is slightly higher in areas where soil PH is within 6 to 7 range, i.e. the optimal pH for bean production, and lower below pH of 6. On the other hand, elevation does not seem to matter much when it comes to variety choice probably because varieties are well adapted over a wide of altitude.

Effect on bean marketed surplus

In this section, we take a look at the contribution of improved bean variety adoption on bean commercialization, measured as the quantity of marketed surplus.

Since our interest was to test whether the decision to adopt and that of market participation were made simultaneously and the fact that market participation is measured at household level, we collapsed the multinomial valued adoption into a binary treatment variable by combining full adoption with partial adoption. The exploratory analysis with switch-probit full information maximum estimation[3] showed that the decision to adopt new varieties and that of market participation were interdependent or made simultaneously, but the correlation is weak (significant at 10%). This result is not surprising given that bean is in transition from being pure subsistence to semi-subsistence and some bean growing households might decide to sell after production exceeds their consumption demand or in case of an emergence for cash needs. In situations where market participation is unplanned and unintentional, production decisions are not expected to affect market participation. Conditional on adoption of new varieties, the probability that a household will sell part of the harvest was estimated to be 69% while it is predicted to be 66% for non-adopters. This means

[3] likelihood ratio test of the interdependent decisions (p-value of chi2 value= 0.385)

that adoption of new improved bean varieties increases the probability of bean commercialization by 3%.

To estimate the impact of improved seed adoption on marketed surplus, we first corrected for the potential simultaneity bias associated with the fact that the decision on the quantity to sell and the decision to participate in the market as sellers of beans may be interdependent although the results from likelihood ratio test did not suggest that this would be a concern[4]. Results from the IPWRA of the marketed surplus on a subsample of those who participate in bean market are reported in table 3. The coefficient on the mills ratio (IMR) was significant in only the outcome equation or full adopters, but not significant in the outcome equation for partial adopters. This shows that inclusion of mills ratio to correct for potential selection bias in the estimation of the improved bean variety on a subsample of those who participate in the market was appropriate.

-----------Table 3------------

Results reported in Table 3 show that adoption of improved bean has contributed to commercialization of bean production in southern highlands of Tanzania in a substantial way. More specifically, the quantity of bean that was sold rose by 38% among full adopters while it increased by 29% among partial adopters, with both effects significant at 1% (table 3). This means that the marketed surplus among full adopters would be 38% lower, or 57 kg less if they had not planted improved seed. On the other hand, partial adopters would have sold 29% less had they not adopted new variety at all.

Results further show that if all households were to shift all the bean area to new bean varieties, the average effect of this adoption on the market surplus would be 72% which is remarkable with a potential to significantly to the income growth of smallholder farmers and lift many out of poverty. Majority of the net selling households reported having used revenue from bean to purchase non-food household items (e.g. clothing, school fees, appliances, kitchenware, furniture and radios). This reaffirms that the investment in bean variety development has important indirect benefits and underscores the importance of improved bean adoption for transforming small bean subsistence farms into economically viable and commercial enterprises.

Effect on women integration into bean output markets

Based on IPWRA approach we estimated the share of marketed surplus that was transacted by men and that for women separately. Results show that within households that adopted new varieties fully, the share of marketed surplus that was transacted by men increase by 24.4% while that transacted by women among the same households decreased by 25%. This result suggests that as farmer integrate into bean output markets, the control over bean sales shift from women to men. The finding that women are excluded from decisions of bean marketing with transformation into commercialization is consistent with the literature which argues that agricultural commercialization tends to exclude women (Djurfeldt, 2017). Results also suggest some heterogeneity among households, with some likely to maintain women in the commercialization process. For example, the unconditional treatment effects reveal that the reduction of women share of marketed surplus would reduce by only 14% if all households adopted fully. While full adoption disfavor women, partial adoption does not seem to exclude them. Results show that if all households were to adopt new varieties but partially, the average share marketed by women would increase by 9% though this was significant at 11% while that of men would stay the same (table 3).

[4] The independence of the quantity sold and the decision on whether or not to participation in the market was tested using likelihood ratio test as part of diagnostic results after two step Heckman estimation. The chi2 p-value= 0.305.

What are the causes for women exclusion?

Results in table 4 reveal that farm level women exclusion from the market integration can be attributed to household specific factors as well as the contextual factors related with market systems. Results show that the presence of a male decision maker in the household tends to lower the marketed surplus that is controlled by women in the sampled households of Tanzania while factors like household wealth, off farm income and education increase the share under women's control. Among full adopters that reside farer away from cooperatives, and those in distant remote villages with respect to the biggest regional urban center, women, on average, tend control a smaller share of the marketed surplus. For example, result suggest that the women's share of the market surplus drop by 23% for a household that access cooperative with 10km away from the village. Then, the average share of the marketed surplus drops further by 73% in the village that 10km or more km from the cooperatives. We believe that this is associated with bulkiness of transporting produce to cooperative for marketing in long distance. When it increases as a result of high yielding variety adoption, men take over the marketing, but according to focus group discussion, they do not handover the revenue to women, meaning that the later lose control of the crop income.

-----------------table 4----------------------

Determinants of household participation in bean output market and participation intensity by adoption status

Results from IPWRA that contain the factors that influence the volume of bean marketed is reported in table 5. The highlights of the results also show that household wealth, scale of production, productivity potential and favorable market conditions increase the probability that a household participates in market as a seller. The scale of bean production is positive and significant in all models, which is expected since expansion of area is supposed to enable higher production. The findings also revealed that bean farmers would be more integrated in the market if they could have better access to cooperatives or associations that are operated within their communities as this would help them build social networks that facilitate information acquisition. Consistent with this finding, the probability that a bean farmer sells any beans and the volume of market surplus reduces with distance from Mbeya, the regional city of Southern Highlands of Tanzania. Although, off farm employment exhibits a negative sign in selection model, its coefficient in the marketed surplus model for local varieties is positive and of larger magnitude (21%). This means that those who choose to participate are likely to sell more when they have access to off farm income and so are better-off households.

-----------------------Table 5----------------------

Conclusions

Improved technology adoption is well recognized as an important route to improving agricultural productivity and transformation of small subsistence farms into economic farm units in developing countries. Motivated by this notion and the fact that many households depend on bean for food and income, substantial efforts have been invested in bean improvement research in Tanzania in the past years, with a goal of increasing bean productivity and accelerating farm integration into market systems. Using survey data from 605 bean growing households in southern highlands of the country, this study employed econometric approaches and evaluated the impacts of improved bean adoption on marketed surplus and gender patterns of crop commercialization.

The analysis indicates that overall, nearly half of the bean growing households in Southern highlands are currently planting improved bean varieties, and new varieties are steadily replacing old one, i.e. those released 15 years before the time of the survey in 2016. While the varieties are well appreciated by intended users, which is a sign of the success of variety improvement, there barriers within seed systems that cause some farmers to delay adoption. These constraints can be mitigated by increasing on farmers' access to cooperatives, information dissemination to reduce the uncertainty about the performance of these varieties is still limited for some farmers.

On the impact of improved variety adoption on marketed surplus, results showed a positive and remarkable increase in the volumes sold. Thus, it is necessary to increase the intensity of improved bean adoption to generate an increase in yield as the excess output above the consumption level of the households will generate marketable surplus, which encourages farmers to participate in the output market. In light of these results, increasing the variables that lead to adoption of improved varieties and market participation intensity should be the focus for bean research that seeks to enhance welfare. Specifically, we recommend promotion of farmer membership in cooperatives should be encouraged. Access to seed and road infrastructure are also essential in order to increase the intensity of its adoption. The long term outcome is that adopting households will accumulate wealth and use it to improve their livelihoods.

The study findings also support the conclusion that while crop improvement research propels bean subsector transformation from subsistence to commercial enterprises, there might be negative effects on women. For example, results reveal a growing masculinisation of market participation for bean in Tanzania, meaning that women are being replaced from they traditionally dominated. The study found that the exclusion of women as bean commercializes is linked to both the functioning of markets themselves and factors inherent to the household.

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Table 1. Descriptive statistics of selected sample characteristics by adoption status

	Non-adopters (N=459)		Full adopter (108)		Partial adopters (N=209)	
Variable	Mean	SD	Mean	SD.	Mean	SD
Age of HH	49.74	11.87	50.48	11.55	48.39	11.67
sex_HHhead	0.82	0.39	0.84	0.37	0.86	0.35
Years of schooling HH head	6.79	2.22	7.53	4.65	7.09	2.34
Dependency ratio	0.58	0.22	0.54	0.22	0.54	0.20
Distance from cooperative (base=in v1llage)						
Within the village	50.98		40.74		43.06	
<10km from village	25.27		26.85		26.79	
>10 km from village	23.75		32.41		30.14	
Wealth index	0.74	0.37	0.72	0.38	0.77	0.36
Soil pH (%)	58.71	2.43	59.14	2.75	59.38	2.10
Distance to inputs market centre (km)	12.08	18.31	14.81	21.66	12.29	16.14
log distance from mbeya 9km)	285.40	210.41	244.39	194.37	202.35	175.52
cost of Agric services (Tsh.)	11302.67	28186.51	13986.12	39488.71	7225.02	18375.16
Off farm income (1-yes)	0.48	0.50	0.40	0.49	0.52	0.50
area under beans (Ha)	0.57	0.54	0.41	0.29	0.79	0.68
House size	5.02	2.06	5.26	1.69	5.25	1.70
Bean plot manager (%)						
Female	76.81		71.58		75.77	
Male	23.19		28.42		24.23	
Bean yield (kg/ha)	696.433	520.1128	940.6857	592.1556	751.5038	513.7076
% of HH sell beans	65.8		75.00		68.42	
Total marketed surplus (kg)	224.62	470.25	214.43	330.90	331.17	536.03
% of marketed surplus by seller						
Women	31.34		20.30		37.45	
Men	69.15		73.57		71.68	
Village level bean grain price	1168.36	540.66	1209.32	472.14	1027.29	570.84
Village level daily agric. wage	5124.18	1726.32	5236.11	1809.19	4758.37	1581.21

Table 2. Determinants of improved variety adoption

Variable	Non-adopter dy/dx	Std. Err.	Full adopter dy/dx	Std. Err.	Partial adopter dy/dx	Std. Err.
Log age of HH	0.011	0.088	0.096	0.062	-0.106	0.081
Years of schooling HH	-0.014^	0.008	0.013**	0.005	0.001	0.008
dependency ratio	0.158^	0.092	-0.088	0.068	-0.070	0.085
Log of elevation	-0.027	0.068	-0.022	0.049	0.049	0.064
Soil_PH (%)	-0.023**	0.009	0.007	0.006	0.017*	0.008
Distance to cooperative (Base=within village						
< 10 km from village	-0.067	0.047	0.021	0.034	0.046	0.044
> 10 km from village	-0.117*	0.054	-0.018	0.040	0.134**	0.051
regional dummies (base=Mbeya)						
Iringa	0.212**	0.055	-0.107**	0.043	-0.106*	0.051
Rukwa	0.228**	0.058	-0.076*	0.039	-0.152**	0.054
Ruvuma	0.273**	0.060	-0.116*	0.051	-0.157**	0.060
Distance to inputs dist centre (km)	0.000	0.001	0.001	0.001	-0.001	0.001
Off farm income (1-yes)	0.031	0.038	-0.055*	0.028	0.024	0.035
wealth index	-0.067	0.053	0.021	0.039	0.046	0.049
% adopters in district, 2013 (IV)	-0.004**	0.001	0.003**	0.001	0.001	0.001
Likelihood ratio Chi2 (28)	91.05**					
Log likelihood	-547.933					
Number of observations	625					

Table 3. Effect of adoption on marketed surplus and gender

Outcome variable	ATET Coef.	ATET Std. Err.	ATET P>z	ATE Coef.	ATE Std. Err.	ATE P>z
log of quantity marketed						
Full adopters	0.384	0.159	0.016	0.723	0.176	0.000
Partial adopters	0.291	0.127	0.022	0.147	0.107	0.172
gendered patterns						
Share of marked surplus transacted by women (0-1)						
Full adopters	-0.250	0.063	0	-0.141	0.064	0.028
Partial adopters	0.002	0.091	0.984	0.090	0.056	0.111
Share of marketed surplus transacted by men (0-1)						
Full adopters	0.245	0.087	0.005	0.238	0.093	0.01
Partial adopters	0.057	0.098	0.565	-0.053	0.059	0.365

Table 4 Determinants of the share of marketed surplus transacted by women in southern Highlands of Tanzania

	Non-Adopters		Full adopters		Partial adopters	
Variables	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Log of age HH	-0.056	0.162	-0.375	0.245	-0.017	0.183
Sex HH head	-0.405**	0.097	-0.571**	0.130	-0.423**	0.133
Years of schooling HH head	0.018	0.018	0.038*	0.018	-0.023	0.019
dependency ratio	0.083	0.140	0.464*	0.225	0.319	0.215
Distance from cooperative (base=in village)						
<10km from village	0.009	0.073	-0.229**	0.087	-0.001	0.138
>10 km from village	-0.006	0.083	-0.738**	0.258	-0.276	0.192
Wealth index	0.210**	0.081	0.538*	0.225	0.166	0.133
log agricultural wage	-0.293**	0.103	0.075	0.152	0.105	0.130
Soil pH	-0.005	0.014	-0.026	0.020	0.008	0.026
Regional dummy=base=Mebya						
Iringa	-0.303**	0.108	-0.061	0.142	0.043	0.149
Rukwa	-0.001	0.217	0.768	0.520	0.504*	0.265
Ruvuma	-0.273*	0.144	0.923**	0.314	0.532**	0.184
distance from input market (km)	0.000	0.002	0.014**	0.006	0.008	0.007
log distance from mbeya (km)	0.037	0.048	-0.082	0.114	-0.194**	0.068
cost of Agric. services (Tsh)	0.000	0.000	0.000**	0.000	0.000	0.000
Off farm income (1-yes)	-0.020	0.052	0.408**	0.130	0.111	0.095
Area under beans (Ha)	-0.058	0.049	-0.212	0.248	-0.078	0.068
manager bean plot (base =female						
Male	0.195**	0.074	0.167^	0.091	0.001	0.107
Mills ratio	0.779**	0.329	0.955	0.838	0.437	0.460
_cons	2.834	1.553	1.639	1.843	-0.135	2.356

Table 5. Determinants of bean marketed surplus in southern Highlands of Tanzania

	sell beans		Non-Adopters		Full adopters		Partial adopters	
	dy/dx	Std. Err.	Coef	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Potential means			5.025	0.080	5.749**	0.183	5.172**	0.096
Log age HH	-0.155*	0.078	0.036	0.389	-2.173**	0.703	-1.234**	0.452
Sex HH head	0.052	0.050	0.466**	0.194	1.455**	0.427	0.428*	0.204
Years of schooling HH	0.013	0.008	0.016	0.042	0.124*	0.058	0.029	0.046
Dependency ratio	0.050	0.085	-0.046	0.313	0.273	0.516	-0.298	0.493
Distance from cooperative (base=in village)								
<10km from village	-0.062	0.043	-0.534**	0.171	-1.120**	0.458	-0.511*	0.221
>10 km from village	-0.168**	0.055	-0.437^	0.238	-2.027*	0.867	-0.738	0.489
Wealth index	0.104*	0.053	0.417*	0.214	0.805	0.711	0.534**	0.184
log agricultural wage	0.100^	0.060	1.001**	0.249	0.713	0.652	-0.386	0.250
Soil pH	0.007	0.008	0.068*	0.035	0.245**	0.051	0.177**	0.033
Regional dummy (base=Mebya								
Iringa	0.029	0.057	0.393	0.270	0.795	0.814	-0.414	0.325
Rukwa	0.439	0.080	2.026**	0.684	5.030*	2.413	0.634	0.731
Ruvuma	0.186	0.074	1.298**	0.425	2.178	1.798	-0.295	0.323
distance from input market (km)	0.004	0.001	0.022**	0.007	0.040*	0.020	0.032^	0.018
log distance from mbeya	-0.077	0.029	-0.451**	0.160	-1.151	0.742	-0.035	0.233
cost of agric services (Tsh)	0.000	0.000	0.000**	0.000	0.0001**	0.000	0.000**	0.000
Off farm income (1-yes)	-0.022	0.036	0.208^	0.122	-0.364	0.333	-0.170	0.184
Area under beans (Ha)	0.171**	0.049	1.009**	0.221	3.296**	0.713	0.671**	0.157
manager bean plot (base =female								
male	-0.044	0.044	-0.151	0.170	-0.708*	0.307	-0.155	0.307
Mills ratio			0.794	0.999	6.694*	2.827	0.630	0.920
Constant			-8.250**	3.236	-10.160	6.581	1.181	3.574
Number of observation	627		374					
Wald chi2(13)	101.3***							
Log likelihood = -664.29436	-338.02							

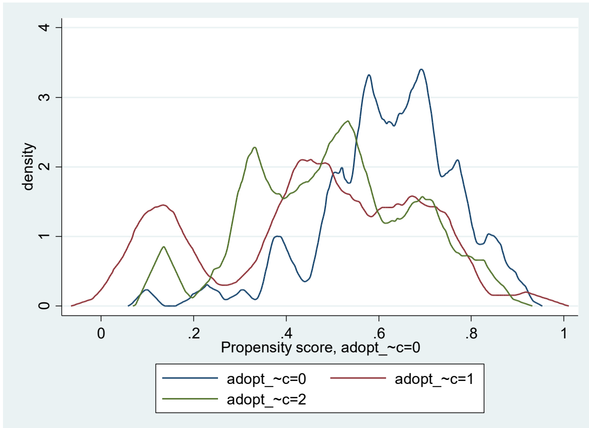

Figure 1a: overlap for of bean sales volume

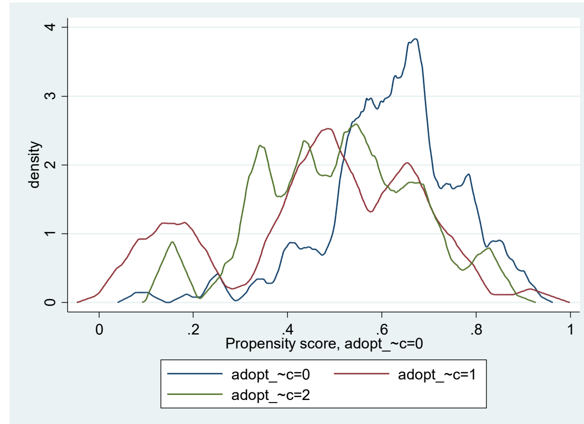

Figure 1 c. overlap test for the share of marketed bean transacted by men

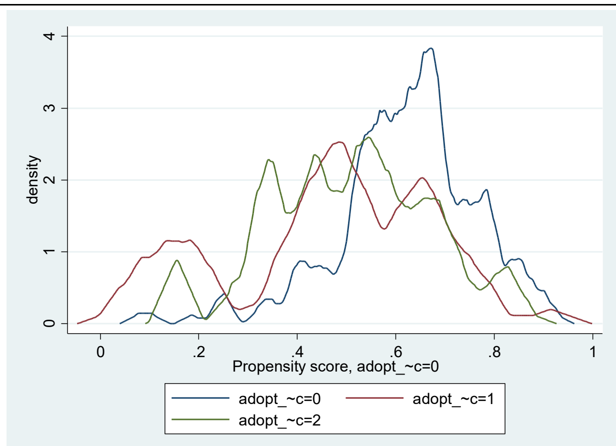

Figure 1b. overlap test for share of marketed surplus transacted by women