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Do youth farmers benefit from participating in contract farming? Evidence from French beans youth farmers in Arusha, Tanzania

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ABSTRACT

Contract farming (CF) is often seen as a system that enhances production efficiency leading to increased agricultural productivity and improved farmer livelihoods. However, there is a conflict in the literature on its impact on young farmers who are involved in farming in Sub-Saharan Africa. This paper evaluates the impacts of CF on crop yield, crop and household income among the youth farmers involved in French bean farming in Tanzania using cross-sectional data of 273 households. The study employs an endogenous switching regression (ESR) model that accounts for observed and unobserved factors to estimate the impact of CF. Further, the propensity score matching (PSM) model is used to check the robustness of ESR results. The results indicate that 162 farmers had contracts and French bean yields and incomes significantly increased with CF. Specifically, the empirical results reveal that CF leads to a gain of 17%, 34% and 37.5% in the yield, crop income and household income. Participation and impact of contract farming differed according to different socio-economic/institutional variables, such as access to extension services.

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1. Introduction

Rapid changes in the agriculture and food industry, notably agricultural industrialisation and commercialisation, have created opportunities for youths to engage in high-value production and marketing, value addition and employment creation in the various value chains (Barrett et al. 2010). However, this transition to high-value commercial agriculture is driven by institutions such as cooperatives, farmers' associations and contractual arrangements which not only coordinate demand and supply but also address consumer concerns regarding the quality and safety of food (Joshi, Joshi, and Birthal 2006; Birthal et al. 2009). African youths have continued to face challenges like low production, lack of markets, price risks, inadequate extension services, lack of production inputs and quality control issues (Bellemare 2018). Coordination through contract farming can help address these challenges and facilitate young farmers to take up agricultural opportunities, thus turning them into commercial producers that produce surplus and generate incomes which can be a pathway to eradicating poverty and hunger. Contract farming helps in mitigating marketing and production risks, reducing transaction costs, and providing credit, inputs, technology, and support services (Nagaraj et al. 2008; Barrett et al. 2012; Minot 2011).

Contract farming is an agricultural production system involving an agreement between farmers (producers) and an agribusiness company (buyer), which outlines conditions for the production and

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marketing of farm products (Minot 2011). The farmer commits to providing an agreed quantity of the produce of specified quality and at a defined period. The buyer agrees to purchase the produce at prices agreed upon and to support production through the provision of inputs and technical advice (Bellemare 2018). In this way, farmers have access to improved inputs (e.g., improved seed, and fertilisers), credit, technical assistance and training in form of extension which leads to increased yield (Saigenji and Zeller 2009)

Contract farming is also a form of the future market which involves shifting of price risks from producers to processors. This is beneficial taking into consideration the nature of the horticultural sector which is faced with a lot of price fluctuations. Studies on contract farming have found that price risk reduction is the principal incentive for producers to enter into contractual agreements (Wainaina, Okello, and Nzuma 2014). With contract farming, price risk is reduced, because of the predetermined price rather than the market price (Martinez 2002).

There are four models of Contract farming namely, centralised model, intermediary model, multipartite model and the informal model (Olomola 2010; Wainaina, Okello, and Nzuma 2014). In the centralised arrangement, a centralised processor and/or buyer procure outputs from many small-scale farmers. There is vertical integration and involves the provision of several services such as extension, pre-financing of inputs and transportation of produce from the farmer to the buyers' processing plant. The multipartite contract farming model is when two or more organisations which could be private agribusiness, state, firms, international aid agencies or nongovernmental organisations coordinate and work together to manage buyers and farmers. On the other hand, the intermediary model has more of the centralised model characteristics with the difference being that they act as an intermediary on behalf of another firm. With this model, the intermediaries organise everything and act on behalf of the final buyer starting. Finally, with the informal arrangements, written contracts are absent, and it involves casual oral agreements between contracting parties.

While contract farming has been given a lot of focus in developing countries, there is a conflict in the available literature on its impact on smallholder farmers` welfare. Some authors argue that it is beneficial to the smallholder farmers since it enables them to easily access local and global markets, consequently improving their welfare (Miyata, Minot, and Hu 2009; Rao and Qaim 2011; Barrett et al. 2010; Bellemare 2012; Narayanan 2014; Wainaina, Okello, and Nzuma 2014; Mulatu et al. 2017; Dubbert 2019). Further, Fleming and Abler (2013), argue that contract farming enhances farmers' income due to economies of scale enjoyed in contract arrangements.

On the other hand, critics of contract farming argue that it creates unequal bargaining relationships between farmers and the companies; transfers production risks to farmers; and tends to favour medium and large-scale producers (Little 1999; Singh 2002). Others argue that contract farming has no significant effect on household welfare, the effect on income is context-specific, varies by scale and depends on the enterprise in question (Birthal et al. 2008; Mwambi et al. 2016).

Given the conflicting literature that contract farming can be both favourable and unfavourable to smallholder farmers especially the youth, the extent to which participation improves their welfare remains contentious. Therefore, this study contributes to the literature by estimating the impact of CF on yield and incomes among the French beans farmers in Tanzania. Given that CF is not randomly distributed across the households (households self-select to participate in CF), we use the endogenous switching regression (ESR) model to address selection bias due to observed and unobserved heterogeneity. Since the ESR may be sensitive to the trivariate normal distribution and exclusion restriction assumptions, we also estimated the PSM model approach to check the robustness of the estimated effects obtained from the ESR model (Shiferaw et al. 2014). Furthermore, unlike other studies (e.g., Bellemare and Bloem 2018; Dubbert 2019; Girma and Gardebroek 2015; Mishra et al. 2018; Mwambi et al. 2016; Ton et al. 2018; Wainaina, Okello, and Nzuma 2014) which focused on smallholder farmers in general, we evaluate the impact of contract farming on production and incomes of smallholder youth French beans farmers in Tanzania. Given that young farmers have different characteristics like highly information technology skilled and lack access to land compared to older farmers who have been in the farming business for a long, we document and provide empirical evidence to whether participation in contract farming has an impact on production and incomes among the youths involved in French beans production in Tanzania.

The rest of the article is organised as follows. The next section outlines the study context while section 3 describes the methodology. Section 4 presents the results while the last section draws conclusions and outlines implications for policy.

2. Study context

The horticulture industry in Tanzania is the fastest growing subsector within the agricultural sector with an annual average growth of about 9–12% per annum (Tanzania Horticultural Report 2017). This growth is more than double the overall annual growth rate of the agricultural sector (Benali, Brümmer, and Afari-Sefa 2018). In 2018, horticulture contributed 38% of the foreign income earned from the agriculture sector (Tanzania Horticultural Report 2017). The horticulture subsector in Tanzania employs about 2.5 million people, which makes the industry a major employer within the agricultural sector (Benali, Brümmer, and Afari-Sefa 2018). French beans (*Phaseolus vulgaris* L.) is a major export vegetable commodity in many horticultural crop-producing countries like Tanzania. The crop is mainly grown by smallholders and virtually all is exported to Europe. French beans can be harvested 45 days after planting and are immediately paid for upon delivery and provides for the daily needs of many smallholder families.

The adoption of French bean farming in Arumeru district by farmers has been at high levels and in recent years, the sector has been given focus due to its ability to generate incomes among the farmers (Ng'atigwa et al. 2020). Moreover, the region's equatorial climate allows the cultivation of French beans all year round. However, high poverty levels, pests, diseases and extremely limited resources in the region have been the biggest blow to production (Mayala and Bamanyisa 2018; Ng'atigwa et al. 2020). Government agencies and in partnership with other development actors have taken the initiative to support the sector, especially focusing on the youth and women (Ng'atigwa et al. 2020). For instance, the Tanzania Horticultural Association (TAHA) in partnership with United Nations Development Programme (UNDP) are connecting youth and women to sustainably produce French beans yields from the current 1.5 tonnes to 4 tonnes per acre. The crop is mainly grown by the youth and TAHA strives to link them to financial services, agricultural technologies and markets. In addition to that, there are high partnerships between exporters and these young producers, who enter into agreements by creating contracts accepted by all the partners with a fixed price according to prefixed quality standards.

The African Union (AU) defines youths as people who are 15–35 years of age. Equally, Kimaro and Towo (2015) while studying the determinants of rural youth participation in agricultural activities in Tanzania, defined youths to be people 15–35 years of age. Therefore, in the context of this study, the term youth is referred to all people of 15-and 35 years engaging themselves in French beans production.

3. Methodology

3.1 Theoretical framework

The study employs the theory of expected utility as developed by Bernoulli (1738), which has been applied in several studies on farmer decision-making in many aspects (Babcock and Hennessy 1996; Gomez-Limon et al. 2004). Following Bernoulli (1738), participation in contract farming (CF) can be viewed as a binary choice decision problem by farm households that try to maximise utility or net returns. The utility is determined by a set of variables (X) which determine the relative returns that a farmer can earn from participating in CF. Thus, X includes farmer, farm and institutional characteristics both of which influence ability to participate in the contractual agreements and optimise farm decisions based on a contract.

The probability that youth households (i) participate in CF is, therefore, determined by a comparison of the expected utility of participation in CF, U_{ip}, against the expected utility of participating in non-contractual agreements, U_{iN}. In making this comparison, the youth farmer evaluates both benefits and the cost of either participating or not. The youth farmer will participate in contract farming only if $U_{ip} > U_{iN}$, implying that the potential benefits outweigh the constraints and this difference in utility can be represented by a latent variable, R_i*, i.e., $R_i{*} = U_{ip} - U_{iN}$.

3.2 Model specification

Several quasi-experimental designs have been used in impact evaluation studies which include; the Heckman selection correction model, propensity score matching and instrumental variable (IV). The use of ordinary Least Squares (OLS) regression will yield inconsistent and biased estimates because only part of the population involved in CF is used and the estimates are sensitive to the functional form if the error term is not adequately interpreted (Heckman and Navarro-Lozano 2004).

Therefore, we first use the endogenous switching regression (ESR) model which accounts for selection bias emanating from observed and unobserved characteristics to obtain unbiased estimates based on actual and counterfactual outcomes (Lokshin and Sajaia 2004). Failure to control for unobserved attributes such as innate skills and risk preferences which affect the farmers' decision regarding whether to adopt CF or not may lead to misleading estimates. From the literature, several studies have used the ESR method to control selection bias (e.g., Abdulai and Huffman 2014; Carter and Milon 2005; Kassie et al. 2015; Shiferaw et al. 2014; Teklewold et al. 2013).

The application of the ESR proceeds in two steps. First, farmer decisions whether to participate in Contract farming (CF) or not (selection equation) and is estimated with a probit model. Second, the three main outcome equations are specified as linear regressions for participants in CF and non-participants separately. To formally motivate the ESR framework, a latent variable C_i^* is defined capture the benefits from participating in CF as:

$$C_i^* = \beta Z_i + \varepsilon_i \text{ with } I_i = \begin{cases} 1 & \text{if } \beta Z_i + \varepsilon_i > 0 \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

where Z_i is a vector of institutional and household characteristics that influence participation in CF. β is a vector of parameters to be estimated whereas ε_i is the normally distributed error term. Equation (1) is the first stage (selection equation) in the ESR framework and the second stage involves estimating separate equations for each outcome variable for both the participants and non-participants in CF (Maddala 1991).

$$Y_1 = \alpha_1 X_1 + \varepsilon_1 \text{ if } CF_i = 1 \tag{2}$$

$$Y_0 = \alpha_0 X_0 + \varepsilon_0 \text{ if } CF_i = 0 \tag{3}$$

where Y_1 and Y_0 are outcome measures (yield and incomes) for participants and non-participants in CF, respectively. Bean yield was computed as the total harvest in kilograms (Kg) in the last season divided by the area planted in hectares. French bean income was the net value from French beans sales per hectare minus the total variable costs per hectare while household income per capita was computed by summing up the income from all crops and off-farm income and dividing it by the household size. X_j ($j = 1, 0$) is a vector of covariates that affect outcome variables. α_j ($j = 1, 0$) is a vector of parameters to be estimated and ε_j is a vector of error terms.

Self-selection into participation may result in nonzero covariance between the error terms of the selection equation. (1) and outcome equations (2) and (3). This is because some of the unobservable heterogeneity influencing participation may also influence outcomes. Given the assumption of the ESR framework of a trivariate normal distribution with zero mean and nonzero covariance on the error terms, the matrix can be modelled as:

$$corr(\varepsilon_i \varepsilon_1 \varepsilon_0) = \Sigma = \begin{pmatrix} \sigma^2_{\varepsilon} & \sigma_{\varepsilon\varepsilon 1} & \sigma_{\varepsilon\varepsilon 0} \\ \sigma_{\varepsilon 1\varepsilon} & \sigma^2_{\varepsilon 1} & \sigma_{\varepsilon 1\varepsilon 0} \\ \sigma_{\varepsilon 0\varepsilon} & \sigma_{\varepsilon 0\varepsilon 1} & \sigma^2_{\varepsilon 0} \end{pmatrix} \tag{4}$$

where σ^2_{ε}, $\sigma^2_{\varepsilon 1}$ and $\sigma^2_{\varepsilon 0}$ are variances of the error terms from the selection and outcome equations respectively. $\sigma_{\varepsilon 1\varepsilon}$ is the covariance between ε_i and ε_1, $\sigma_{\varepsilon 0\varepsilon}$ is the covariance between ε_i and $\varepsilon_0 . \sigma_{\varepsilon 1\varepsilon 0}$ is the covariance between ε_1 and ε_0 but is never defined as Y_1 and Y_0 are not observed simultaneously. Therefore, the expected values of the error terms for equation (5) and (6) is given by:

$$E(\varepsilon_1|CF_i = 1) = E(\varepsilon_1|\varepsilon_i > -\beta Z_i) = \sigma_{\varepsilon 1\varepsilon}\frac{\phi(\beta Z_i)}{\Phi(\beta Z_i)} = \sigma_{\varepsilon 1\varepsilon}\lambda_1 \tag{5}$$

$$E(\varepsilon_0|CF_i = 0) = E(\varepsilon_0|\varepsilon_i \leq -\beta Z_i) = \sigma_{\varepsilon 0\varepsilon}\frac{-\phi(\beta Z_i)}{1-\Phi(\beta Z_i)} = \sigma_{\varepsilon 0\varepsilon}\lambda_0 \tag{6}$$

where ϕ is a standard normal probability density function and Φ is a standard normal cumulative function. λ_1 and λ_0 are selectivity terms representing the inverse Mills ratios for participants and non-participants in CF, which are included in the outcome equations (2) and (3) to account for selection bias (Abdulai and Huffman 2014).

Although the covariates in the selection and outcome equations may overlap, proper identification requires that at least one variable in Z is omitted (Lokshin and Sajaia 2004). Therefore, we instrumented participation in CF with the variable distance to other French bean farmers. This instrument was omitted in the outcome equations (2) and (3). The instrument related to the distance between farmers has been used before by Dubbert (2019). We expect that participation in CF reveals how farmers are clustered in a given geographical area. There is a high likelihood that if clustering is high, farmers will interact among themselves making it easy for information to flow among themselves and vice versa in the case of less clustered locations (Michelson 2017). Furthermore, companies are likely to engage farmers who are more clustered as higher cluster density enhances access to farmers and collection of outputs is easy and with a relatively lower cost, compared to regions where French bean farmers are less populated (Barrett et al. 2010). A valid instrument should influence participation in CF but not the outcome variables (yield and incomes), except through CF. The identifying assumption for this study will be that this instrument is correlated with participation in CF, but not correlated with French beans yield and incomes in any other way than through participation in CF.

A falsification test was done to check whether the distance to other French bean farmers was a valid instrument following Di Falco, Veronesi, and Yesuf (2011); An instrument is valid if it affects the participation equation (participation in CF in our case) but not the outcome variables (bean yield and incomes) for farmers who did not participate in CF. We use this variable because distance affects information sharing which has an impact on the decision of a farmer to participate in CF. Therefore, farmers with information on the CF system only can participate in contract farming. Distance from one farmer to the other cannot, however, only directly affect the outcome. According to Table A1 of the appendix, the falsification test on the instrumental variable used, shows that it is statistically significant in the participation equation (in selection equation: *p-value* = 0.08) but not in the outcome equations of the non-participants (outcome equation: *p-value* = 0.72, 0.65 and 0.72 for bean yield, bean income and household income respectively).

The re-specified outcome equations incorporate the inverse Mills ratios derived from the selection equation as:

$$Y_1 = \alpha_1 X_1 + \sigma_{\varepsilon 1\varepsilon}\lambda_1 + \mu_1 \ \text{ if } CF_i = 1 \tag{7}$$

$$Y_0 = \alpha_0 X_0 + \sigma_{\varepsilon 0\varepsilon}\lambda_0 + \mu_0 \ \text{ if } CF_i = 0 \tag{8}$$

The ESR derives consistent conditional expectations, useful in computing observed and counterfactual outcomes for the CF participants and non-participants. Counterfactuals are the expected outcomes for CF participants had they not participated and for non-participants had they participated. Following Di Falco, Veronesi, and Yesuf (2011), we can estimate the outcome scenarios from equations (7) and (8) as follows:

$$(a)E(Y_1|CF_i = 1) = \alpha_1 X_1 + \sigma_{\varepsilon 1 \varepsilon}\lambda_1 \tag{9}$$

$$(b)E(Y_0|CF_i = 0) = \alpha_0 X_0 + \sigma_{\varepsilon 0 \varepsilon}\lambda_0 \tag{10}$$

$$(c)E(Y_0|CF_i = 1) = \alpha_0 X_1 + \sigma_{\varepsilon 0 \varepsilon}\lambda_1 \tag{11}$$

$$(d)E(Y_1|CF_i = 0) = \alpha_1 X_0 + \sigma_{\varepsilon 1 \varepsilon}\lambda_0 \tag{12}$$

Equations (9) and (10) are the expected outcomes conditional on CF participation and non-participation respectively. Equation (11) is the expected outcome for non-participants had they participated (counterfactual outcome for participants). Equation (12) is the expected outcome for participants had they not participated (counterfactual outcome for non-participants) (Table 1).

Therefore, the average treatment effect on the treated (ATT) is the difference between equations (9) and (11) (Di Falco, Veronesi, and Yesuf 2011). This is the difference between what the participants produced and earned from participating in CF and what they would have produced and earned had they not participated:

$$\begin{aligned} ATT &= E(Y_1|CF_i = 1) - \; E(Y_0|CF_i = 1) \\ &= X_1(\alpha_1 - \alpha_0) + \lambda_1(\sigma\varepsilon_1\varepsilon - \sigma\varepsilon_0\varepsilon \end{aligned} \tag{13}$$

The outcome for non-participants is given by the average treatment effect on the untreated (ATU) which is the difference between equations (12) and (10). This captures the difference between what non-participants would have produced and earned if they had participated in CF and what they produced and earned by not participating as shown below:

$$\begin{aligned} ATU &= E(Y_1|CF_i = 0) - \; E(Y_0|CF_i = 0) \\ &= X_0(\alpha_1 - \alpha_0) + \lambda_0(\sigma\varepsilon_1\varepsilon - \sigma\varepsilon_0\varepsilon) \end{aligned} \tag{14}$$

We further use the expected outcomes equations (9)–(12) to compute the heterogeneity effects. For example, households that participated in contract farming may have produced more and earned more income than households that did not participate even though they decided to participate due to unobservable characteristics. We define the effect of base heterogeneity for the group of households that decided to participate as the difference between (a) and (d):

$$\mathrm{BH1} = E(Y_1|CF_i = 1) - \; E(Y_1|CF_i = 0) \tag{15}$$

Table 1. Conditional expectations, treatment, and heterogeneity effects.

	Decision stage		
Category	To participate	Not to participate	Treatment effects
CF participants	(a) E ($y_1|CF_i = 1$)	(c) E ($y_0|CF_i = 1$)	ATT
CF non-participants	(d) E ($y_1|CF_i = 0$)	(b) E ($y_0|CF_i = 0$)	ATU
Heterogeneity effects	BH_1	BH_2	TH

Note: (a) and (b) represent observed expected outcomes; (c) and (d) represent counterfactual expected outcomes.
$CF_i = 1$ if youth households participated in Contract farming; $CF_i = 0$ if youth households did not participate.
Y_1: outcome if youth households participated in contract farming.
Y_0: outcome if youth households did not participate.
ATT: the effect of the treatment (i.e., participation) on the treated (i.e., households that participated).
ATU: the effect of the treatment (i.e., participation) on the untreated (i.e., households that did not participate).
BH_i: the effect of base heterogeneity for households that participated ($i = 1$), and did not participate ($i = 2$).
TH = (ATT − TU), i.e., transitional heterogeneity.

Similarly, for the group of households that decided not to participate the effect of base heterogeneity is the difference between (c) and (b):

$$BH2 = E(Y_0|CF_i = 1) - E(Y_0|CF_i = 0) \tag{16}$$

We finally investigate the transitional heterogeneity (TH), of whether the impact of participating in contract farming is larger or smaller for households that participated in contract farming or for households that did not participate in the counterfactual case that they did participate, computed as the difference between equations (15) and (16) (i.e., ATT and ATU).

To assess the robustness of the ESR results, we further use the PSM method to generate the average treatment on the treated (ATT) of the outcome variables and compare them to those of ESR. PSM involves constructing a comparison group based on an individual's probability of participating in a program conditional on observable characteristics (Ravallion 2009). This proceeds in two-stage: first, the entire sample is used to estimate a probit or logit model that generates propensity scores (z) – estimates of the probability that a youth with a vector of characteristics z, participates in contract farming. The vector z is assumed to be those observable variables that determine whether a youth participates in contract farming. In this estimation, youths with similar observable characteristics are likely to have similar propensity scores (z), even if some of them do not participate in contract farming. Using similarity in propensity scores, we, therefore, construct comparable groups i.e., groups of farmers with similar propensity scores (z) but where one group participates in contract farming while the other group does not participate.

In the second stage, we calculate the average outcome for the two groups and then estimate the impacts of contract farming as the difference in average outcomes between these groups. This difference is the average treatment effect on the treated (ATT) i.e., the effect on those youths who participated in contract farming:

$$\tau_{ATT}^{PSM} = E_P(z|R = 1)[E\{Y_1|R = 1, \ P(z)\} - E\{Y_0|R = 0, \ P(z)\}] \tag{17}$$

where Y_1 and Y_0 are outcomes for participants and non-participants of contract farming respectively; $R = 1$ indicates that the youth who participated in contract farming and $R = 0$ refers to a comparison group of the youth that did not participate in contract farming.

3.3 Data and sampling

The study was undertaken in Arusha, Tanzania and this region was purposively chosen for two reasons; first, contract farming of French beans is commonly practised and second, the area has a high density of smallholder French beans farmers of which a majority are young farmers. We used a three-stage stratified random sampling procedure to obtain respondents for the study. In the first stage, Arumeru district in the Arusha region was purposively selected to form the sampling frame because contract farming of French beans is commonly practised. In the second stage, we selected eight wards purposively since they had a considerably higher number of young contracted French bean farmers compared to the other wards. The selected wards were Kikwe, Mbuguni, Burka, Imbassny, Poli, Sing'si, Useriver and Nkoarisambu.

In the third stage, respondents were randomly selected from the list of contracted farmers as well as non-contracted farmers. The list of 756 youth farmers that formed the sampling frame in each ward was obtained with the help of the leaders of the youth groups involved in French bean farming in the district. This resulted in a sample of 273 respondents, of which 162 farmers had contracts and 111 farmers did not have contracts in French bean farming. The sample size of 273 respondents was informed by the total number of contracted youth farmers, population of youth farmers and available budget. Data were collected and entered using computer-aided personal interviews (CAPI) application, Census and Survey Processing System (CSPro). The data collected included demographic, socio-economic and institutional factors that are likely to affect participation in CF.

4. Results and discussion

4.1 Descriptive statistics

Table 2 shows the outcome and explanatory variables considered in the study, drawn from the literature on contract farming (Begum et al. 2012; Wainaina, Okello, and Nzuma 2014; Dubbert 2019). Descriptive statistics indicate that there were significant differences between the French bean contracted and non-contracted farmers regarding all the outcome variables (Table 2). On average, contracted farmers produced an average of 1205.25 kilograms of French beans per hectare more than non-contracted farmers. The same was observed for the French bean income per hectare and household income per capita where, on average, contracted farmers realised TSh 1193607 and TSh 467842[1] more from French bean and household income, respectively. Additionally, there were also significant differences in the independent variables. Contracted farmers significantly sold their beans at better prices than non-contracted ones where, on average, they had a price of Tshs. 1084 compared to Tshs. 813 of those not contracted. This explains why contracted farmers had more income from French beans than non-contracted ones.

Contracted farmers were significantly closer to collection centres of French beans with an average distance of 1.76 kms as compared to non-contracted farmers who were away from collection centres by 2.69 kms. Although the difference in distance to collection centres between the contracted and non-contracted farmers is small, this variable determines whether a farmer will enter into contractual

Table 2. Demographic and socio-economic characteristics of sampled households.

	Contracted		Non-Contracted			
	Mean	Std. Dev	Mean	Std. Dev	Diff	*t* stat
Outcome variables						
French bean yield (Kg/hectare)	5028.50	2363.13	3823.25	2452.50	1205.25***	4.07
Net Bean income (TSh)	3214711	5300142	2021103	3103973	1193607**	2.13
Household income per capita (TSh)	1458619	1020066	990777	909930	467842***	3.88
Independent variables						
Socio-economic						
Sex of respondent (1 = Male, 0 = Female)	0.72	0.44	0.72	0.44	0.00	0.02
Education of respondent (years)	8.45	2.39	8.87	2.55	−0.42	1.39
Primary occupation (1 = Farmer, 0 = Otherwise)	0.98	0.11	0.99	0.09	0.00	0.25
Marital status (1 = Married, 0 = Otherwise)	0.85	0.35	0.77	0.41	0.08*	1.77
Age of respondent (number)	34.19	6.27	32.93	7.11	1.25	1.53
Experience in French bean farming (years)	3.98	2.91	3.86	3.73	0.12	0.30
Household size (number)	4.90	1.70	4.80	2.02	0.07	0.33
Distance to the market (Kms)	4.64	4.39	5.00	4.59	−0.35	0.65
Transport cost to the market (TSh)	1544	2691	1478	2481	65.99	0.20
Distance to the main road (Kms)	3.20	3.52	3.28	3.19	−0.07	0.18
Distance to Arusha town (Kms)	22.59	7.35	22.46	7.23	0.12	0.13
Distance to the collection centre (Kms)	1.76	3.44	2.69	5.58	−0.93*	1.7
Distance to other French bean farmers (Kms)	1.34	2.47	2.33	4.07	0.98***	2.21
Price of French beans (Tshs)	1084	897	813	107	271***	3.16
French beans rejects (Kgs)	443.90	2885.28	248.57	842.44	195.32	0.69
Cost of French bean production (Tshs)	774002	648166	867759	485617	125836	1.38
Farm characteristics						
Owns land (1 = Yes, 0 = No)	0.93	0.25	0.90	0.3	0.03	0.92
Size of land owned (hectares)	1.18	2.02	0.79	0.91	1.02*	1.90
Total land under French beans (acres)	1.24	1.26	1.08	1.05	0.15	1.09
Institutional variables						
Access to credit (1 = Yes, 0 = No)	0.37	0.48	0.36	0.48	0.37	0.11
Distance to credit facility (Kms)	7.27	9.55	7.40	8.851	0.13	0.07
Access to extension services (1 = Yes, 0 = No)	0.65	0.60	0.47	0.49	0.05	0.85
Distance to extension provider (Kms)	7.97	8.24	8.02	7.60	0.05	0.04
Group Membership (1 = Yes, 0 = No)	0.79	0.72	0.40	0.44	0.06	1.15
Know other French bean farmers (1 = Yes, 0 = No)	0.78	0.41	0.80	0.40	−0.01	0.35

Note: * significant at the 10% level, ***significant at the 1% level.
1 USD = TSh 2,307.69 when the survey was conducted.

agreements to produce French beans or not. The closer the collection centre, the more likely a farmer will be contracted (Barrett et al. 2010). It was also revealed that the distance between the contracted farmers and other French bean farmers was shorter (1.34 kms) as compared to that of non-contracted farmers (2.33 kms). The difference in total land owned was also statistically significant whereby contracted farmers owned more acres of land (2.91 acres) as compared to non-contracted farmers who on average owned 1.95 acres. Regarding marital status, 85% of contracted farmers were married as compared to 77% of the non-contracted. In terms of sex, 72% of both the contracted and non-contracted were males.

Although no statistical differences, the average number of years of school for both the contracted and non-contracted was about 8 years. Additionally, the farmers sampled on average had 4 years of experience in French bean production. On average households had about 5 members which has an implication of significant levels of human capital for both physical and technical capital. The average age of contracted and non-contracted farmers was about 34 and 32 years respectively with most of them (over 98%) practising farming as their primary occupation, which implies that the majority of the households earned their income mainly from on-farm activities.

On average, about 36–37% of the farmers had access to credit for agricultural use. Farmers attributed the low access to credit to high-interest rates on loans and payback plans that do not favour their nature of farming. About 79% and 72% of contracted and non-contracted farmers respectively belonged to farmer groups and 60–65% had access to extension services on French bean production. The findings imply that farmers have higher social capital and better access to information and social services.

4.1.1 Stochastic dominance analysis

The cumulative density functions (CDF) for the outcome variables of both the contracted and non-contracted households are presented in Figures 1–3. Figure 1 shows the CDFs for beans for contracted and non-contracted households. The yield cumulative distribution of the contracted households is to the right and below those without contracts. This indicates that outcomes of the contracted households unambiguously hold first-order stochastic dominance over those of the non-contracted households. Similarly, for most of the parts of the net income distribution (i.e.,

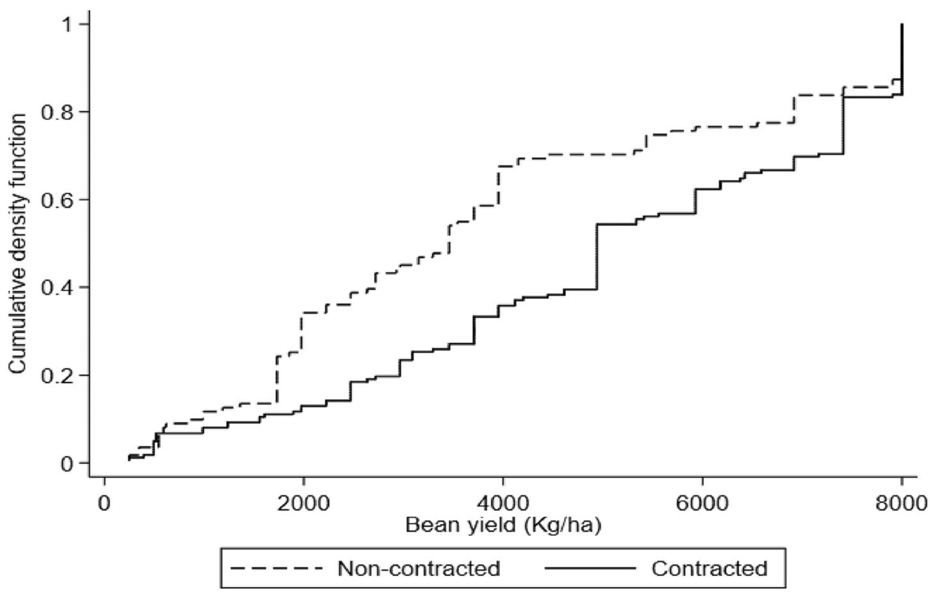

Figure 1. Cumulative distribution for the impact of contract farming on French bean yield.

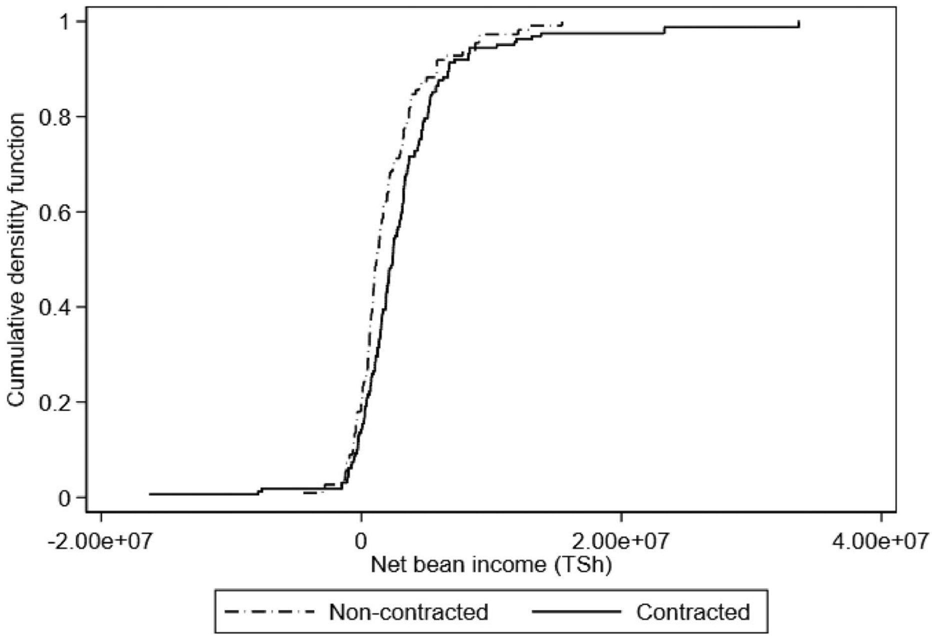

Figure 2. Cumulative distribution for the impact of contract farming on French bean income.

between 30% and 90%), the net income distribution for the contracted households hold first-order stochastically dominates that of non-contracted (Figure 2). Figure 3 also shows that the likelihood of contracted households obtaining higher household income is higher for the contracted household than those without a contract. For instance, about 62% of the non-contracted households obtain less than or equal to Tsh1000 000 compared to only 41% of the contracted.

The Kolmogorov–Smirnov statistics test (Table 3) for cumulative distribution functions (CDFs), or the test for the vertical distance between the two CDFs, also affirms the results in Figures 1–3 and this is an important economic incentive for households to participate in contract farming.

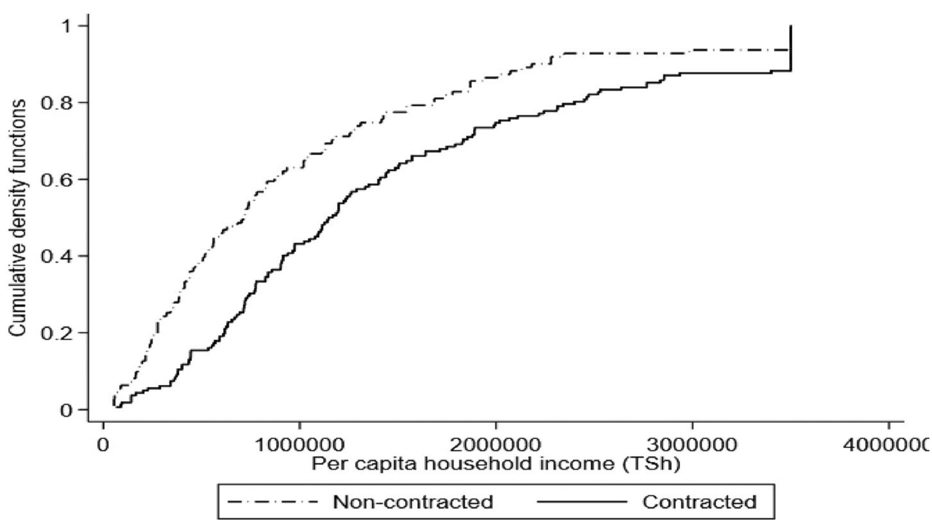

Figure 3. Cumulative distribution for the impact of contract farming on household income per capita.

Table 3. Kolmogorov–Smirnov statistics test for cumulative distribution (*P*-values in parenthesis).

Outcome variable	Distribution
Bean yield (kg/hectare)	0.32 *** (0.00)
Net bean income (TSh)	0.22*** (0.00)
Household income per capita (TSh)	0.27 *** (0.00)

Note: ***significant at the 1% level. Standard errors in parentheses.

Although we have observed some significant differences between the contracted and non-contracted in Table 2, it could be misleading if we attribute these mean differences to the effects of contract farming because bivariate mean comparisons fail to account for self-selection which may confound the results. This specific issue is addressed in the next section.

4.2 Empirical results

The results of the three endogenous switching regression models are presented in Table 4. Column 1 of Table 4 shows the results for CF participation from the participation equation. The results for outcome equations are given in columns 2 and 3 for bean yield, 4 and 5 for bean income per hectare, and 6 and 7 for household income per capita. Columns 2, 4 and 6 show the results for outcome equations for contracted households while the results in columns 3, 5 and 7 are for outcome equations for non-contracted households.

4.2.1 ESR estimates of the determinants of participation in contract farming

The first stage of the endogenous switching regression model (ESR) is a probit regression with the output on the factors that influence participation in contract farming and the results are presented in Table 4. The model is statistically significant as revealed by the LR-chi-squared ($p = 0.014$) suggesting that our variables significantly and jointly explain participation in CF. The results suggest that several factors were associated with the probability of farmers participating in CF. The coefficient of the variable representing the size of land owned has a positive coefficient and is significantly different from zero, indicating that farmers with larger farms are more likely to participate in CF. As expected, land is a very important aspect that contractual companies look at when recruiting farmers to participate in contractual agreements. Therefore, smaller farms are likely to be excluded. Similarly, literature shows that larger farms tend to benefit more from the contract in terms of credit disbursement (Chang et al. 2006). The number of visits by an extension agent has a positive and significant influence on the likelihood of a farmer participating in CF. This is probably because extension services facilitate awareness and flow of information, access to training on new interventions and the benefits associated with them. The findings are consistent with those of Wainaina, Okello, and Nzuma (2014) who concluded that farmers who obtain technical advice from extension agents are likely to be more aware and informed of alternative production methods like contract farming.

Finally, our instrument, distance to other French bean farmers, was negatively correlated with participation in CF and is statistically significant at the 5% level suggesting that the farm radius among the French beans farmers is associated with participation in CF. The wider the distance between the French bean farmers, the more they are likely not to participate in CF. This is because the wider distance between farmers limits social capital where farmers can get the opportunity to share the benefits of CF. Our finding is consistent with that of Dubbert (2019), who found that farm radius among the farmers influenced participation in CF.

Table 4. Parameter estimates of the impact of Contract Farming (CF) on livelihood outcomes from endogenous switching regression models.

Variable	Participation (1/0)	Bean yield (Kg/ha)		Net bean income (TSh)		Per capita household income (TSh)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Age (number)	0.00	15.43	−3.58	33455.58	−26868.70	−306.44	4070.14
	(0.02)	(36.53)	(45.40)	(60731.62)	(50730.39)	(12229.53)	(13308.06)
Household head sex (1 = Male, 0 = Female)	−0.04	−270.11	542.55	2047980.57	140872.59	113988.81	402571.54**
	(0.26)	(781.09)	(727.05)	(1425562.71)	(662389.41)	(277719.79)	(193498.46)
Occupation (1 = Farmer, 0 = Otherwise)	−0.47	1498.55	1361.08	2571735.48	1571902.58	381947.06	479124.83*
	(0.45)	(1181.96)	(930.83)	(2470855.28)	(1364095.58)	(685574.90)	(268457.88)
Education (years)	−0.06	−38.99	264.04**	−119598.91	289214.64*	−19158.97	103317.14**
	(0.04)	(115.41)	(112.94)	(177875.67)	(152485.05)	(38443.37)	(32855.07)
Household size (number)	0.00	−147.32	42.41	80954.23	−148383.85	243436.83***	209519.84***
	(0.05)	(113.99)	(115.33)	(224536.89)	(129016.79)	(43192.47)	(36359.03)
Log of experience (years)	0.17	604.75	643.74	684254.15	322246.43	147279.99	226248.47**
	(0.17)	(545.84)	(393.64)	(977707.92)	(483787.31)	(213842.67)	(107531.51)
Marital status (1 = Married, 0 = Otherwise)	0.10	691.17	−848.19	474626.76	93765.12	168469.18	−463834.72**
	(0.28)	(620.23)	(646.96)	(1044309.12)	(721229.77)	(216905.33)	(207163.06)
Size of land owned (hectares)	0.12*	−122.60	429.90	−18032.26	114269.23	−46405.66	129989.81
	(0.06)	(201.64)	(269.52)	(280319.50)	(407324.27)	(56439.20)	(109796.37)
Distance to the collection centre (Kms)	−0.01	−205.33	−156.92***	−633024.94**	−134020.51**	−79173.48*	−52544.20***
	(0.02)	(132.21)	(37.12)	(275685.66)	(64682.25)	(41651.91)	(11914.23)
Distance to the main road (Kms)	0.02	128.55	93.18	503120.65**	216557.78	49965.80	36776.29
	(0.03)	(96.11)	(97.03)	(235261.25)	(138725.37)	(36970.97)	(28242.45)
Group membership (1 = Yes, 0 = No)	0.21	−5.11	1198.84**	974112.83	1752002.38**	−263168.70	360485.33**
	(0.23)	(638.05)	(546.88)	(1097245.94)	(583955.31)	(236138.50)	(157066.49)
Distance to credit facility (Kms)	−0.01	41.26*	76.10*	−48509.73	137018.19**	−920.38	42990.76**
	(0.01)	(24.36)	(43.24)	(73791.88)	(60962.75)	(12158.11)	(20288.76)
Village price (TSh)	0.00	−1.87	−1.55	12715.88**	3555.38	332.53	−651.40
	(0.00)	(1.87)	(1.74)	(5620.81)	(2156.03)	(722.28)	(494.75)
Extension visits (1 = Fortnight, 0 = Otherwise)	0.47*	−362.74	1568.59*	−470706.39	1196349.90	−404934.42	−138203.69
	(0.27)	(945.12)	(927.76)	(1463260.40)	(1358866.24)	(318180.58)	(249195.03)
Distance to other French bean farmers (Kms)	−0.05*						
	(0.03)						
Constant	0.22	4685.95	−1449.40	−1.94e+07**	−8219571.59*	2466340.50*	29818.08
	(1.31)	(3676.85)	(2722.00)	(9631417.32)	(4630538.88)	(1472914.28)	(901266.00)
LR Chi^2	29.30**						
Observations	273	162	111	162	111	162	111

Note: *significant at the 10% level, **significant at the 5% level, ***significant at the 1% level. Standard errors in parentheses.

4.2.2 ESR estimates of the determinants of contract farming on yield, net bean income and household income

We also report the estimates for the outcome variables for both the contracted and non-contracted farmers as shown in columns 2–7 (Table 4).

Even though the education of the farmer does not significantly determine participation in CF for both contracted and non-contracted farmers, it is an important correlate of productivity and incomes among the non-contracted farmers (Table 4). This is probably because educated farmers may not highly participate in agricultural enterprises but they may generate more income from formal employment which increases their household income (Wainaina, Okello, and Nzuma 2014). Years of experience in bean farming had a positive association on the household income of the non-contracted farmers. This is also observed among the farmers whose primary occupation is farming suggesting that if the primary occupation of the farmer is farming and has more years of experience in French bean farming will have more incomes. Further, the results indicate that the sex of the household head correlates to household income among the non-contracted farmers. In particular, male farmers have a higher household income than their female counterparts. This finding could be attributed to the fact that male farmers tend to have greater access to productive resources such as land than their female counterparts (Wainaina, Okello, and Nzuma 2014).

Productivity, bean and household incomes significantly and negatively reduced with distance to collection centres. This implied that farmers who were far away from the collection centres realised less yield and household income. Collection centres serve as a central provider of agro-inputs, information and technical advice which are important elements of a farmer in agricultural activities (Veit 2009). Thus, farmers who are far away from collection centres may not be able to access these services which may hurt their production levels and affect income returns. The household size shows the intensity of bean cultivation in terms of labour. This variable had a positive and significant influence on the household income of both the contracted and the non-contracted farmers implying that households with more members had more incomes. The high household size denotes higher investments in family labour which reduces the need for hired labour (Simmons 2002). Similarly, distance to credit facilities is estimated to influence yield and incomes. In many cases, contracts are interlinked with input and service provision, credit plays a significant role in dealing with liquidity constraints that characterise smallholder systems in Sub-Saharan. In this circumstance, farmers who have access to credit are more likely to invest their resources in the production of crops that meet the requirements of the buyers to earn premium prices hence increasing incomes (Mwambi et al. 2016).

French bean prices had a positive correlation on bean income among the contracted farmers and this could be because participation in CF offers premium prices. This finding is similar to Mishra et al. (2018), who observed positive price effects on incomes among lentil farmers in Nepal who participated in CF. Finally, the number of visits by extension agents had a positive and significant effect on bean yield among the non-contracted farmers. This finding is expected because extension services provide more information on emerging and new technologies that help farmers to improve their productivity and incomes (Marwa et al. 2019)

4.2.3 Average treatment effects of participation in contract farming

The results in Table 5 present the main impact assessment outputs from the ESR model which shows the expected bean yield per hectare, bean income per hectare and household income per capita under both actual and counterfactual scenarios. On each outcome variable, we focus on the first two rows, where the diagonal elements a and b in the decision stage represent the actual outcomes and diagonal elements c and d represent the counterfactual outcomes. However, the impacts are given by differences between the rows i.e., between actual and counterfactual outcomes. The average treatment effects on the treated (ATT) are given by the difference between how much the contracted farmers produced and earned (a) and what non-contracted farmers would have

Table 5. Average expected bean yield, bean and household incomes; treatment and heterogeneity effects from ESR.

Outcome variable	Category	Decision stage: To participate	Decision stage: Not to participate		Treatment effects
Bean yield (Kg/hectare)	CF participants	(a) 5028.50 (843.76)	(c) 4274.24 (4274.24)	ATT	754.26*** (1846.40)
	CF non-participants	(d) 4786.33 (1499.27)	(b) 3823.25 (1401.60)	ATU	963.08*** (1461.96)
	Het. effects	$B_1 = 247.17$	$B_2 = 450.99$	TH	−203.82
Net bean income (TSh)	CF participants	(a) 3214711 (2599478)	(c) 2397018 (1792057)	ATT	817692*** (2591554)
	CF non-participants	(d) 2750721 (4325742)	(b) 2021103 (1834276)	ATU	729617*** (3393062)
	Het. effects	$B_1 = 463990$	$B_2 = 375915$	TH	88075
Household income per capita (TSh)	CF participants	(a) 1458619 (580082)	(c) 1060573 (658276)	ATT	398046*** (698188)
	CF non-participants	(d) 1331097 (822988)	(b) 990777 (654262)	ATU	340320*** (672385)
	Het. effects	$B_1 = 127522$	$B_2 = 69796$	TH	57726

Note: ***significant at the 1% level. Standard errors in parentheses.

produced and earned had they participated in CF (c), while the difference between what the contracted would have produced and earned had they not participated in CF (d), and what non-contracted produced and earned without adoption (b) yields the average treatment effects on the untreated (ATU). Similarly, Table 6 presents the results of treatment effects from the PSM model based on the nearest neighbour and kernel-based matching algorithms.

The last column of Table 5 presents the treatment effects of participating in CF on bean yield and incomes. Overall, after computing the counterfactual outcomes and controlling for confounding variables, we find that participation in CF leads to a positive and significant impact on all the outcomes. Specifically, a farmer who participated in CF would have produced 754.26 kgs/ha (that is about 17.6%) less if he did not participate, while a farmer that did not participate, would have produced 963.08 kgs/ha (that is about 25%) more if he had participated. These results imply that participation in CF significantly increases crop productivity even though the transitional heterogeneity effect is negative i.e., that the productivity effect is smaller for households that participated in CF. These findings are in line with those of Miyata, Minot, and Hu (2009); Narayanan (2014); Minot (2011); Casaburi, Kremer, and Mullainathan (2014) and Dubbert (2019) who concluded that participation in CF increases farm productivity. Participation in CF enables farmers to access better technology and inputs provided by the contracting firms, which upgrades their productivity (Wang, Wang, and Delgado 2014; Minot 2011). The companies normally specify technical standards to be followed by the contracted farmers and to achieve these standards, the farmers are provided with recommended and quality inputs such as chemicals and seeds that improve production efficiencies (Simmons 2002; Ramaswami, Birthal, and Joshi 2006). They are also provided with technical training and other consulting services as part of the contractual agreement (Joshi, Joshi, and Birthal 2006; Begum et al. 2012). It is also likely that farmers who are contracted receive support services such as insurance and loans from financial institutions, NGOs and government agencies that boost their production capacities (Barrett et al. 2010).

Table 6. Average treatment effects and results from propensity score matching model.

Outcome variable	Matching algorithm	Contracted	Non-contracted	ATT
Bean yield (Kg/hectare)	NNM	5014.79	4235.06	779.73** (366.40)
	KBM	5014.79	4086.27	928.52*** (321.37)
Net bean income (TSh)	NNM	3252102	2087761	1164340** (586459)
	KBM	3252102	2269272	982830** (535363)
Household income per capita (TSh)	NNM	1463881	1088812	375069*** (147112)
	KBM	1463881	1012582	451298*** (126762)

Note: ** significant at the 5% level, ***significant at the 1% level. Standard errors in parentheses.

The ESR results also show that participation in CF has a positive and significant effect on beans and household income. On average, a farmer who participated in CF would have earned TSh. 817692 (34%) and TSh. 398046 (about 37.5%) less from bean and household income had he not participated in CF, respectively. Similarly, for the farmers that did not participate, they would have earned bean and household income of TSh. 729617 (36%) and TSh. 340320 (34%) more if he had participated, respectively. The transitional heterogeneity effect for both bean and household incomes is positive, that is, the effect of CF on incomes is significantly bigger for the farm households that participated relatively to those that did not participate. The increased income could be a result of increased productivity due to participation which is sold at premium prices given by the contracting companies. These findings are consistent with those of Minot (2011); Casaburi, Kremer, and Mullainathan (2016), Bellemare and Lim (2018); Ton et al. (2018) and Dubbert (2019) who all concluded that CF had positive and significant effects on incomes. This finding suggests that getting smallholder commercial French bean farmers to participate in contract farming can help improve their welfare by increasing their net incomes.

The revenue generated from the French beans enterprise due to participation in CF is re-invested by households in further income-generating opportunities leading to increased household incomes. These findings are similar to Mishra et al. (2018), who concluded that lentil farmers in Nepal highly participated in CF due to higher prices given by companies that led to higher crop and household incomes than non-contracted farmers. Similarly, participation in CF enhances economies of scale which in turn leads to an increase in incomes (Miyata, Minot, and Hu 2009; Rao and Qaim 2011; Fleming and Abler 2013).

Table 6 presents the results of the PSM model (equation 17). Before estimating the causal effects of CF, we first tested whether the overlap assumption was satisfied and accessed the quality of matching on propensity scores. Figure A1 in the appendix shows the propensity score distribution and common support for propensity score estimation. The results show that the common support condition is satisfied as there is substantial overlap in the distribution of the propensity scores of the CF and non-CF groups. Similarly, Table A2 in the appendix presents the results from covariate balancing tests before and after matching. The reduction in the mean absolute standardised bias between the matched and unmatched models was used to assess the balancing of covariates. The balancing tests show a substantial reduction in the mean absolute bias between the matched and unmatched models, which indicates that PSM was successful in reducing selection bias due to observed characteristics.

The average treatment effect on the treated (ATT) for the bean yield ranges between 779.73 kgs/ha (18%) based on NNM and 928.52 kgs/ha (22%) based on KBM. Similarly, the ATT for the bean income is positive and significant at 5% and is between TZS. 982830 (43%) based on KBM and TSh.1164340 (56%) based on the NNM, while that of household income is between TSh. 375069 (34%) based on the NNM and TSh. 451298 (44%) based on KBM, respectively. These ATTs can also be considered as an opportunity cost of not participating in CF.

5. Conclusion and implications

This study assessed the impacts of participating in Contract farming (CF) on yield and incomes using cross-sectional data collected in January 2020 among the youth farmers growing French beans in Arusha, Tanzania. The study was majorly informed by the conflicting arguments that contract farming can be both favourable and unfavourable to smallholder farmers. Further, in this context, we narrowed down and focused on the youth farmers aged 35 years and below who were involved in French bean production. Given that young farmers have different characteristics compared to older farmers, we documented empirical evidence by assessing whether CF improved their welfare and examined the factors that affect participation in contract farming. We applied an endogenous switching regression (ESR) model to control for self-selection in participation and to estimate the impact of CF participation. Further, we used the propensity score matching (PSM) approach to check the robustness of the results of ESR.

From the results, we found that farm size, the number of extension visits and distance between French bean farmers was associated with the participation in CF. Similarly, we also found that participation in CF was associated with increasing bean yield and contributed to the improvement of bean and household income of youth French bean farmers in Tanzania. The observed gains of CF can also be considered as an opportunity cost of not participating in CF. The positive effects of CF on the yield potential and the (average) productivity can be explained by the contractor's provision of credit, extension service and seeds of high-yielding varieties to the contracted farmers who become efficient in production.

Therefore, CFs arrangements can be an adequate and appropriate tool to improve the productivity of youth French beans farmers while improving their welfare. This is to imply that, CF as an agricultural production system has a potential role in reducing rural poverty, especially among the youth who are the majority in Tanzania. Although empirical evidence from this study shows positive impacts of CF through the contractual arrangements that help structure markets and provide producers with market options that offer better prices, there is a need to have clear terms and conditions within the contract itself. For instance, the mechanisms governing the terms of the contract should be clearly defined and understood by both parties. Further, we recommend the implementation of policies that make it easier for smallholder farmers to participate in CF. These could include targeting policies that aim at improving extension service delivery among the farmers as it has proven to facilitate participation in CF.

Although we have used robust econometric methods commonly used in the evaluation literature, a few caveats are worth mentioning. Considering that we use data from a cross-sectional study, our identification strategy hinges on finding a good and valid instrument, which is difficult in practice, hence the results in this study should be interpreted with caution. Future studies should explore using panel data or randomised controlled trials (RCT) design to control for both observed and unobserved heterogeneity in order to attach a causal interpretation to the impact results. Finally, the sample size used in this study is relatively small, hence future studies should consider using a larger sample size for the results to be generalisable to a larger population of youth farmers. Second, future st However, future research studies should investigate how to help farmers and buyers to realise a win-win contract farming situation without conflict.

Note

1. Tanzanian Shilling (TSh) is a Tanzanian currency, and 1 USD = TSh 2,307.69 when the survey was conducted.

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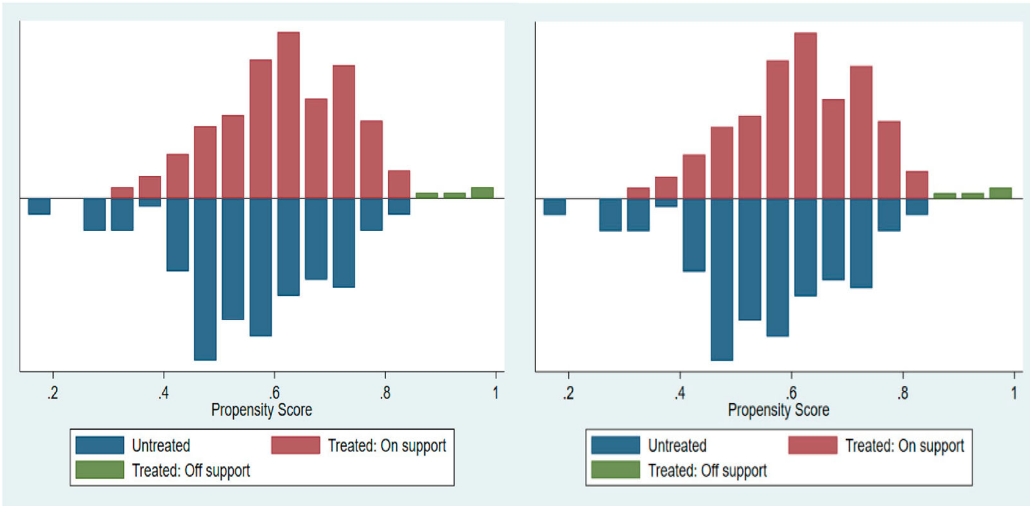
Appendix



(a)Nearest Neighbour matching (b) Kernel-based matching

Figure A1. Distribution of the estimated propensity scores and the common support region.

Table A1. Parameter estimates – test on the validity of the selection instrument.

	Participation (0/1)		Bean Yield		Bean income		Household income	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
Constant	0.215	0.87	−867.24	0.787	−7,332,154	0.06	181,256	0.85
Age (Number)	0.004	0.81	−1.60	0.96	−23,832	0.64	4607	0.72
Sex (1 = Male, 0 = Female)	−0.039	0.88	513.62	0.42	91,029	0.90	390,450**	0.05
Occupation (1 = Farmer, 0 = Otherwise)	−0.469	0.29	1160.09	0.61	1,265,580	0.65	426,891	0.55
Education (years)	−0.057	0.14	241.51***	0.00	254,777**	0.02	97,376***	0.00
Household size (number)	0.005	0.92	45.84	0.71	−142,366	0.37	−208,008***	0.00
Log of experience (years)	0.165	0.34	717.77*	0.07	436,745	0.37	246,817**	0.04
Marital status (1 = Married, 0 = Otherwise)	0.095	0.74	−816.04	0.24	141,082	0.87	−456,823**	0.04
Size of land owned (hectares)	0.120**	0.05	482.6*7	0.07	193,094	0.56	142,484	0.09
Distance to the collection centre (Kms)	−0.012	0.58	−160.67***	0.00	−139,370**	0.01	−53,230***	0.00
Distance to the main road (Kms)	0.024	0.37	102.92	0.19	231,595**	0.02	39,462	0.11
Group membership (1 = Yes, 0 = No)	0.212	0.36	1293.59***	0.01	1,898,122***	0.00	386,482	0.01
Distance to credit facility (Kms)	−0.007	0.61	73.03*	0.08	132,414**	0.01	42,249***	0.00
village price (Tsh)	0.000	0.69	−1.42	0.37	3743*	0.06	−620	0.22
Extension visits (1 = Fortnight, 0 = Otherwise)	0.469*	0.08	1772.80**	0.05	1,505,895	0.17	−86,478	0.75
Distance to other French bean farmers (Kms)	−0.054*	0.08	−24.187	0.725	−38,641	0.65	−7706	0.72
Observations	273		111		111		111	
Pseudo R^2	0.05							
R^2			0.32		0.34		0.51	

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

Table A2. Balancing of covariates before and after matching according to treatments.

Variable		Mean (NNM)			%bias reduction	*t*-test		Mean (KBM)			%bias reduction	*t*-test	
		Treated	Control	%bias		*t*	*t p* > *t*	Treated	Control	%bias		*t*	*t p* > *t*
Age (number)	Matched	34.19	32.94	18.70		1.54	0.13	34.19	32.94	18.70		1.54	0.13
	Unmatched	34.11	34.36	−3.80	79.60	−0.36	0.72	34.11	34.37	−4.00	78.70	−0.37	0.71
Sex (1 = Male, 0 = Female)	Matched	0.89	0.84	14.80		1.22	0.22	0.89	0.84	14.80		1.22	0.22
	Unmatched	0.89	0.90	−2.80	81.40	−0.27	0.79	0.89	0.90	−4.80	67.80	−0.47	0.64
Occupation (1 = Farmer, 0 = Otherwise)	Matched	0.99	0.99	−3.20		−0.26	0.80	0.99	0.99	−3.20		−0.26	0.80
	Unmatched	0.99	0.97	21.50	563.90	1.29	0.20	0.99	0.99	0.70	77.40	0.06	0.95
Education (years)	Matched	8.45	8.87	−17.10		−1.39	0.16	8.45	8.87	−17.10		−1.39	0.16
	Unmatched	8.46	8.41	1.90	88.80	0.17	0.87	8.46	8.43	1.00	94.40	0.09	0.93
Household size (number)	Matched	4.93	4.86	4.00		0.33	0.74	4.93	4.86	4.00		0.33	0.74
	Unmatched	4.91	4.93	−1.50	62.60	−0.14	0.89	4.91	5.00	−5.20	−29.80	−0.47	0.64
Log of experience (years)	Matched	1.47	1.37	18.00		1.49	0.14	1.47	1.37	18.00		1.49	0.14
	Unmatched	1.47	1.52	−8.30	54.00	−0.70	0.49	1.47	1.49	−4.20	76.60	−0.36	0.72
Marital status (1 = Married, 0 = Otherwise)	Matched	0.86	0.77	21.50		1.78	0.08	0.86	0.77	21.50		1.78	0.08
	Unmatched	0.85	0.87	−3.30	84.80	−0.32	0.75	0.85	0.88	−6.00	72.00	−0.61	0.54
Size of land owned (hectares)	Matched	1.18	0.79	24.80		1.90	0.06	1.18	0.79	24.80		1.90	0.06
	Unmatched	0.93	0.92	0.40	98.40	0.05	0.96	0.93	0.91	1.10	95.50	0.15	0.88
Distance to the collection centre (Kms)	Matched	1.76	2.69	−20.10		−1.70	0.09	1.76	2.69	−20.10		−1.70	0.09
	Unmatched	1.80	1.50	6.50	67.50	0.81	0.42	1.80	1.78	0.50	97.50	0.06	0.95
Distance to the main road (Kms)	Matched	3.21	3.29	−2.30		−0.18	0.86	3.21	3.29	−2.30		−0.18	0.86
	Unmatched	3.25	2.82	12.60	456.30	1.19	0.24	3.25	3.28	−1.10	52.80	−0.09	0.93
Group membership (1 = Yes, 0 = No)	Matched	0.79	0.73	14.10		1.16	0.25	0.79	0.73	14.10		1.16	0.25
	Unmatched	0.78	0.78	2.20	84.30	0.20	0.84	0.78	0.77	2.80	80.10	0.26	0.80
Distance to credit facility (Kms)	Matched	7.31	7.36	−0.90		−0.07	0.94	7.31	7.36	−0.90		−0.07	0.94
	Unmatched	7.32	7.29	0.70	26.30	0.05	0.96	7.32	7.41	−1.60	−77.00	−0.13	0.89
Village price (Tsh)	Matched	979.07	967.49	8.50		0.70	0.48	979.07	967.49	8.50		0.70	0.48
	Unmatched	981.13	970.86	7.60	11.30	0.68	0.50	981.13	978.61	1.90	78.20	0.16	0.87
Extension visits (1 = Fortnight, 0 = Otherwise)	Matched	0.13	0.06	22.60		1.78	0.08	0.13	0.06	22.60		1.78	0.08
	Unmatched	0.13	0.11	4.30	81.00	0.34	0.73	0.13	0.11	4.90	78.30	0.40	0.69
Distance to other French bean farmers (Kms)	Matched	1.43	2.22	−26.00		−2.21	0.03	1.43	2.22	−26.00		−2.21	0.03
	Unmatched	1.45	1.55	−3.30	87.30	−0.37	0.71	1.45	1.51	−1.9	92.80	−0.22	0.83