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Does contract farming arrangement improve smallholder tobacco productivity? Evidence from Zimbabwe

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A R T I C L E I N F O

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A B S T R A C T

Contract Farming Arrangements (CFA) can be viewed as a pro-active response to lack of reliable markets and steeply rising input prices. CFA proponents argue that CFA can enhance technical efficiency of tobacco farming and productivity. Thus, in this study, the paper interrogates the effect of CFA on tobacco productivity in southern Africa: Hurungwe district of Zimbabwe. The study controls for both observable and unobservable factors, like age, education, and ability to use information-unknown to the researchers, explaining farmers decision to participate in CFA. The study uses the Endogenous Switching Regression (ESR) model, which also acts as a robust check for the Propensity Score Matching techniques as it studies both observable and unobservable factors influencing CFA participation. Based on the ESR model, this study finds that CFA improves tobacco productivity by 39%. Nonetheless, CFA is labour-intensive. Hence, women and the elderly are less likely to participate in CFA, suggesting the need to develop gender-sensitive labour-saving technologies. Even though tobacco products kill their users, we would like to explore whether CFA can make farming more productive or not. We hypothesize that if tobacco farming would be more productive, then perhaps farmers will have enough money to buy food so they can be healthier even if the tobacco leaves, they grow can kill people elsewhere. Thus, these results inform CFA-related policies that improve smallholder tobacco productivity in Southern Africa. With existing tobacco controls, these results are equally valid to other cash crops where most developing economies anticipate the majority resource-constrained smallholder farmers to shift their production systems entirely away from tobacco in the immediate future.

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1. Introduction

Southern Africa economy is dependent on the performance of the agricultural production [1–3]. In Zimbabwe, three significant landscape policy changes have shaped agriculture sector since the early 1980s, which is the backbone of the economy [4–6]. First, the country implemented the growth with equity program between 1980 and 1990, favoring smallholder farmers [7]. Second, the economic structural adjustment program in the 1990s championed the market liberalization. Third, the fast-track land reform program in the 2000s dismantled the predominantly commercial farming sector, thereby reducing the unequal distribution of land in the country [8,9].

Several scholars have studied the performance of the agricultural sector in Zimbabwe. Mazwi et al. [10] found that agricultural production significantly declined in the 2000s, with production reducing from 2.87 million metric tons in 2004 to 0.95 million metric tons in 2018 (see Fig. 1). Following the post-2000 era, the economy witnessed deepening poverty levels [8].

Between 2009 and 2018, the country witnessed unpredictable and dwindling tobacco production [10,11]. Scholars [11] attributed the dampened tobacco production to global tobacco control campaigns, low adoption of agricultural technologies, declining soil fertility, erratic precipitation patterns, lack of access to capital, insufficient rural credit markets, and lack of insurance [12–15]. Dorward et al. [16] reported that agricultural price insurance changes the supply curve of agricultural products by reducing their supply elasticity, subsequently positively affecting the stabilisation of outputs. Martins-da-Silva et al. [17] highlights that tobacco use is associated with an annual global economic cost of two trillion dollars. Ultimately, the economies fail to generate enough foreign currencies [9].

Globally, tobacco kills about eight (8) million people every year and many people experience poor health, thereby increasing fiscal pressure to most governments, funding public health financing against nicotine poisoning (green tobacco sickness), pesticide exposure, respiratory effects, musculoskeletal and other injuries [18]. Tobacco production also implies less land available for food production. In the event of insufficient markets for food, the country is likely to suffer from hunger, leading to more deaths [19,20].

In many contexts, prefinancing contract farming arrangements (CFA) present opportunities for addressing the country's missing agricultural credit markets, especially among tobacco farmers. According to the existing theory of change, CFA prefinances smallholder farmers with inputs and associated extension services for improving tobacco production activities, thereby strengthening the productivity and marketing of tobacco in the country [12,21]. It is important to note that every farmer engages in agricultural production, including tobacco, with the sole objective of profit maximization [22]. However, CFA faces several challenges because it is implemented with different definitions, nomenclature, enforcements, interest rates, and procedures [19,23], pushing most smallholder farmers into indebtedness [24]. Even though tobacco products kill their users, we would like to explore whether CFA can make farming more productive or not. We hypothesize that if tobacco farming would be more productive, then perhaps farmers will have enough money to buy food so they can be healthier even if the tobacco leaves, they grow can kill people elsewhere. In addition, these questions are still relevant in Southern African Economies like Malawi, Mozambique, Zimbabwe, and Zambia, where tobacco significantly contributes to agricultural export earnings [9].

2. Tobacco production in Zimbabwe

Zimbabwe is the largest producer of tobacco in Africa and the sixth largest in the world. Twenty-five percent of African tobacco comes from Zimbabwe, and it is one of the most important cash crops as it currently accounts for 45% of the total agricultural export earnings, dropping from 78% in 1992. Tobacco also constitutes 30% of the total exports and contributes 10% of the GDP [10]. Tobacco production employs about 250,000 people as of 2020, representing 5% of Zimbabwe's total labour force and about 25% of the formal employment. However, tobacco production has declined from 236.9 million kg in late 2000 to 189 million kg in 2017 (see Fig. 2) due to lack of funding, technical know-how, extension and advisory services, and marketing skills among smallholder farmers [10].

Even if farmers become more productive following CFA, they will only get more money if buyers are willing to pay more for the tobacco leave that is produced by a productive smallholder farmer. Meanwhile, smallholder farmers sell tobacco in two modes: under auction and contract farming arrangements. Farmers selling tobacco through the auction independently acquire inputs and sell

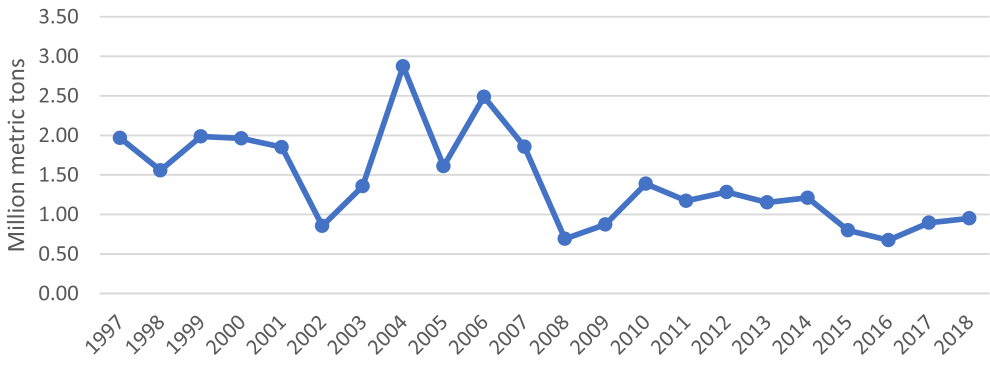

Fig. 1. Agricultural production 2001–2018 (source: World Bank, 2020).

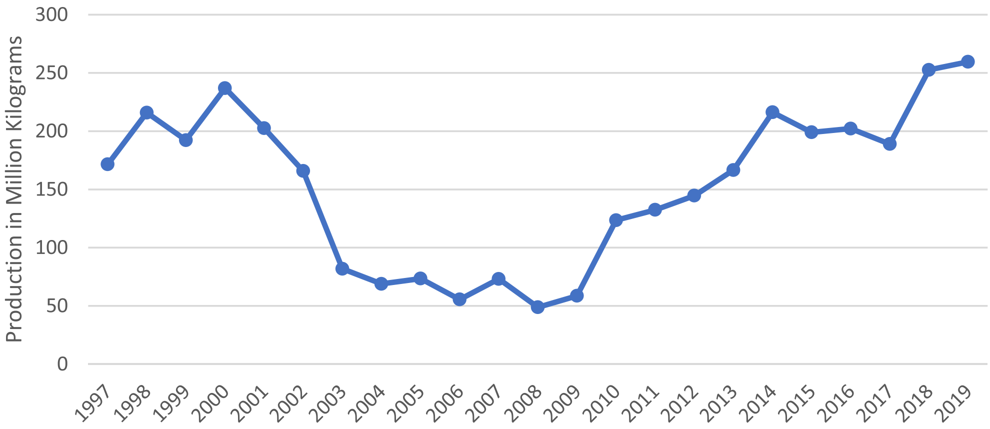

Fig. 2. Tobacco production 1997–2019 (source: Timb, 2020).

tobacco at the highest bidding prices [9]. While farmers under CFA access inputs, extension services, and credit through contractors viz., the China National Tobacco Corporation, British American Tobacco, Zimbabwe Leaf Tobacco, Mashonaland Tobacco Company, Cotton Company, and the Cargill Company [9]. In 2018, approximately 80% of farmers in Zimbabwe were under CFA and tobacco production increased from 48.8 million kg in 2008 to 259.5 million in 2019 (see Fig. 2).

3. Contract farming arrangement in Zimbabwe

Contract farming arrangement (CFA) provides credit, markets, and finances to smallholder farmers, especially in developing countries, that the market fails to provide [24]. It also shifts risks in inputs and output prices to the contractors and promotes information symmetry in the tobacco industry [21]. Widely, CFA is coordinated between farmers and buyers-processors. It specifies market obligations, inputs, and production quotas [4]. Thus, farmers have stable prices and reduced transaction costs [25]. CFA is not new in Zimbabwe [9]. It dates to the 1950s [8] and gained momentum in the 1990s, following the Economic Structural Adjustment Programs. Contract farming has been employed in agricultural production for many years such that about 45 % of farmers grow crops under CFA. Nonetheless, the FTRP's economic instabilities made the CF benefits short-lived, where most contractors failed to pay farmers [26].

Worldwide, existing studies show the contradictory role of CFA. On the one hand, Mishra et al. [13,14] highlights that CFA has no significant influence on the technical efficiency of potato smallholder farmers in India. While Khan et al. [24] indicates low physical yield per acre among farmers under contracts due to poor adoption of new technologies. Chingosho et al. [9] found unequal power relations between contractors, processors, and CFA farmers, where farmers are disadvantaged. Lencucha et al. [19] note that farmers often complain that their tobacco is not honestly graded as the quality it deserves, so they receive less revenues since tobacco farmers have a relatively weak bargaining power. Further, Ragasa et al. [21] spot CFA having negative impact on profitability because of transaction costs and higher input prices than under a competitive market. Lencucha et al. [19] also highlights that input prices for tobacco production are usually higher, hence, compromising the profit maximization objective.

On the other hand, Scoones et al. [8] report that CFA helps farmers substantially accumulate household and agricultural assets. Also, World Bank [27] notes that CFA to allows companies avoid direct involvement in production and labour management. It also enhances reliable input provision, markets, and credit accessibility [13]. Khan et al. [24] further CFA increases the number of salaried workers, thereby creating jobs for the majority to support their livelihoods. Ragasa et al. [28] state that CFA increases technology adoption as farmers are assured of financing mechanisms. Mishra et al. [13] found that CFA provided high quality inputs, which incentivises most farmers to participate in CFA. Debela et al. [29] finds CFA improving nutrition among oil palm farmers, and tobacco production under CFA as more efficient.

Indeed, the role of CFA in reducing poverty remains unclear despite the increasing global movement. Farmers are yet to derive potential benefits from CFA [9] and still produce 62% less than the expected production [10]. Farmers obtain lower prices from the current CFA, thereby defaulting on loan repayments [11]. Although farmers are assured of inputs, extension service and market for the product, the contract terms are characterized by transaction cost, uncertainty, and information asymmetry [19]. In addition, climate change shocks and effects still characterise the vulnerability of smallholder tobacco farmers as they are exposed to food insecurity and ultimately, trapping them in poverty cycle. Unfortunately, research on the effect of CFA on crop productivity is still unclear to inform policy-decision making in the Southern region [28]. Existing literature has neither studied observable nor unobservable factors influencing farmers decision to participate in CFA, especially, in Southern Africa. Previous studies have intensively assessed the political economy of CFA, with a focus on agrarian change and power relations between the contractor and farmers [8]. Hence, in this study, we have two main objectives: i) understanding which farmers are more likely to participate in contract farming and ii) determine whether CFA supported farmers are more productive.

4. Sampling design and data generation process

The Data Generation Process for this study follows the cross-sectional primary data approach. We conduct this study in Hurungwe district in Zimbabwe (Fig. 3), which is a dominant tobacco producing district [30]. Tobacco is also the main source of livelihood for over 80 % of its residents [26]. Tobacco is still an important crop in the district, with the number of farmers increasing from 20,558 in 2013 to 28,597 in 2018 [5]. The district receives rainfall between 750 and 100 mm per year, which fall between November and April.

Data for the study administered a face-to-face household survey to 240 farmers. Using a semi-structured household questionnaire, the study compiled farm-level data on quantity of seeds, organic manure, and in-organic fertilizers in kg, labour in personal-days, and farm-size in hectares allocated for tobacco production. While informed by literature, this study used the aforementioned factors of production to examine the tobacco productivity [15]. Similarly, Rana et al. [15] studied the growth of tobacco production in Bangladesh and used factors like land, seeds, labour, and fertilizer to determine tobacco production factors.

In addition, the study compiled data on membership to agricultural club, where extension, input accessibility and credit would be smoothly facilitated. In addition, while informed by literature on CF [24], the study collected household socioeconomic data, viz., sex, education, and age in years, primary occupation, off-farm income in US $, household size, and number of draft animals.

While acknowledging the role of large sample size in reducing sampling errors and improving the estimates of the econometric analysis, literature provide several studies with sample size less than 200 in a population of over 100,000 potential study participants. Hence, the sample size of 240 was adequate to answer the study research questions. In addition, when tested through the clustersamplesi, the 240 number of farmers was able to detect the minimum effect of CFA by 80%. In literature, there are studies that used a sample size of 130 farmers to study the effect of tobacco on improving household livelihood, for instance, Rana et al. [15] in Meherpur district in Bangladesh. Miran et al. [31] used a sample of 300 farmers to assess the sustainability of tobacco production in Turkey. Ali et al. [32] evaluated tobacco farming in Bangladesh and its impact on the environment using only 100 farmers. Dube and Mugwagwa [33] assessed the impact of contract farming on household income in Makoni district of Zimbabwe using only 98 smallholder farmers. Chazovachi et al. [5] work published in Taylor and Francis, studied the sustainability of contract farming among tobacco farmers in Makoni district of Zimbabwe using 35 participants.

The survey participants (240) were randomly drawn using the multi-stage sampling procedure. First, the study purposively selected Hurungwe district in Zimbabwe, following its tobacco dominance, livelihoods, and presence of contracts in the district. Second, the study sampled traditional areas with and without a contract scheme, which were further sub-divided into villages. Villages were grouped into CFA and non-CFA (NCFA). Third, the study solicited the list of farmers for each of the sampled villages, that is one list for

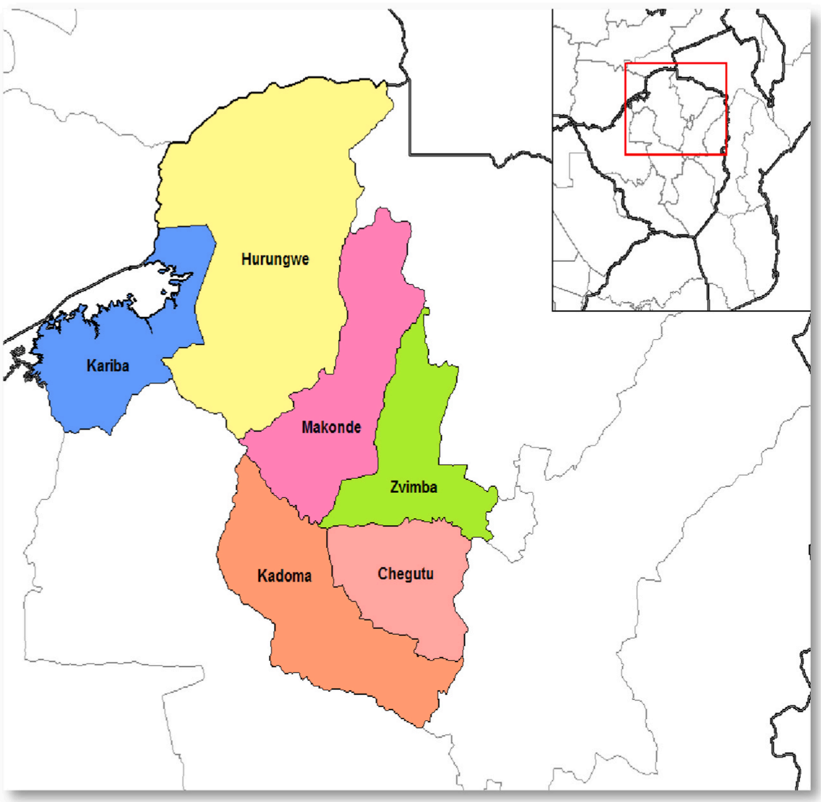

Fig. 3. Map showing the study area.

the CFA and NCFA villages. Four, the study randomly and systematically sampled farmers from the CFA and NCFA villages. In general, the study has a sample of about 75 and 165 farmers for CFA and NCFA participation. During interview, each of the smallholder farmer was asked whether they were under CF or NCF and none of the farmers sampled under CF reported NCF participation, and vice versa. There were no overlaps between CF and NCF sampled villages due to the distances separating the villages.

5. Technical and empirical framework

Based on the expectation theory of production, the study assumed that smallholder farmers make rational, efficient, and functional decisions [34] to participate in CFA, to objectively produce along the production possibility frontier. However, optimised objective utility function is affected by household and farm characteristics, which further affect farmers' decision to participate in CFA [28]. In this study, we are conscious of the tobacco controls, where it is common knowledge that tobacco kills people. However, farmers, in most southern African countries like Malawi, Zimbabwe, Zambia, and Mozambique, still engage in this crop production to derive enough money to enable them buy food and become heathier. Moreover, tobacco is still the mainstay of the national economy in the coming immediate future before most smallholders fully shift to other cash crops like groundnuts, sunflower, and soybeans.

Hence, we assume farmers participate in CFA if it maximizes their utility of obtaining money, given the underlying constraints. Theoretically, it is strongly assumed that through CFA, farmers can have access to inputs, finances, and extension services which can be directly used in their tobacco production. These services would therefore enhance the productivity of tobacco in the study area. Usually, farmers do not have access to these inputs and services as most of them are poor and subsistent farmers [35]. However, Lencucha et al. [19] highlights that farmers participate in CFA because these factors are unknown to the researchers or programmers. Hence, in this study, we adopt self-selection type of modelling to capture other factors that may induce the farmer from joining CFA.

Primal production theory assumes non-allocable exogenous inputs (x_i) are technologically transformed to derive an endogenous output (y_i), which can be estimated through either parametric or non-parametric methods. SFA models and the Data Envelopment Analysis (DEA) are some of the parametric and non-parametric methods, respectively. The SFA models have been widely used in developing countries since farmers are exposed to a lot of factors, they do not have control over and poor record keeping [36]. The SFA is opted because of easy interpretation, its robustness to measurement errors, and flexible estimation given the computer rigor currently present [10]. The SFA can also handle both random noise and inefficiency effect in the same model without the results being bias or in the presence where there are several unobserved factors. In addition, tobacco production also follows the laws of diminishing marginal returns which is basically easily captured when studied using the SFA techniques [22,37]. Moreover, lack of daily data collection and availability at farmer level makes the SFA the most preferable econometric techniques as the DEA are usually data intensive [38]. Nonetheless, the validity of the SFA depends on the quality of the data. Following the use of recall data, the SFA may also results into inefficient estimates. Furthermore, the SFA assumes the dependent variables as well as the error terms to be normally distributed, and if this assumption is not achieved, the results may also be misleading for policy calibration.

In terms of SFA, literature presents the Cobb-Douglas (CD) function as the most employed model studying agricultural production [39–41]. The CD follows developments by Refs. [42,43]. The study adopts the mathematical construction of SFA as demonstrated by Ref. [44]. The linearized CD-SFA is specified as in equation (1):

$$ln\ y_i = \beta_o + \sum \beta_j\ ln\ x_{ij} - \left(\sum_j \beta_j\right)\theta \tag{1}$$

where $\ln y_i$ represents the natural log of tobacco productivity (yield), delivered from tobacco production divided by cultivated farm size. x_j is a vector of logged factors of production which includes land area in hectares, seeds and in-organic fertiliser in kg and labour in personal-days. Empirically, several studies have assessed tobacco productivity using yield as the main dependent and with actual factors of production as the exogenous variables [3,31,45]. For instance, Jayne et al. [46]assessed the crop productivity of sub-Sahara Africa using output divided by area. β_j denotes a share of each factor of production while A is the state of the technology; the θ is a composite of a random error term (v_i) and an idiosyncratic error term (μ_i), such that $(\theta = v_i - \mu_i)$ [39]. The random error (ν_i) is assumed to be identically and independently distributed (iid) with $N(0, \delta_v^2)$. The idiosyncratic error (μ_i) is iid with $N(0, \delta_\mu^2)$, non-negative, and truncated above zero. Equation (1) can be estimated as half normal, truncated, or exponential distribution. In this paper, we assume a half-normal distribution, which is appropriately applied in a competitive market [39]. After estimating the CD-SFA, the study predicts the technical efficiency and compare it between CFA and NCFA farmers. Presence of self-selection compels the study to perform a PSM and ESR techniques to interrogate the effect of CF on tobacco productivity.

6. Propensity score matching technique

Participation in CFA is not a random process [47], depending on the attributes of contractors and farmers. Contracted smallholder farmers usually have unique attributes which results in CFA self-selection, namely, farm size, farmers' club membership, tobacco experience, and curing facilities [31]. For instance, Lencucha et al. [19] and Kassie et al. [48] highlight that farmers participate in CFA because they have some prior information which is not well observed by the researchers. Besides, farmers' socioeconomic characteristics, such as gender, education, distance to markets, marital status, and household size, enhance participation in CFA.

Self-selection makes the ordinary least square (OLS) estimation generate bias estimates [21]. Different methods have been used to correct for selection bias, such as, the Heckman two-step model, Instrument Variables (IV), PSM, ESR, and Difference in Difference

(DID) [24]. The Heckman two-step model depends heavily on the assumption of normal distribution in error terms and the IV approach requires correct specification of appropriate instruments in the estimation [49]. While the DID require the baseline data on the sampled farmers. In this study, the Propensity Score Matching (PSM) Technique is adopted. However, it only addresses self-selection resulting from observable variables. Nonetheless, it matches the CFA and NCFA farmers who have the same profiling of commonly supported observable factors [25,50].

In this study, the PSM follows a six-step [50]. First, the propensity scores of CFA are estimated using logit model, where CFA is the dependent variable and gender, education, membership, tobacco experience, and labour are some of the independent variables. A propensity score is a predicted probability of participating in a program given a set of observable characteristics. Third, the study uses the matching algorithms, namely, nearest neighbor matching (NNM), radius matching (RM), and Kernel matching (KM) to balancing CFA and NCFA farmers. Four, we identify a balanced region of common support. Five, we estimate the average treatment effects on the treated (ATT) as presented in equation (2).

$$ATT = E[y_i|CFA_i = 1, p(x_i)] = E[y_i|CFA_i = 1, p(x_i)] - E\left[y_i\middle|CFA_i = 0, p\left(x_j\right)\right] \quad (2)$$

where variables are as prior defined. Six, the study checks for the robustness of the estimates, through sensitivity analysis by varying the calliper/bandwidth (i.e. from 0.1., 0.2, to 0.25), radius (i.e. from 0.1., 0.2, to 0.25), or number of nearest neighbors (i.e. from 1, 2 to 3). However, heterogeneity can originate from both observable and unobservable characteristics, namely, management ability, time preference, and motivation to augment tobacco productivity, rendering estimates from PSM become biased [51], hence, the study further implements the ESR model to thoroughly capture the effect of CFA on tobacco productivity. The study conducts a sensitivity analysis based on rbounds and mbounds [50] and found no significant changes when varying the bounds from 1 to 100 and in multiple of 5.

7. Endogenous Switching Regression model

The study further adopts the ESR model to accounts for both observable and unobservable factors [22,48,52], where binary CFA can lead to two tobacco productivity outcomes as in equation (3):

$$y_{ji} = \begin{cases} y_{ji} = \varnothing_1 x_{1i} + \omega_1 CFA_{1i} + \varepsilon_{1i} \ if \ \vartheta_i Z_i + \mu_i > 0 \rightleftarrows CFA_i = 1 \\ y_{ji} = \varnothing_0 x_{0i} + \omega_0 CFA_{0i} + \varepsilon_{0i} \ if \ \vartheta_i Z_i + \mu_i \leq 0 \rightleftarrows CFA_i = 0 \end{cases} \quad (3)$$

where y_{ji} denotes tobacco productivity. The x_{ji} represents both household and farm characteristics. The Z_{ji} is the vector for observable factors. The $\varnothing_j$ is the vector of the unknown parameters. The ε_{ji} and μ_i are the non-zero error terms, with trivariate normal distribution, mean vector zero, and the covariance matrix (Ω) [53]. The covariance between ε_1 & ε_0 and ε_{ji} & μ_i are not defined, following never simultaneously observed outcomes [13]. The expected values of the truncated error terms (ε_1 and ε_0) are given as in equation (4) and

Table 1
Characteristics of contract and non-contract farmers.

		Pooled sample			NCFA			CFA			
		Obs	Mean	Std. Dev	Obs	Mean	Std. Dev	Obs	Mean	Std. Dev	*t*-test
Age	Years	240	41.42	12.30	165	39.21	12.48	75	46.28	10.41	−7.074***
Maize farm size	Hectare(Ha)	240	1.56	0.80	165	1.51	0.71	75	1.68	0.96	−0.178
Tobacco farm size	Ha	240	1.20	0.54	165	1.12	0.51	75	1.39	0.57	−0.268***
Credit Accessibility	Yes = 1	240	0.07	0.26	165	0.07	0.25	75	0.08	0.27	−0.0130
Input distance	Km	240	59.66	55.21	165	59.41	57.75	75	60.20	49.51	−0.788
Output distance	Km	240	186.67	97.56	165	240.64	52.71	75	67.93	61.66	172.71***
Education	Years	240	11.33	3.05	165	11.35	3.22	75	11.28	2.67	0.0720
Extension services	Accessed = 1	240	0.96	0.19	165	0.95	0.23	75	1.00	–	−0.055
Extension visits	Number	240	5.08	3.31	165	3.32	1.99	75	8.96	2.10	−5.645***
Household labour	Personal days	240	364.70	146.10	165	346.84	135.92	75	404.00	160.38	−57.15***
Total farm size	Ha	240	5.59	1.42	165	5.18	1.36	75	6.48	1.11	−1.301
Farmers club membership	Members = 1	240	0.14	0.35	165	0.08	0.27	75	0.27	0.45	−0.188***
Inorganic fertilizers	kg	240	737.56	357.62	165	681.88	352.44	75	860.07	340.08	−178.19***
Agrochemical costs	US Dollar	240	167.17	79.18	165	143.67	70.97	75	218.85	71.76	−75.18***
Field days	Days	240	0.85	0.36	165	0.78	0.41	75	0.99	0.12	−0.205***
Hired labour	personal days	240	59.62	77.11	165	53.88	59.98	75	72.23	104.86	−18.342*
Household size	Number	240	6.46	1.99	165	6.18	1.90	75	7.08	2.06	−0.898
Maize yield	kg/ha	240	3515	1191	165	3446	1169	75	3666	1233	−219.8
Off-farm income	Yes = 1	240	0.86	0.35	165	0.92	0.27	75	0.73	0.45	0.188***
Seed	kg	240	6.56	2.81	165	6.39	2.95	75	6.93	2.45	−0.539
Tobacco experience	Years	240	8.63	5.34	165	8.04	5.42	75	9.93	4.94	−1.891
Tobacco variety	Improved = 1	240	2.77	12.56	165	3.47	15.11	75	1.23	0.42	2.246
Tobacco yield	kg/ha	240	1175	359	165	1125	360	75	1285	333	−159.59***
Total labour	Personal days	240	422	152	165	399	145	75	472.08	156	−72.704***

t-statistics in parentheses: "*p < 0.05; **p < 0.01; and ***p < 0.001"; Source: Author estimation.

equation (5):

$$E\left(\varepsilon_1 \middle| CFA = 1\right) = \sigma_{\mu 1}\frac{\varphi(\vartheta_i Z_i)}{\Phi(\vartheta_i Z_i)} \equiv \sigma_{A\mu}\gamma_{Ai} \tag{4}$$

$$E\left(\varepsilon_0 \middle| CFA = 0\right) = \sigma_{\mu 2}\frac{\varphi(\vartheta_i Z_i)}{(1-\Phi)(\vartheta_i Z_i)} \equiv \sigma_{N\mu}\gamma_{Ni} \tag{5}$$

where φ is the standard probability density function, Φ the cumulative density function. The γ is a vector of the inverse mills' ratios computed from equation (3) and control for self-selection bias [54].

The study can fit the ESR model through several techniques, namely, a two-step, the Wooldridge control function, and the maximum likelihood methods [52]. However, the first two estimation methods result in heteroskedastic residuals and require potentially cumbersome adjustments to derive consistent standard errors [53]. All the three estimated methods are consistent with literature and the study uses access to extension as an excludability restriction [55].

8. Results and discussion

8.1. Summary statistics of household characteristics

Table 1 shows summary of household characteristics in Hurungwe district of Zimbabwe, where we interviewed 75 and 165 farmers under CFA and NCFA, respectively. There are some considerable differences between socioeconomic characteristics of CFA and NCFA farmers. Smallholder farmers participating in CFA are seven years older than NCFA farmers. CFA farmers are visited 5 times more than NCFA farmers. As expected, the study finds more CFA farmers in farmers' clubs than NCFA farmers, indicating easy access to agricultural extension services, credit, and inputs. NCFA farmers are far from the output markets compared with CFA farmers, indicating easier access to markets among CFA farmers. Similarly, Lencucha et al. [19] states that CFA farmers often live further from markets because contracts help them with transportation of inputs and outputs. All CFA farmers participate in agricultural field days than NCFA farmers. Additionally, the study notes that CFA farmers allocate about 18 more personal days than the NCFA farmers, implying the labour intensiveness of CF for tobacco production. Our qualitative interviews suggest the need of investing in labour serving technologies, especially for elderly CFA farmers. Furthermore, CFA farmers derive more tobacco yield than NCFA farmers. However, NCFA farmers have more access to off-farm income than CFA farmers, which is also expected. These results are in line with Debela et al. [29].

8.2. Cobb-Douglas stochastic frontier analysis

Table 2 shows regression outputs of three SFA models. Column (1) presents results for the classical OLS (COLS) regression, Column (2) highlights estimates from the corrected medium absolute deviation (CMAD) regression. Finally, column (3) report results from the CD- SFA. The three models are run to act robust check for one another. Prior to estimation of the models, the study run some data validation and whether they meet the SFA assumptions, using the OLS residual and Skewness tests [39,40], which both support the data meeting the SFA data requirement. The choice of variables in this model is supported by previous work by Muyanga et al. [46,56] Pangapanga-Phiri et al. [22], and Rana et al. [15]. The study results show that logs of farm size, fertilizer, labour, and seed substantially influence yield of tobacco in the study area at 5% level of significance. All signs related to factors of production in the model are consistent with economic theory. Log of farm size is negatively related to tobacco yield by 73%, implying increase in farm size reduces farm productivity due to higher managerial ability demanded by large farms. This is in line with what literature presents, for example, Muyanga et al. [46,56] found that within the range of farms smaller than 5 ha, there is a significant inverse relationship between farm size and gross farm output per hectare. Likewise, Ali and Deininger [32] found that plot-level data from Rwanda point toward constant

Table 2
Regression outputs of Stochastic Frontier Analytical (SFA) Models.

		(1)	(2)	(3)
		COLS	CMAD	CD_SFA
ln(farm size)	Hectare	−0.731***	−0.533***	−0.731***
		(-7.36)	(-5.11)	(-7.45)
ln(fertilizer)	Kilogram	0.474***	0.399***	0.474***
		(5.74)	(4.60)	(5.81)
ln(labour)	Personal days	0.425***	0.392***	0.425***
		(5.18)	(4.56)	(5.24)
ln(seed)	Grams	0.162*	0.104	0.162**
		(2.56)	(0.16)	(2.59)
ln(chemical)	Liters	0.0926*	0.133**	0.0926*
		(2.15)	(2.95)	(2.18)
Intercept		0.750	1.461*	0.751
		(1.32)	(2.45)	(1.30)

t statistics in parentheses: "*p < 0.05; **p < 0.01; and ***p < 0.001"; Source: Author estimation.

returns to scale and a strong negative relationship between farm size and crop output per hectare. However, an increase in log of fertilizer, labour, seeds, and chemical by one-unit augmented tobacco yield by 47, 43, 16, and 9%, respectively. These results are stable across the three SFA models and findings by Nguyen et al. [47].

Fig. 4 shows vioplot of the technical efficiencies of all farmers. Generally, the study finds smallholder farmers to be 59% technically efficient, where CFA farmers (64 %) are at most seven (7) percent more efficient than NCFA farmers (57 %), see Appendix-Table One (1). This indicates that CFA and NCFA farmers produce 36 and 43% less, respectively, given the current level of inputs. Although we did not test whether CFA lead to more profit for farmers, these results are however promising as they would make CFA farmers produce tobacco efficiently hence better profits or more income than their counterparts to allow them buy food that would make them healthier. Elsewhere, Lencucha et al. [19] noted that farmers under CFA do not make more profits as they suffer from higher input prices as compared to NCFA farmers. Besides, Appendix-Figure One (1) illustrates the distribution of technical efficiency between NCFA and CFA farmers. The study demonstrates that 35 and 56% of NCFA and CFA farmers have technical efficiency above 50%, respectively. This further validates the notion that CFA farmers are more productive than NCFA farmers.

8.3. *Propensity score matching*

Appendix-Table 2 summarizes the mean values of the relevant variables between CFA and NCFA farmers. This is required prior to estimation of the PSM to identify a common support region between the CFA and NCFA farmers. In general, about 73 CFA farmers are matched to 162 NCFA farmers. Appendix-Fig. 2 graphically illustrates matching test between CFA and NCFA farmers. There are some farmers in the CFA and NCFA who are out of the region of the common support. Nevertheless, the evidence in the region of common support [50] suggests the use of the PSM to estimate the ATT of CFA and NCFA.

Appendix-Table 3 shows the PSM results from the three matching algorithms, viz., the kernel, neighbor, and radius marching techniques. The study observes almost the same yield obtained between CFA and NCFA farmers across the three matching algorithms. We find that CFA farmers have more yield than NCFA farmers at 5% level of significance. After sensitizing the results, we observe consistent results across the various calipers, radius, and neighbors. Higher yield among CFA than NCFA farmers is attributed to larger access to inputs, club membership, and extension services. Based on the sensitivity analysis in Appendix-Table 4, the PSM results on determine the effect of CFA on farm productivity are neither underestimated nor overestimated. These results are acceptable in global literature [2]. Similarly, Chen and Chen [57] found that contract farming improved agricultural production in developing countries. Likewise, Arouna et al. [2] study revealed that contract farming has positive effects on both productivity and welfare measures. The study notes that extension services include improved agronomic practices, which lead to augmented yield. These results are consistent with Meemken and Bellemere [58]. However, Chen and Chen [57] cautioned that there will be an increasing productivity inequality between farmers in the CFA and those not in the CFA unless something is done by policy decision-makers.

8.4. *Endogenous treatment effect of CFA on tobacco productivity*

There are several unobservable factors, such as managerial ability, credit, and field days, that jointly correlate with CFA and tobacco yield, which may not be controlled through the PSM approach. Lencucha et al. [19] caution that some farmers join the CFA because they do not have an alternative to access inputs provided through the CFA, suggesting existence some other un-observed

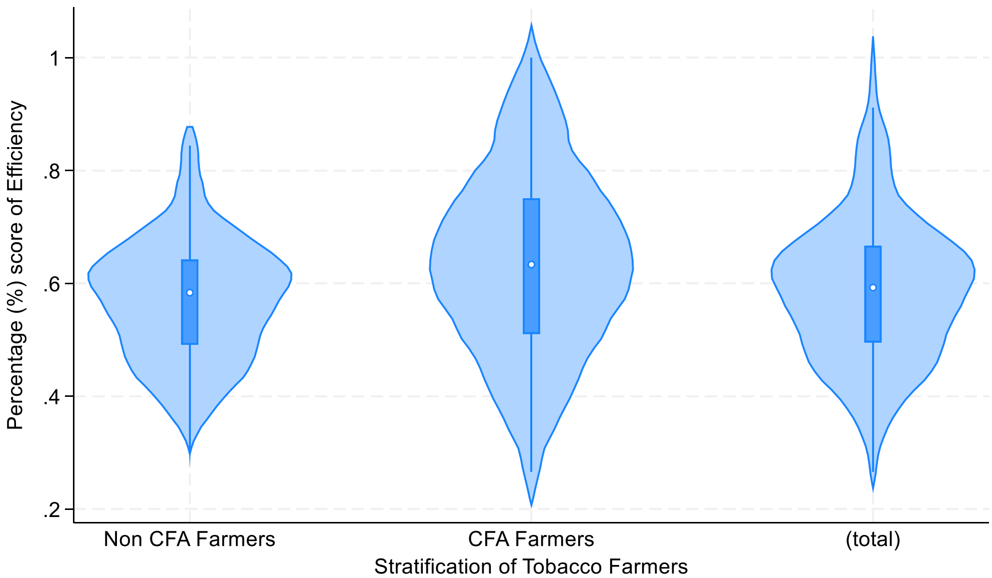

Fig. 4. Vioplot showing technical efficiency between CFA and NCFA farmers.

Table 3
What is the endogenous treatment effect of Contract participation on tobacco yield.

		(1)	(2)	(3)	(4)	(5)
		log(Yield)	log(Yield)	log(Yield)	log(Yield) NCFA	log(Yield) CFA
ln(farm size)	Hectare	−0.864***	−0.887***	−0.887***	−0.806***	−0.597*
		(-13.09)	(-14.49)	(-19.09)	(-7.52)	(-2.56)
ln(fertilizer)	Kilograms	0.612***	0.592***	0.592***	0.540***	−0.00228
		(11.28)	(8.58)	(8.43)	(6.51)	(-0.01)
ln(labour)	Personal days	0.456***	0.474***	0.474***	0.401***	0.508***
		(8.04)	(6.67)	(6.23)	(4.29)	(3.40)
ln(seed)	Grams	0.173*	0.207**	0.207***	0.230**	0.460**
		(2.39)	(2.96)	(3.88)	(3.28)	(2.97)
Contract participation	Participated = 1	0.394**	0.271**	0.271**		
		(2.73)	(3.09)	(2.61)		
Contract participation						
Age	In Years	−0.0298	0.00593	0.00593		0.297***
		(-0.61)	(0.15)	(0.13)		(4.35)
Age squared	Years squared	0.0285	0.0221	0.0221		−0.0281***
		(0.58)	(0.05)	(0.05)		(-4.17)
Gender	Male = 1	−0.0105	−0.199	−0.199		0.311
		(-0.03)	(-0.61)	(-0.42)		(0.91)
Household size	Number	−0.0360	0.0347	0.0347		0.0790
		(-0.35)	(0.46)	(0.44)		(1.21)
Education	Years	−0.0166	−0.0272	−0.0272		0.00523
		(-0.45)	(-0.62)	(-0.71)		(0.15)
Off-farm income	US Dollars	−0.816*	−0.831**	−0.831**		−0.732**
		(-2.28)	(-2.74)	(-2.84)		(-2.75)
Hired labour	Personal days	0.0275	0.0171	0.0171		0.0373**
		(1.61)	(1.09)	(0.75)		(3.11)
Credit Access	Accessed = 1	−0.566	−0.263	−0.263		−0.900*
		(-1.28)	(-0.63)	(-0.63)		(-2.07)
Distance to input markets	Kilometers	−0.0823	−0.182	−0.182		0.408**
		(-0.56)	(-1.08)	(-1.07)		(3.06)
Tobacco prices	US Dollars	0.693	−0.00790	−0.00790		0.469
		(1.19)	(-0.02)	(-0.01)		(0.79)
Tobacco experience	Years	0.0266	−0.0334	−0.0334		−0.0292
		(0.61)	(-1.11)	(-0.98)		(-1.11)
Field days	Number	0.628*	0.947**	0.947**		0.708**
		(2.25)	(3.25)	(2.97)		(2.79)
Membership or Club	Member = 1	0.489	0.678*	0.678*		0.654*
		(1.52)	(2.47)	(2.46)		(2.53)
ln(fertilizer)	Kilograms					0.340*
						(2.25)
ln(labour)	Personal days					−0.300*
						(-2.12)
ln(seed)	Grams					−0.723***
						(-4.20)
ln(farm size)	Hectare					−0.275**
						(-2.69)
N		240	240	240		240

t statistics in parentheses: "*p < 0.05; **p < 0.01; and ***p < 0.001"; Source: Author estimation.

factors to CFA participation. To thorough account for the potential endogeneity bias, we further estimate the ESR treatment effect. Table 3 shows factors affecting participation in CFA and the treatment effect of CFA on tobacco yield. Columns (1), (2), and (3) are results, estimated through the maximum likelihood, two stage, and control function approaches, respectively. Columns (4) and (5) results are run, following Lokshin and Sajaia [53] Stata move-stay. The study observes the estimates consistent across all the four columns. The study finds that CFA significantly improves tobacco yield by 39%. These results are consistent with previous studies by Bidzakin et al. [54]. Meemken and Bellemare [58] found that farmers under CFA have higher productivity and income than their counterparts. Similarly, using sample selection model, Bezabeh et al. [1] found that contract farming increased farm yield and income higher than farmers outside contract farming arrangement. Similarly, highly productive operation with low per-unit costs will require fewer acres or inputs of production to achieve the desired level of income compared to a lower-producing/higher-cost operation. Therefore, productivity not only affects per unit profit but also total profit. In other words, a productive farmer is more likely to run a profitable investment than non-productive farmer.

Several factors affect household participation in CFA, namely, age, off-farm income, credit accessibility, distance to input markets, field days, membership to a club, fertilizer, labor, seed, and farm size. Age is found to have a positive effect on CFA participation, while squared age has a negative influence on the same. Basically, older farmers may not have the energy to cope with the high labour demands of tobacco production specially when under a contract farming where it becomes compulsory for them to produce the quota given. This agrees to previous findings where CFA is associated with higher labour demands [58]. Furthermore, off-farm income has negative effect on CFA participation, proposing the need of in-kind input to farmers instead of cash payments. Literature presents that credit accessibility is positively related to CFA participation [59]. One of the reasons why farmers join CFA is to access credit. However, during our qualitative interviews, it was noted that farmers who have access to other sources of credit other than CFA are likely not to participate in CFA as their financial stand is still okey. Similarly, farmers with adequate labour, seed, and farm size are less likely to participate in CFA than their counterparts. Nevertheless, an increase in the amount of inorganic fertilizer for tobacco productivity improves CFA participation; this is related to that CFA provides inorganic fertilizer that can be applied in their tobacco farms. Likewise, distance to contracted input markets in kilometres, attendance in the field day demonstrations, and membership to any farming club enhanced CFA participation. Our qualitative interviews highlighted that it is important for farmers to be in groups or clubs as it become a platform where farmers exchange ideas as well as technologies. Hence, stakeholders include government should intensify awareness campaign targeting the importance of farmer clubs in enhancing crop production and productivity. Moreover, clubs help in bargaining power. Importantly, the study note prices of tobacco plays no significant role in influencing farmers decision to join CFA and this explains the role of acquiring inputs from CFA as some of the major determinants of participation. These results are also consistent with findings by Khan et al. [24].

However, based on the data limitation, the study has not tested the hypothesis around assessing the changes that would be attributed to CFA because of lack of panel data. Moreover, this study did not test whether CFA led to more profit for framers. Though CFA enhanced productive of tobacco farming, tobacco has negative consequences on the health of people. However, these results would equally be applied to other related cash crops that are cultivated by resource constraint smallholder farmers. In addition, the study would be more useful to all districts in Zimbabwe if it had a wider sample coverage of tobacco farmers from other districts. Hence, further research with a large longitudinal sample size that include tobacco farmers from other districts would be recommended to capture the effect of CFA on tobacco productivity and intended livelihood changes in space and over time. Further, future studies should also extend the analysis to capture both technical efficiencies and profit optimization objectives of the tobacco farmers.

9. Conclusion and policy implications

The study examines the effect of CFA on tobacco productivity in Hurungwe district in Zimbabwe. The study controls for both observable and unobservable factors, like age, education, and ability to use available information and technologies, through the ESR model, which also acted as a robust check for PSM techniques. Even though tobacco products kill their users, we would like to explore whether CFA can make farming more productive or not because tobacco is still an important crop at the household level before it is fully replaced in the immediate future. We hypothesize that if tobacco farming would be more productive, then perhaps farmers will have enough money to buy food so they can be healthier even if the tobacco leaves, they grow can kill people elsewhere. Based the ESR model, this study finds that CFA improves tobacco productivity by 39%. However, CFA participation is affected by several factors, namely, age, field days, membership to a club, and farm size. The study found that women and older farmers were less likely to participate in CFA as it was deemed more labour-intensive. This study has demonstrated some broader implications of CFA for informing policy making, especially for resource-constraint smallholder farmers in Southern Africa. Hence, the study recommends that generally, smallholder farmers should have access to CFA as well as belong to farmers clubs, where they can access information, experiences, inputs, and encourage loan repayment among themselves. CFA should also attach credit accessibility to in-kind inputs to avoid farmers shifting financial resources towards off-farm activities. CFA should also integrate labour saving technologies to allow women and elderly participation in CFA. On the other hand, the study notes a negative relationship between off-farm income and CFA. Hence, educating such farmers to be aware of the benefits of CFA participation, especially as they participate in tobacco crop production, is vital. Thus, these results are relevant for informing CFA-related policies that improve smallholder tobacco productivity in Southern Africa. With increasing tobacco controls, these results are still relevant for other general cash crop farming that are cultivated in Southern Africa where agriculture is still the main engine for economic growth and most farmers are notably resource constrained. Nonetheless, based on the data availability and type, the study has yet to test the hypothesis around assessing the changes that would be attributed to CFA because of lack of panel data. Moreover, this study did not test whether CFA led to more profit for framers. In addition, the study would be more useful to all districts in Zimbabwe if it had a wider sample coverage of tobacco farmers from other districts. Hence, further research with a large longitudinal sample size that include tobacco farmers from other districts would be recommended to capture the effect of CFA on tobacco productivity and intended livelihood changes in space and over time.

Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Innocent Pangapanga-Phiri: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation,

Conceptualization. **Eric Mungatana:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Gwenzi Mhondoro:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendices.

Appendix Table 1
Technical efficiency between CFA and NCFA farmers

	POOLED	NCFA	CFA	DIFFERENCE
EFFICIENCY	58.85 (12.79)	56.67 (10.30)	63.60 (16.13)	6.91***

Appendix Table 2
Balancing tests of various covariates used in the PSM

		CFA	NCFA	%bias	t	p > t	V(C)
Gender	Male = 1	0.93	0.91	7.70	0.45	0.66	.
Married	Married = 1	0.93	0.90	9.70	0.60	0.55	.
Farm size	Hectare	1.05	0.98	15.50	0.97	0.34	1.02
Labour	Personal days	205.37	202.82	1.00	0.05	0.96	1.09
Household size	Number	6.89	6.64	12.50	0.80	0.42	0.76
Education	Years	11.29	11.48	(6.60)	(0.42)	0.68	0.84
Tobacco experience	Years	9.67	8.96	13.70	0.83	0.41	0.71
Distance to input markets	Kilometers	3.83	3.84	(0.70)	(0.04)	0.97	0.82
Membership	Member = 1	0.27	0.16	31.90	1.73	0.09	.

Appendix Table 3
Average treatment effects from various Propensity Score Matching techniques

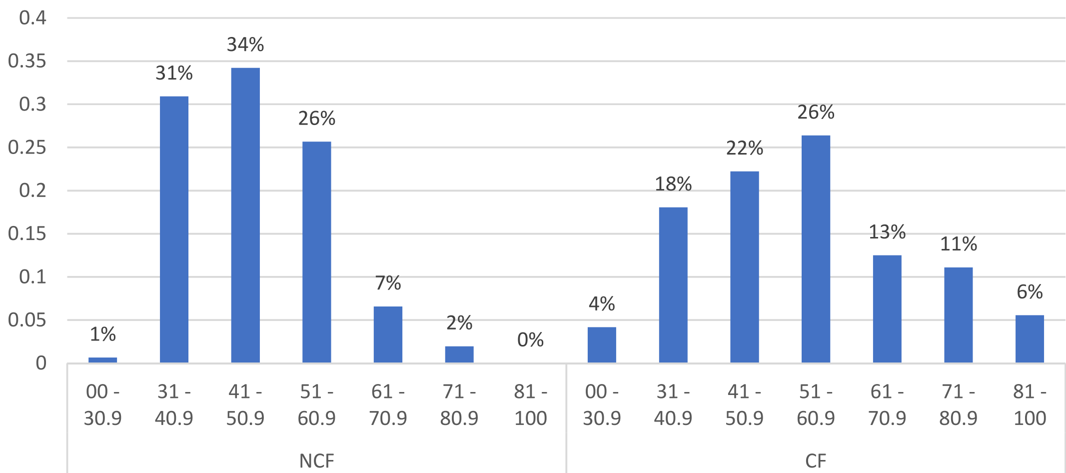
Technique	Bandwidth/caliper	Sample	CFA	NCFA	Difference	% Change	S.E.	P-value
Kernel	0.10	Unmatched	1385.00	1125.41	259.59	23.07 %	49.06	5.29***
		ATT	1370.71	1234.35	136.36	11.05 %	55.90	2.44*
	0.20	Unmatched	1385.00	1125.41	259.59	23.07 %	49.06	5.29***
		ATT	1370.71	1220.11	150.60	12.34 %	53.63	2.81**
	0.25	Unmatched	1385.00	1125.41	259.59	23.07 %	49.06	5.29***
		ATT	1370.71	1209.68	161.03	13.31 %	52.69	3.06***
Neighbor	1.00	Unmatched	1385.00	1125.41	259.59	23.07 %	49.06	5.29***
		ATT	1370.71	1235.57	135.14	10.94 %	76.67	1.76*
	2.00	Unmatched	1385.00	1125.41	259.59	23.07 %	49.06	5.29***
		ATT	1370.71	1197.67	173.04	14.45 %	62.12	2.79**
	3.00	Unmatched	1385.00	1125.41	259.59	23.07 %	49.06	5.29***
		ATT	1370.71	1238.36	132.34	10.69 %	66.48	1.99*
Radius	0.10	Unmatched	1385.00	1125.41	259.59	23.07 %	49.06	5.29***
		ATT	1370.71	1229.98	140.73	11.44 %	55.17	2.55*
	0.20	Unmatched	1385.00	1125.41	259.59	23.07 %	49.06	5.29***
		ATT	1370.71	1203.57	167.14	13.89 %	52.68	3.17**
	0.25	Unmatched	1385.00	1125.41	259.59	23.07 %	49.06	5.29***
		ATT	1370.71	1194.96	175.75	14.71 %	51.71	3.40**

t statistics in parentheses: "*$p < 0.05$; **$p < 0.01$; and ***$p < 0.001$"; Source: Author estimation.

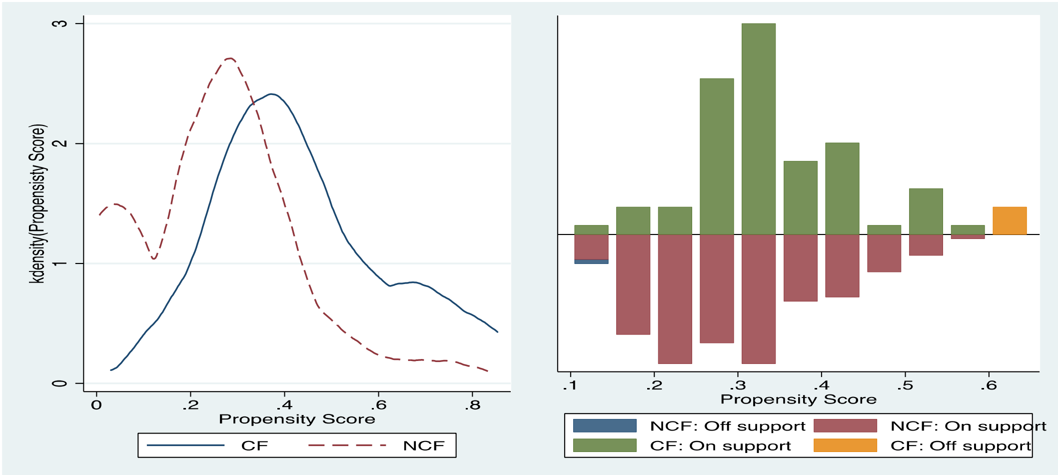
Appendix Table 4
Sensitivity Analysis

Mantel-Haenszel (1959) bounds for variable bc_h				
Gamma	Q_mh+	Q_mh-	p_mh+	p_mh-
6	−.074304–.074304	.529616	.529616	
11	−.074304	−.074304	.529616	.529616
16	−.074304		.529616	
21		−.074304		.529616
26	−.074304	−.074304	.529616	.529616
31	−.074304	−.074304	.529616	.529616
36	−.074304	−.074304	.529616	.529616
41	−.074304	−.074304	.529616	.529616
46		−.074304		.529616
56	−.074304	−.074304	.529616	.529616
61				.
66	−.074304	−.074304	.529616	.529616
71	−.074304	−.074304	.529616	.529616
76	−.074304		.529616	.
81	−.074304	−.074304	.529616	.529616
86	−.074304	−.074304	.529616	.529616
96	−.074304	−.074304	.529616	.529616

Gamma: odds of differential assignment due to unobserved factors.
Q_mh+: Mantel-Haenszel statistic (assumption: overestimation of treatment effect).
Q_mh-: Mantel-Haenszel statistic (assumption: underestimation of treatment effect).
p_mh+: significance level (assumption: overestimation of treatment effect).
p_mh-: significance level (assumption: underestimation of treatment effect).



Appendix Fig. 1. Distribution of technical efficiency between NCF and CF farmers



Appendix Fig. 2. Matching Testing of Propensity Scores of CFA and CFA farmers
Source: Author estimation.

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