



EFFECT OF COMMERCIALIZATION ON HOUSEHOLD FOOD SECURITY AMONG SMALLHOLDER PRE-COOKING BEAN AGRIPRENUERS IN KENYA

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ABSTRACT: *Agricultural commercialization is a strategy proposed to alleviate food insecurity problems in Africa. This paper contributes to the debate on the effect of agricultural commercialization on household food security by assessing its effect on household food security. Cross-sectional data for the 2022/2023 farming season were collected from 413 smallholder pre-cooking bean farmer households in Kimilili Sub-County, Kenya. A propensity score matching model was used for data analysis. Crop output market participation share (COMPS) and crop input market participation share (CIMPS) were converted to Z scores and jointly used as a proxy of agricultural commercialization of a household. Findings indicated that agricultural commercialization had a significant negative Average Treatment Effect on the Treated (ATT) of -0.0731 and -0.0836 food insecurity experience scale scores using nearest neighbor and Kernel matching, respectively. The paper recommends a combination of agricultural commercialization with diversification to improve the household food access dimension of food security.*

KEYWORDS: Agricultural commercialization, Effect, Food security, Propensity score matching.



INTRODUCTION

Global efforts have been made towards achieving the Sustainable Development Goal (SDG) to “end hunger, achieve food security and improve nutrition and promote sustainable agriculture” (FAO, 2019). However, food insecurity is still a problem in all countries of the World. Both developed and developing countries suffer from hunger (United Nations, 2019). Among the African regions, Sub-Saharan Africa (SSA) is the most adversely affected. Most of the SSA countries have Global Hunger Index scores between 20.0 and 34.9, which are rated as serious (Von Grebmer *et al.*, 2023). Malnutrition is common in the population of these countries with undernourishment; insufficient calories and protein intake, and micronutrient deficiencies, “hidden hunger” dominating (FAO *et al.*, 2019). Undernourishment prevalence in Eastern Africa currently stands at 30.08% which is rated as severe; 133.1 Million people in the region are undernourished (FAO *et al.*, 2019). From the 2023 Global Hunger Index Report, Kenya has a Global Hunger Index Score of 22.0, rated as serious (Von Grebmer *et al.*, 2023). According to The World Food Programme (2019), 29% of the children in rural areas and 20% of those living in cities of Kenya, respectively, are stunted. Kenya is ranked second after Niger among the top twenty countries affected by multiple micronutrient deficiencies and first in Vitamin A deficiency. Kenya has a hidden hunger index of 51.7 with deficiency prevalence percentages of 35.8, 34.5, and 84.4 for Zinc, Iron, and Vitamin A respectively (Global Hidden Hunger Indices and Maps, 2019). A large population of those adversely affected by all forms of malnutrition reside in rural areas and depend on small-scale agriculture as a source of food and income (FAO, 2017). The big issue to be addressed is how to make these rural smallholder farmers sustainably food and nutrition secure.

Efforts made to solve the problem include promotion of local production of nutritious, early maturing, high yielding and marketable crops like pulses. Pulses are rich in proteins and other vital micronutrients required for reducing undernourishment and micronutrient deficiencies. According to Ritho *et al.* (2023), beans are the most critical pulses in SSA. A reasonable amount of 24% of all beans produced worldwide are from SSA (Rawal & Navarro. eds. 2019). Furthermore, beans form a significant part of the poor rural population diets in East and Central Africa. Per capita bean consumption for Kenya was 12.26 Kilograms in the year 2013 (FAOSTAT, 2022). Like other pulses, beans are rich in proteins and micronutrients thus have the potential to reduce undernourishment (Ritho *et al.*, 2023). However, the bulk of the product is consumed in the form of dry grain that takes long (three to four hours) to cook, thus limiting its consumption (Pan African Bean Research Alliance-PABRA, 2017). Under the current Global trends of urbanization, increased income, high energy costs and changing food systems (FAO 2017), consumer preferences have changed to food products that are easy to prepare. These justify the development and release of pre-cooking bean varieties to the market. Pre-cooking bean varieties are high-yielding, take a shorter time to cook, rich in iron, zinc and other micronutrients and are preferred by processors as well as consumers (Ritho *et al.*, 2023). Furthermore, precooking bean varieties mature earlier than conventional varieties of beans, and their produce has a relatively higher market price and demand (PABRA, 2017). Pre-cooking bean varieties production and marketing has been promoted with the belief that they can enhance food access. The research question of this paper is how pre-cooking bean commercialization affects the household food security status of smallholder agripreneurs in Kimilili Sub-County, Kenya? The next sections of the paper give theoretical underling, methodology, followed by results, discussions, implications to research and practice, conclusion, future research and finally references.



THEORETICAL UNDERPINNING

This study uses the non-separable agricultural household model to understand how farming households make decisions. This model, developed by Singh *et al.* (1986), considers farm households as both producers and consumers of their agricultural goods. A household's production and consumption choices are interconnected. They produce goods for both personal use and for sale in the market. To produce these goods, they use various inputs, which they either acquire from the market or produce themselves. Ultimately, a farm household's goal is to maximize utility, not just profit. They first aim to maximize their profits from production. They then use the income generated from these sales to maximize their overall satisfaction (utility) as consumers. The extent to which a household participates in the markets, or its commercialization, is a function of a household's marketable surplus, transaction costs, household-specific characteristics, and institutional factors. Mathematically, the proportion of sales (commercialization) is expressed as:

$$PS = f(MS, TC, HC, IF) \quad (1)$$

Where: PS is the proportion of sales (commercialization), MS is the marketed surplus, TC is the transaction costs, Household characteristics, and IF institutional factors.

METHODOLOGY

Research design

This study used a survey research design. Surveys are used for descriptive, explanatory and exploratory research. This study is exploratory. Therefore, the survey research design was the most suitable design to answer the research question of this paper.

Study area

The study was conducted in Kimilili Sub-County, Bungoma County, Kenya. The study area was selected since it was one of the Sub-Counties in Bungoma County where governments and Non-governmental organizations encouraged smallholder farmers to commercialize their farm activities. Pre-cooking bean commercialization was promoted in the Sub-County for several reasons: to reduce high levels of protein and micronutrient deficiencies as the bean is rich in iron, zinc and other micronutrients; to increase productivity because it is high yielding; to improve farmers' income since the bean has a relatively higher market price, demand and is preferred by processors. Kimilili Sub-County's geographical coordinates are 0° 45' 0" North, 34° 43' 0" East. The Sub-County covers an area of 181.20 Km² divided into two divisions; Kimilili 94.00 Km² and Kamukuywa 87.20 Km² each having two wards. The Kimilili division has Kibingei 51.90 Km² and Kimilili 42.10 Km² wards, while Kamukuywa has Maeni 41.00 Km² and Kamukuywa 46.20 Km² wards (GOK, 2023). The map of the study area is shown in Figure 1

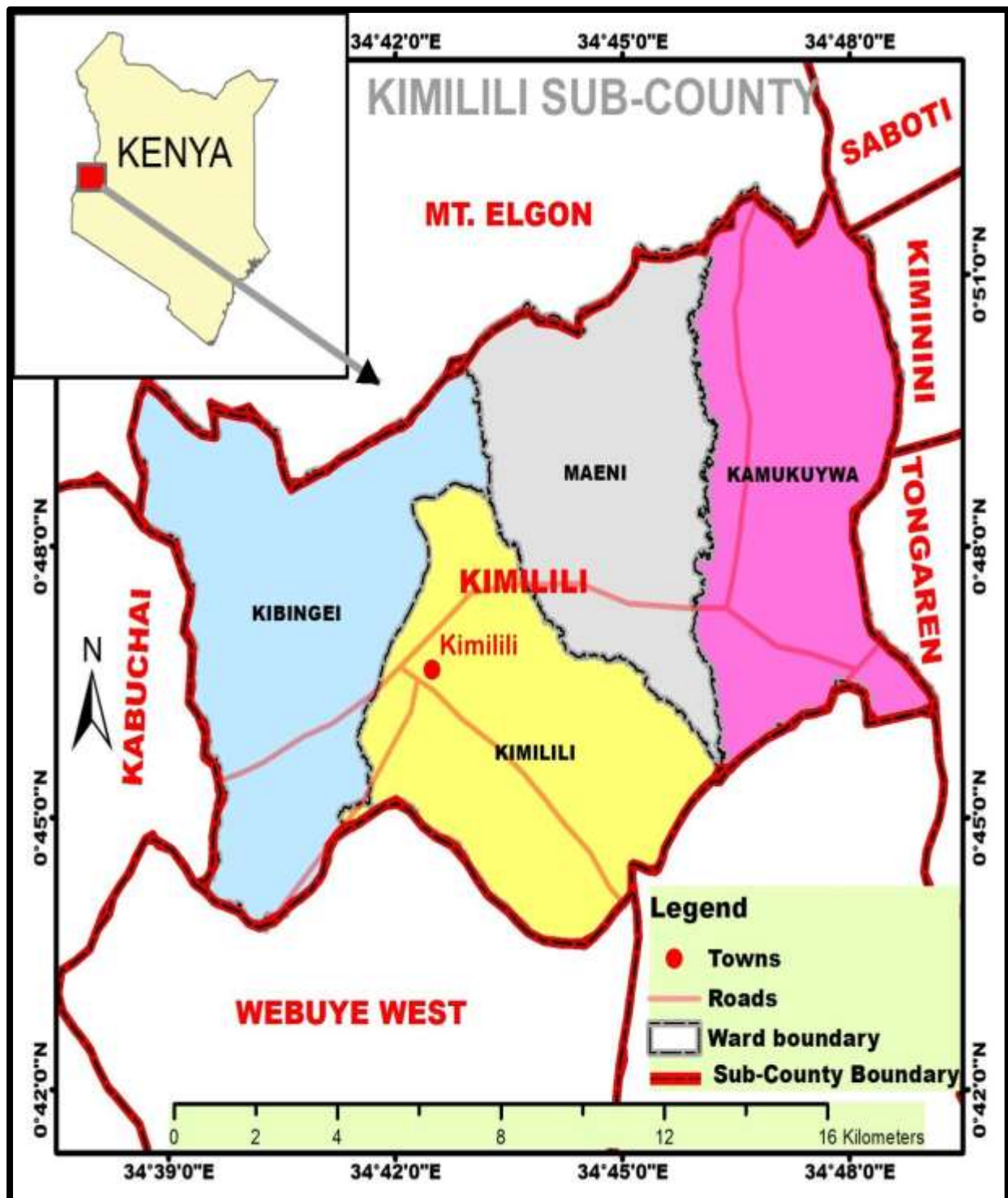


Figure 1: Map of the study area.

Source: World Resource Centre (2022).



Sampling procedure

The target population of this study was smallholder pre-cooking bean agripreneurs in Kimilili Sub-County, Kenya. A multistage sampling procedure was used to obtain the required sample. In the first stage, Kimilili Sub-County was purposely selected because it is among the Sub-Counties of Bungoma County where pre-cooking bean production and commercialization had been promoted. In the second stage, all four County assembly wards were considered. Based on information about pre-cooking bean production quantities from the ward Ministry of Agriculture offices, Kibingei Sub-Location was selected from Kibingei ward; Kimilili rural Sub-location from Kimilili ward; Sikhendu Sub-Location from Maeni ward and Nabikoto Sub-Location from Kamukuywa ward were selected. A simple random sampling technique was used to select the respondents from each Sub-location proportionate to their smallholder pre-cooking bean farmers' population sizes.

Sample Size determination

The required sample size was determined using proportionate to the number of households sampling methodology adapted from Anderson *et al.* (2007):

$$n = \frac{pqZ^2}{E^2} \quad (2)$$

Where; n= Desired sample size; Z= confidence level ($\alpha=0.05$); p= proportion of the target population containing the major interest q; q= 1-p; E= allowable error. Since the proportion of the population was not known, p=0.5, q=1-0.5=0.5, Z=1.96 and E=0.05 (Fisher *et al.*, 1991).

The sample size, was calculated as;

$$n = \frac{(0.5)(0.5)(1.96^2)}{(0.05)^2} = 384 \quad \text{Smallholder pre-cooking bean agripreneurs} \quad (3)$$

The number of pre-cooking bean agripreneurs who were interviewed was 415. However, two questionnaires were incomplete so data from them were not considered for analysis bringing the sample size to 413.

Data Collection methods and sources

A semi-structured questionnaire was the tool used for data collection. A pilot survey was carried out in Webuye West Sub-County to assess the validity and reliability of the data collection tool before using it. Primary data was collected from smallholder pre-cooking bean agripreneurs through face-to-face interviews. The data collected from the questionnaire were managed using STATA Version 2017 software.

Analytical Framework

The research question of this paper is how pre-cooking bean commercialization affects the household food security status of smallholder agripreneurs in Kimilili Sub-County, Kenya? The dependent variable was household food security status which was binary (1= Food Secure, 0=Food Insecure). To answer the research question, a Propensity Score Matching (PSM) model was used for analysis. Pre-cooking bean commercialization was the treatment variable



and household food security status was an outcome variable. Both treatment and outcome variables were binary. The (PSM) model was developed by Rosenbaum and Rubin in 1983 to simultaneously balance multiple observed covariates between the treated and control groups. In this case, the treatment variable was commercialization, where the treated group was commercialized smallholder pre-cooking bean agripreneurs. The non-commercialized smallholder pre-cooking bean agripreneurs constituted the control group. Implementing the Propensity Score Matching (PSM) model followed five steps: selecting covariates and independent variables that affect the treatment commercialization. Estimating propensity scores was done using the probit model. Restricting the analysis to the area of common support and application of matching methods. Checking the balancing property; various tests were used and finally, estimating the average treatment effect of the treated group (ATT).

$$ATT = E(y_{1i} - y_{0i} | D_i) = E(y_{1i} | D_i = 1) - E(y_{0i} | D_i = 1) \quad (4)$$

Where $E(.)$ is the expectation, y is the outcome, and D is the decision variable.

Commercialization was measured using Z scores; household heads who had positive Z scores constituted the commercialized (treated group) while those who had negative scores formed the non-commercialized (control group). From the data out of 413 household heads that were interviewed, 211 households were not commercialized while 202 were commercialized. The Propensity Score Matching model was suitable for this analysis because: there was no baseline data, the data was cross-sectional and the control group was larger than the treated. Furthermore, it measures the effect of treatment based on propensity scores of being treated. Matching based on multiple covariates may lead to dimensionality problems which could only be solved by matching using propensity scores which is a single variable created in PSM (Rosenbaum & Rubin, 1983). The outcome variable (household food security status) of commercialized smallholder pre-cooking bean agripreneurs (treatment group) was compared to that of non-commercialized smallholder pre-cooking bean agripreneurs (control group) with similar propensity scores to get treatment effects.

RESULTS

The implementation of the Propensity Score Matching (PSM) model followed five steps which were: selection of covariates, estimation of the propensity scores, restriction of analysis to the area of common support, checking the balancing property and estimating the average treatment effect of the treated group. Results for each stage are presented.

Selection of covariates

These were variables identified as influencing the treatment variable, pre-cooking bean commercialization. They were fixed in the pre-cooking bean agripreneurs' households before commercialization. The covariates were correlated with the outcome variable (household food security status) and were not balanced across commercialized and the control (non-commercialized) pre-cooking bean agripreneurs households. The variables were; age, schooling years, active members, inactive members, log of land size, log fertilizer used, relative support, grain traders, gender, land ownership type, hired labour, extension access, and trust in traders. The variables are presented in Table 1.

**Table 1: Factors affecting pre-cooking bean commercialization used as covariates in the Propensity Score Matching model**

Variable description	Measurement	Expected relation
Age	Age of an agripreneur in years	+/-
Schooling years	Number of years spent in formal schooling	+
Active members	Number of members aged between 15 and 64 years	+/-
Inactive members	Number of members below 15 and above 64 years	+/-
Log of land size	Log of Hectares of land owned	+/-
Log fertilizer used	Log of Kilograms of fertilizer used/Hectare	+/-
Relative Support	Number of relatives who can support	+/-
Grain traders	Number of grain traders who can buy pre-cooking bean	+/-
Gender	Gender of agripreneur Binary; 1= Male, 0= Female	+/-
Land ownership type	Binary Owned with title =1 without title=0	+/-
Hired labour	Use of hired labour Binary 1=Yes, 0=No	+/-
Extension access	Extension services accessed Binary 1=Yes, 0=No	+
Trust in traders	Having trust in traders Binary 1=Yes, 0=No	+

Estimating propensity scores

Propensity scores are probabilities of falling in the treated group. At this stage the actual propensity scores are not known and so they need to be estimated. Several models could be used to estimate propensity scores and include; probit model, Logit model, discriminant analysis and Mahalanobis distance analysis. Mahalanobis distance analysis was not suitable for this situation because it uses exact matching and cannot work well when covariates are highly dimensional as in this case. Probit model and Logit model were the most suitable. Probit model was used to estimate the propensity scores because the data was normally distributed between treated and control groups. The analysis was executed using STATA version 17. Results of the probit model are shown in Table 2.

Table 2: Results of Probit estimation of propensity scores

Variable description	Coefficient	Standard error
Age	-0.0056	0.0059
Schooling years	0.0044	0.0233
Active members	-0.1076**	0.0402
Inactive members	-0.0143	0.0389
Log of land size	0.4177**	0.1987
Log fertilizer used	0.2342***	0.0559
Relative Support	-0.0348*	0.0188
Grain traders	0.0264	0.0359
Gender	0.1005	0.1544
Land ownership type	-0.3091*	0.1747
Hired labour	0.8324***	0.1479



Extension services access	0.2150	0.1608
Trust in traders	0.2286	0.1454
Constant	-0.4399	0.6120

Note: Number of observations = 413; Log likelihood = -226.66947; log-likelihood χ^2 (13) = 119.0000, Prob > χ^2 = 0.0000; Pseudo R^2 = 0.2079; ***, ** and * denote significant at 1%, 5% and 10% levels, respectively.

A log-likelihood of -226.66947 indicates how the model converged quickly. The log-likelihood ratio chi-square statistic LR chi-square (13) = 119.0000, probability chi-square = 0.0000 and McFadden Pseudo R-squared = 0.2079 show that the model wholly and significantly fitted the data well. Furthermore, these show that the decision to commercialize pre-cooking beans (participate in the input and output markets) is attributed to the explanatory variables considered in the probit model. They also demonstrate that the combination of explanatory variables meets the balance requirement.

Restricting the analysis to the region of common support using nearest neighbor matching and kernel matching

To determine the effect of pre-cooking bean commercialization on household food security status, it is important to consider that commercialized agripreneurs could have realized higher levels of food security status even if they had not participated in the input and output markets. As a result, this study adopted propensity score matching techniques that account for all observable factors to distinguish the instinct effect of pre-cooking bean commercialization on household food security status. The commercialized agripreneurs were 202 while the non-commercialized were 211. Commercialized smallholder pre-cooking bean agripreneurs were matched with the non-commercialized with similar propensity score values. Matching was only done on the region of common support determined by the propensity scores of the treated and control cases. Two matching methods were used, namely Nearest Neighbor Matching (NNM) and Kernel matching (KM). The region of common support is the overlap of propensity scores between treated and control cases. The optimal number of blocks was 5. The common support condition is shown in figures 2 and 3 for the bar graph and line graph, respectively.

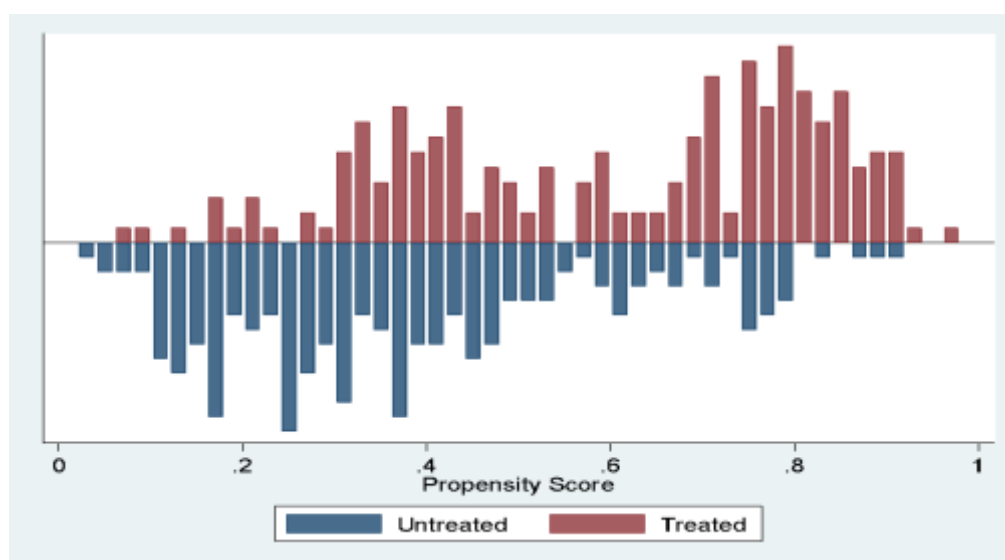


Figure 2: Bar graph presentation of the region of common support

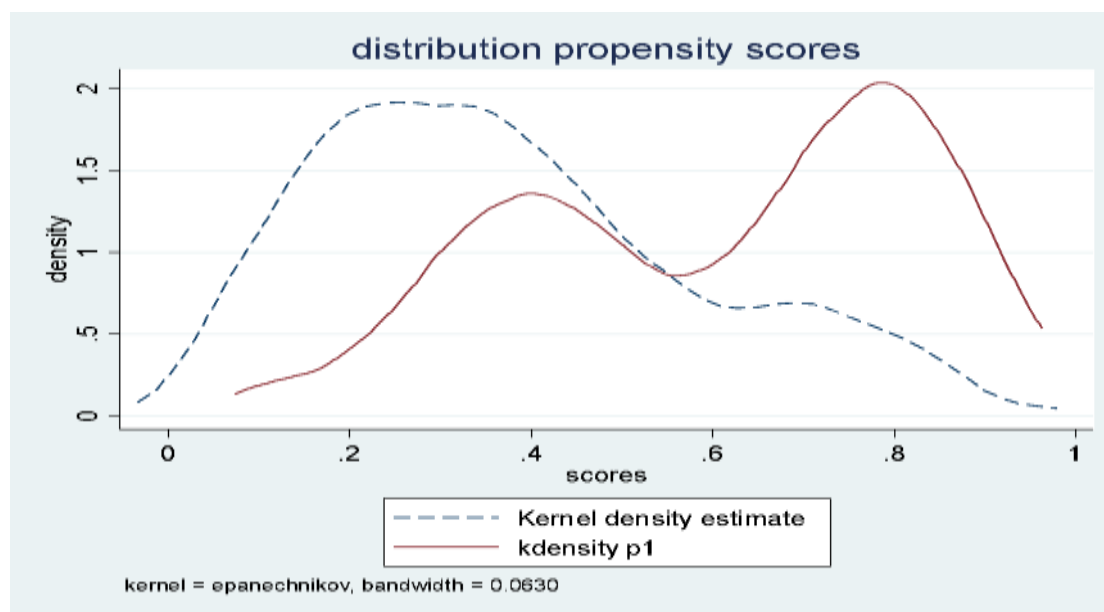


Figure 3: Line graph presentation of the region of common support

Checking the balancing property

The propensity Score Matching (PSM) model was chosen to deal with confounding problems and ensure that treated and control cases that had similar observable characteristics were compared. To ensure that average treatment effects on the treated (ATT) estimation results were reliable as well as valid, it was necessary to check the balancing property of the propensity scores. The balancing property was tested using percentage bias, t-test, Rubin's B, Rubin's R and McFadden's Pseudo R^2 .

The balancing property is valid if the t-test results indicate that the differences in means of variables between treated and control smallholder pre-cooking bean agripreneur households are statistically insignificant after matching. Based on this test the balancing property was satisfied. Furthermore, the percentage bias of each covariate after matching should be less than twenty percent (20%) for validation of the balancing property. All variables satisfied this condition after matching, therefore validating the balancing property. Table 3 shows the balancing tests of propensity scores and covariates before and after matching based on percentage bias and t-test.

Table 3: Balancing tests of propensity scores and covariates before and after matching based on percentage bias and t-test

Variable description	Sample	Sample mean		Bias		t-test	
		Treated	Control	% Bias	% Reduction bias	t	p>t
Age	Unmatched	44.7570	46.5730	-12.9000		-1.3100	0.1900
	Matched	44.5030	43.6900	5.8000	55.2000	0.5600	0.5760
Schooling years	Unmatched	10.0300	8.6777	39.5000		4.0100	0.0000
	Matched	9.8289	9.9733	-4.2000	89.3000	-0.4300	0.6690
Active members	Unmatched	3.2228	3.5782	-19.6000		-1.9800	0.0480



Inactive members	Matched	3.2674	3.2050	3.4000	82.4000	0.3400	0.7320
	Unmatched	3.2178	3.2938	-4.1000		-0.4200	0.6740
Log of land size	Matched	3.2674	3.2157	2.8000	32.0000	0.2900	0.7720
	Unmatched	0.8942	0.6923	50.7000		5.1600	0.0000
Log fertilizer used	Matched	0.8446	0.8673	-5.7000	88.8000	-0.5400	0.5910
	Unmatched	3.7788	2.7895	73.2000		7.4200	0.0000
Relative Support	Matched	3.6849	3.6451	2.9000	96.0000	0.3300	0.7430
	Unmatched	2.9802	3.2133	-6.1000		-0.6200	0.5360
Grain traders	Matched	3.0428	3.0018	1.1000	82.4000	0.1000	0.9210
	Unmatched	2.4802	2.0332	22.1000		2.2400	0.0260
Gender	Matched	2.4439	2.5152	-3.5000	84.0000	-0.3000	0.7610
	Unmatched	0.3663	0.2749	19.6000		2.0000	0.0460
Land ownership type	Matched	0.3529	0.3975	-9.6000	51.3000	-0.8900	0.3750
	Unmatched	1.6980	1.7915	-21.5000		-2.1900	0.0290
Hired labour	Matched	1.7326	1.7433	-2.5000	88.6000	-0.2300	0.8150
	Unmatched	0.5941	0.2085	85.3000		8.6900	0.0000
Extension service access	Matched	0.5615	0.5348	5.9000	93.1000	0.5200	0.6050
	Unmatched	0.3218	0.2133	24.6000		2.5100	0.0130
Trust in traders	Matched	0.2941	0.3013	-1.6000	93.4000	-0.1500	0.8810
	Unmatched	0.4951	0.4218	14.7000		1.4900	0.1360
	Matched	0.4866	0.4938	-1.4000	90.3000	-0.1400	0.8910

Two matching algorithms were used in this study: three nearest neighbor matching (NNM3) and Kernel matching (KM). Several indicators were considered with respect to the algorithms. These were McFadden's pseudo R^2 , likelihood-ratio chi-square, probability chi-square, mean standardized bias, Rubin's B, Rubin's R and total percentage bias reduction before and after matching were assessed. Table 4 presents a summary of the balancing test indicators.

Table 4: Summary of balancing tests of the covariates used

Matching algorithms	Three nearest neighbors Matching NNM (3)	Kernel (KM)	matching
Before Matching			
Pseudo R^2 before matching	0.2080	0.2080	
LR chi2 before matching	119.0000	119.0000	
Probability chi2 before matching	0.0000	0.0000	
Mean standardized bias before matching	30.3000	30.3000	
Rubin's B before matching	116.4000	116.4000	
Rubin's R before matching	1.0200	1.0200	
After matching			
Pseudo R^2 after matching	0.0050	0.0060	
LR chi2 after matching	2.6800	2.9100	



Probability chi2 after matching	0.9990	0.9980
Mean standardized bias after matching	3.9000	4.6000
Rubin's B after matching	16.9000	17.6000
Rubin's Rafter matching	1.0200	1.0700
Total % bias reduction	87.1287	84.8185

Estimating the average treatment effect by matching based on propensity scores

The effect of pre-cooking bean commercialization on household food security status among smallholder agripreneurs in Kimilili Sub-County, Kenya, was estimated using the average treatment effect on the treated (ATT). The ATT Propensity Score Matching estimator is the most recommended. Comparisons between the commercialized and non-commercialized households were made. Household food security status was the outcome variable measured using the Food Insecurity Experience Scale (FIES) developed by Ballard *et al.* (2013). Scores from zero to three were the food secure and from four to eight the food insecure. The scores were got by adding the yes, 1 and the no, 0 answers to the scale questions. The treatment was pre-cooking bean commercialized agripreneurs while the non-commercialized agripreneurs were the control group. Smallholder agripreneur households who had a positive sum of input and output market participation indicators Z scores were considered commercialized. Agripreneurs who had a negative sum of input and output market participation indicators Z scores were considered non-commercialized. Participation in the input and output markets were considered equally important so none of them was assigned a greater weight. The average treatment effect on the treated (ATT) was estimated using two different matching estimators that were the nearest neighbor 3 matching and the Kernel matching. Table 5 presents the results of ATT after matching using the different matching methods

Table 5: Estimation of the effect of pre-cooking bean commercialization on household food security among smallholder pre-cooking bean agripreneurs

Matching Algorithm	Food security indicator	Sample size		Mean outcome		ATT	Standard error	t-statistics
		Treated	Control	Treated	Control			
Nearest neighbor matching (3)		202	211	0.6471	0.7201	-0.0731	0.0609	-1.2000*
Kernel matching (KM)		202	211	0.6471	0.7307	-0.0836	0.0538	-1.5500**

Note: * and ** represent significant at 10% and 5% t level respectively, *t*- values were calculated using bootstrap method with 50 replications. ATT denotes Average Treatment Effect on the Treat



DISCUSSION

Results from the probit model (Table 2) indicated that land size, fertilizer used, and hired labor had a significant positive influence on pre-cooking bean commercialization which was participation in the input market as buyers of pre-cooking bean inputs and participation in the output market as sellers of pre-cooking bean output. On the other hand, active members, relative support, and land ownership type had a significant negative influence on pre-cooking bean commercialization.

Land size presented in the log form had a significant positive effect on pre-cooking bean commercialization at 5% significance level. This result implies that an increase in land size by one hectare holding all other factors constant, would result in a direct increase in the pre-cooking bean input and output market participation by 41.77%. This result was expected. Land is the main factor of production for agricultural products like pre-cooking beans. Owning a large size of land means more land is allocated to each farm enterprise including the pre-cooking bean. This is expected to affect participation in the input and output markets positively. On the input side, a large land size would require a high quantity of inputs for optimal production. The large amounts of inputs could not be produced only on the farm necessitating the sourcing from input markets through buying. This promotes the participation of agripreneurs in the input markets as buyers of inputs. Farming a large size of land is expected to result in a high quantity of output. Part of the large amount of yield produced could be used as food for the agripreneurs household, some reserved as seed for the next production season and the remaining part for the market. This encourages agripreneurs to participate in the output market as sellers of output. This finding is in line with previous studies on food crops commercialization where land size had a significant positive effect on participation in inputs and output markets by smallholder farmers (Anteneh & Endalew, 2023; Endalew *et al.*, 2020; Mathobela, 2021; Mukaila, 2024).

Similarly, fertilizer use had a significant positive effect on smallholder agripreneurs' participation in pre-cooking bean input and output markets at the 1% significance level. This finding indicates that an increase in fertilizer used by one kilogram per hectare of landholding, holding other factors constant, would result in an increase in the participation in the pre-cooking bean input and output markets by 23.42%. This outcome was expected. Fertilizer is used in order to enhance productivity. Smallholder farmers who require large quantities of fertilizer could use some that has been produced on their farms and source the remainder from input markets. Therefore fertilizer use makes smallholder pre-cooking bean agripreneurs participate more in the input markets as buyers of inputs. On the output market participation side, the effect of fertilizer use is indirect through the quantity of output produced. Fertilizer use is expected to increase the amount of crop yields harvested per hectare of land. The increased amount of yield is used for home consumption as food, part of it is reserved as seed for the next production season and the remaining portion is sold to the output markets. With the increase in yield arising from fertilizer use, the farmer remains with a relatively large amount to sell. Fertilizer use promoted the participation of smallholder pre-cooking bean agripreneurs in the input market as buyers and the output market as sellers. This finding corroborates those reported in similar earlier studies on the effect of fertilizer use on food crop commercialization (Mukaila, 2024).

The use of hired labour had a significant positive influence on smallholder agripreneurs participation in the pre-cooking bean input and output markets at 1% significance level. This



outcome implies that smallholder agripreneur use of hired labor would increase the probability of participating in the input and output markets. This result was anticipated. Pre-cooking bean production is labour intensive and the agrineuers family labor alone could not be able to carry out all the operations required, necessitating the sourcing of more labor from the market. Furthermore, the production operations had to be completed within the recommended timelines for them to yield the desired output so hired labor could help speed up the process. On the output commercialization side, use of hired labor affects participation in the market indirectly through increased yields. The completion of the production operations within the recommended timelines is expected to result in a high quantity of produce that could leave a large amount of marketed surplus to the agripreneur. This motivates the smallholder pre-cooking bean agripreneur to participate in the output market as a seller. A similar finding was reported by Onuche *et al.* (2020) when analyzing technical efficiency; they found labor to have a significant positive effect on profitability at a 1% significance level.

Active members were the number of members within a smallholder pre-cooking bean agripreneurs' household aged between 15 and 64 years. This had a significant negative effect on participation in the input and output markets at the 5% significance level. An increase in the number of active household members by one person, holding other factors constant, would result in an instantaneous reduction in the probability of participating in the pre-cooking bean input and output markets by 0.1076. This outcome was expected. Active members are the ones who can assist in the provision of unpaid family labor in pre-cooking bean production and marketing activities. Having many active members within the smallholder pre-cooking bean agripreneurs' household means more free labor that can be used to carry out production and marketing activities. This discourages smallholder pre-cooking bean agripreneurs from hiring labor at a cost to carry out the same production and marketing activities. Many active members reduce the probability of participation in the input market as buyers. Regarding participation in the output market as sellers, active members could have a negative effect. Many active members mean a large amount of the produced pre-cooking bean is consumed as food leaving less or no surplus for the next season's seed and market. This discourages participation in the output market as sellers of precooked beans. This result confirms those reported earlier (Mathobela, 2021; Mukaila, 2024).

Relative support was the number of relatives who could help the smallholder agripreneur at the time of financial and food shortages. This had a significant negative effect on the agripreneurs' participation in the pre-cooking bean input and output markets at the 10% significance level. The result shows that an increase in the number of people related to the agripreneur who could assist during financial and food shortages by one person holding other factors constant would result in an instantaneous decline in the probability of participating in the pre-cooking bean input and output markets by 0.0348. This outcome was expected. When smallholder agripreneurs know that they have people who can help them during financial and food shortages they relax and do not look for ways of enhancing crop productivity. This reduces their probability of participating in the input and output markets (Mukaila, 2024).

Land ownership type had a significant negative influence on participation in the input and output markets at the 10% significance level. This outcome implies that smallholder pre-cooking bean agripreneurs owning land with a title deed, holding other factors constant, would result in a decrease in their probability of participating in the pre-cooking bean input and output markets by 0.3091. This outcome was not expected. However, the reported result could be attributed to agripreneurs with titles being unwilling to work towards getting the most from



their land, as they were sure they owned the land and they could use it anytime. Probably, agripreneurs without titles were farming on land that they had been temporarily given by their parents. They were not sure whether, if their parents decided to subdivide and legally transfer the land to them, they would get the same piece as well as amount of land or not. This uncertainty could have motivated them to look for ways that could enable them to maximize output from the land. They were inspired to use more inputs to enhance productivity, which on-farm production alone could not make available, necessitating sourcing the extra from the input markets. The increase in productivity yielded more than was sufficient for home consumption, next season seed reservation and the market. Land tenure security affects farmers' motivation and investment decisions about commercialization (Suhardiman *et al.*, 2023).

The average treatment effects (presented in Table 5) of pre-cooking bean commercialization on the household food security status of smallholder agripreneurs in Kimilili Sub-County were -0.0731 scores using the nearest neighbor matching method. This result implies that commercialized smallholder pre-cooking bean agripreneurs were expected to have 0.0731 lower scores than their non-commercialized counterparts. Likewise, the Kernel matching method gave the ATT of -0.0836. This finding indicates that commercialized smallholder pre-cooking bean agripreneurs had 0.0836 higher scores than their non-commercialized colleagues. The effect of pre-cooking bean commercialization on household food security ranged from -0.0731 to -0.0836 scores for the food insecurity experience scale. These results were significant at 10% and 5% significance levels, respectively. These results conclude that pre-cooking bean commercialization worsened the household food security access component of the commercialized households. This result was not expected. Participation in the input market is anticipated to increase productivity, which leads to large amounts of pre-cooked beans used as food, reserved for seed and marketed as surplus. Increased amount of marketed surplus means high income from the produce sales that could be used to buy food and non-food items necessary to improve access to food (Assefa *et al.*, 2024; Madududu *et al.*, 2021). The reported negative effect could be attributed to smallholder pre-cooking bean agripreneurs producing and selling everything before setting aside a portion for household consumption, thus reducing physical access to food. Probably, they participated more in the output market as sellers than in the input market as buyers of inputs.

Similar results were reported by Carletto *et al.* (2017), who used Household Per Capita Food Expenditure as an indicator for food access. The study reported that commercialization led to an increase in Household Per Capita Food Expenditure meaning was negatively related to the child's stunting and underweight likelihood. Likewise, Krause *et al.* (2019) used the Coping Strategy Index (CSI) to confirm that the CSI significantly decreased linearly with increasing levels of African Indigenous Vegetable (AIV) commercialization, indicating the stronger negative effect of the decision to sell AIVs on the access dimension of food security as more of the harvest was sold. Ngcaba and Maroyi (2021) used the Share of Household Food Expenditure (SHHFE) as an indicator for food access. The study concluded that agricultural commercialization increased the household dependency on markets for food, leading to high SHHFE, which is an indicator of food insecurity. Additionally, Ntayko and van den Berg (2019) reported that market production increased dependence on the market for food and thus decreased the food access dimension of food security.



IMPLICATION TO RESEARCH AND PRACTICE

The negative ATT reported in this study has major implications for research and policy practice. To research, it challenges the assumption that commercialization automatically leads to better food security due to increased income. This forces researchers to focus on investigating specific mechanisms behind this negative effect in terms of resource reallocation, risks, gender and intra-household dynamics, as well as nutritional trade-offs associated with nutritious high-value food crop commercialization. Furthermore, extending beyond average effects and exploring heterogeneous effects on different groups of participants would be of great importance.

To practice, the finding points towards strategy redesign by combining commercialization with other support systems like market access and risk management, nutritional education and financial literacy. Promotion of home gardens would encourage a wide range of food crop production. Interventions should be tailored to the specific context, considering the local diet, farming systems, and gender roles to avoid unintended negative consequences. Empowering farmers by encouraging them to form cooperatives to boost their bargaining power.

CONCLUSION

Participation in pre-cooking bean input and output markets by smallholder agripreneurs within Kimilili Sub-County, Kenya, worsened their household food security status on the food access dimension.

FUTURE RESEARCH

Future research should consider going beyond measuring the average effect and identify specific pathways of harm or gain. Furthermore, examining how income from commercialization is managed within the household, as well as using alternative measures of food access like dietary diversity scores, would be important.

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Data availability statement

The dataset used in this study is available from the corresponding author upon reasonable request.

Ethical approval

Data collection began following clearance from the National Commission for Science, Technology and Innovation (NACOSTI) (License No: NACOSTI/P/25/414853)

Informed consent

Informed consent was obtained from the respondents verbally