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Impact of Organic Vegetable Production System in Kiambu and Kajiado Counties of Kenya

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Abstract: Though there are many documented reasons that make farmers to adopt organic farming system, economic benefits present a major motivation. The study was conducted to evaluate the impact of organic production system on profitability of smallholder vegetable production systems in the two counties so as to appraise its contribution to improvement of rural livelihoods. The study collected data on costs and returns for a sample of 208 smallholder vegetable farmers who were composed of 78 organic and 130 conventional farmers. Impact of organic production system was evaluated using propensity score matching technique. Organic vegetable production system was found to have a positive significant impact of increasing farm gross margin by US$0.58 representing 89.5% among smallholder producers in Kiambu and Kajiado Counties of Kenya. The study recommended promotion of organic production system as a tool that can be used to improve livelihoods especially in the rural areas.

Key words: Organic, profitability, impact, organic vegetables, smallholder production systems.

1. Introduction

In Africa more than 75% of farming community practices subsistence and/or traditional agriculture. Due to the low skills, knowledge and asset base, agricultural productivity has declined over the years and is 2-3 times lower than the world average [1]. There is therefore a growing need to provide food to increasing population through innovative and adapted sustainable farming systems. Organic production system is gaining popularity as one of the options which can enhance production of healthy food in a sustainable way [2]. It contributes to the achievement of MDG (Millennium Development Goal) number one and seven on eliminating poverty and hunger and enhancing environmental sustainability, respectively [2].

In Kenya, there are more than 200,000 farmers who have been trained on organic farming principles and practices [3]. Currently certified land under organic management in Kenya stands at 104,211 ha while the sector employs 12,647 producers/wild harvesters directly [4]. The vigorous growth of organic agriculture in the country is partially hampered by the perceived high economic risk leading to low adoption [5]. This is contributed by limited empirical documentation of its economic benefits, which also limits support by government and development partners. In order to support appraisal of organic agriculture as a viable alternative production system

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which contributes to livelihood improvement, there is a need to evaluate its impact on profitability especially for smallholder farmers.

The numbers of studies evaluating the impact of organic production system on profitability are numerous. Of these, only few studies consider long term economic impact and most of them have been undertaken in developed countries (mainly USA) and on certain crops (corn, soy and wheat) [6]. In Africa and other developing countries there are only few studies which compare organic and conventional production system [7]. The comparison between the two systems however faces several challenges [8-11]. The challenges can be categorized as: (1) high differences as far as the productive techniques are concerned; (2) different technical-productive paradigm which is difficult to define a peculiar one for each group; (3) heterogeneity mostly because conventional farming is a mix of agronomic techniques, some of which are similar to the organic ones.

Most of the organic system impact studies show organic production system as having a positive impact to farm profitability [10-16]. Comparably few studies show adoption of organic farming system having no impact on profitability [16, 17]. Some studies show organic production system having no impact on farm profitability during conversion but show profitability increasing with achievement of full organic status [12, 18]. The impact of organic system on profitability is shown to have disparities depending on crops, regions and technologies employed in the study [18].

This study focused on establishing the impact of organic farming on profitability of vegetable production system among smallholder producers in Kiambu and Kajiado Counties of Kenya so as to appraise its contribution to household livelihoods.

2. Materials and Methods

The study was conducted in Kiambu and Kajiado Counties of Kenya. The two counties were selected due to their proximity of Nairobi County which is the main organic produce market. A farm survey was conducted among a sample of 78 organic certified and 130 non organic smallholder farmers through scheduled interviews. The conventional farmers were sampled using snow ball technique where K-means clustering approach was used based on the organic sample as postulated by Cisilino and Madau [9], Zanoli, et al. [11]. Data was collected on production costs, yield, prices, target market, social economic and farm characteristics of smallholder organic and non organic vegetable farms growing kales, spinach and cabbages for a recall period of two seasons and evaluated. Secondary data was collected between January and February 2012 while primary data was collected between March and June 2012. Primary data collection was done using structured questionnaire which was administered through scheduled interviews for both smallholder organic and non organic farmers. Data was collected on acreage, yield, prices, costs and target market for the previous two seasons for the year 2010/2011. To enhance reliability and validity of the tools used in data collection, pretesting was done with a group of smallholder vegetable farmers from Githunguri division with the same characteristics as the trial and control groups.

The variables used in the study were defined thus: age in years; gender which was a dummy with 1 representing male and 0 for female; farming experience in terms of years that the farmer has been doing commercial vegetable production; occupation was taken as a dummy where 1 represented farming and 0 otherwise; land size in acres; number of land parcels represented by the number of land parcels a farmer owns, land ownership which was a dummy where 1 represented farmer owned and 0 otherwise; irrigation which was a dummy with 1 representing availability of irrigation and 0 for non availability; county location where 1 represented Kiambu and 0 for Kajiado; target market where 1 represented retail markets and 0 for wholesale markets. The transaction costs, production costs and incomes were computed in Kenya shillings. Yield was considered in weight with kilogram as the unit of measurement.

The impact of organic production system on profitability was evaluated using PSM (propensity score matching) where the observable estimated treatment effects were compared to counterfactual of no treatment [19]. PSM was used as an impact estimator to get unbiased estimates of average treatment effects. This was done first by establishing the estimators for logit regression used in estimating propensity scores. Nine variables representing social economic and farm characteristics were use in matching. They included land size, location, gender, age, occupation of household head, years of experience, number of farm parcels owned, availability of irrigation and land ownership. The choice of PSM as an impact estimator was informed by its reliability and comparability with experimental impact estimators especially when similar survey instruments are used [20].

To provide an organized framework for empirical analysis of the stated hypothesis using PSM variables Y_0^i and Y_1^i were defined as potential profitability outcome of randomly assigned smallholder vegetable producer i while practicing organic Y_1^i or not practicing Y_0^i. The following matching assumptions were also made for PSM to hold [19]:

$M-1: (Y_0, Y_1) \coprod D/|X$ Unconfoundedness assumption

$M-2: 0 < \Pr(D=1)\,|X) < 1$ Common support assumption

where Y_0 is the outcome for non organic smallholder vegetable farmers, Y_1 is the outcome for practicing organic farmers, D is the treatment indicator where D = 1 signifies a farmer practicing organic, $\coprod$ is the notation for statistical independence and $\Pr(D=1)\,|X)$ is the propensity score. When the matching assumptions are met, the unbiased impact of organic production system on vegetable production through matching by propensity score can therefore be estimated. In the logit regression model, μ is assumed to follow a logistic distribution. The error terms in the outcome equations of both the organic ε_1 and non organic ε_0 smallholder farmers and are allowed to be correlated with cov(μ, ε_1) = 0 and cov(μ, ε_0) = 0 so that the unconfoundedness assumption can be satisfied [21].

The average causal impact of practicing organic was therefore measured by average treatment effect as follows:

$$\propto = E\left[Y_1^i - Y_0^i\right] \quad (1)$$

and also by average treatment effect of the treated

$$\propto_T = E\left[Y_1^i - Y_0^i/D=1\right] \quad (2)$$

where D indicates whether the smallholder vegetable farmer is practicing organic farming (D = 1) or not practicing organic farming (D = 0). The symbol $\propto$ measures the impact of organic production system to the whole population in this case referred to as the treatment while $\propto_T$ represents the impact for the sub population. The mean difference between observables can therefore be written as:

$$\left(Y_1^i/D=1\right) - E\left(Y_0^i/D=0\right) = ATT + \varepsilon \quad (7)$$

where ε is the bias given by

$$\varepsilon = E\left(Y_0^i/D=1\right) - E\left(Y_0^i/D=0\right) \quad (8)$$

Where, ATT is the average treatment of the treated; $E\left(Y_1^i/D=1\right)$ represents the profitability outcome of practicing organic smallholder vegetable farmers; $E\left(Y_0^i/D=0\right)$ represents profitability outcome of non organic farmers, $E\left(Y_0^i/D=1\right)$ is the profitability outcome of nonorganic farmers if they were practicing organic farming and ε is the error term.

Correspondingly, the true parameter of ATT can be identified if the outcome of the treatment and control on condition of no practicing organic farming is the same:

$$E(Y_1/D=0) = E(Y_0/D=0) \quad (9)$$

By putting the propensity scores, unbiased estimate of the average treatment effect can be got thus:

$$\propto_T (pr(x)) = E\left[Y_1^i/pr(x)\right] - E\left[Y_0^i/pr(x)\right] \quad (10)$$

where $\propto_T (pr(x))$ is the average treatment effect with propensity score (x), $E[Y_1^i/pr(x)]$ is the expected profitability of smallholder i practicing organic vegetable production with propensity score (x) and $E[Y_0^i/pr(x)]$ is the expected profitability of non organic smallholder vegetable farmer i with propensity score (x).

A logit regression model was used to evaluate the impact where nature of farming took a binary form where 1 represented organic farmers and 0 otherwise.

Covariate balancing tests were conducted to check whether within each quartile of the propensity score distribution, the average propensity score and mean (x) were the same. PSM quality indicators for residual and outcome variables were used to evaluate endogenous selection (unobservable heterogeneity) and biasness. Partial correlation test and variance inflation factor test was done for testing multicollinearity for explanatory variables. Mhbounds was used to compute Mantel-Haenszel bounds to check sensitivity of estimated average treatment effects and critical hidden bias [22]. In addition, selection bias and observable heterogeneity were controlled by using matched pairs, identical survey instruments, similar geographical and labour conditions and a rich set of control variables.

3. Results and Discussions

3.1 Descriptive Statistics

Age, level of education, farming experience, number of training, land size, number of parcels of land owned by the farmer, and source of labour were significantly different for the two cohorts (Table 1). However position in the household, marital status, topography, occupation, source of financing and type of irrigation for the two cohorts was the same. As observed by Demiryurek and Ceyhan [13], Jans and Cornejo [23], the organic vegetable farming group was older compared to conventional farmers group and had bigger land sizes and more parcels of land compared to non organic farmers. The adoption of

Table 1 Difference in means of characteristics of adopters and non adopters.

Variables	**Conventional** ***N* = 120**	**Organic** ***N* = 71**	**Mean difference** ***t*-test**
Position in the household	1.74	1.75	-0.05 (0.12)
Marital status	1.88	1.83	0.05 (0.05)
Age	37.73	46.68	-8.95*** (1.68)
Level of education	2.87	3.39	-0.53*** (0.13)
Experience	9.35	6.37	2.99*** (1.02)
Number of trainings	1.75	2.94	-1.19** (0.56)
Topography	1.66	1.55	0.12 (0.10)
Occupation	1.55	1.46	0.09 (0.09)
Total farm size	0.57	3.04	-2.47*** (0.59)
Number of parcels	1.17	1.43	-0.27** (0.11)
Source of finance	1.00	1.01	-0.01 (0.01)
Type of irrigation	2.40	2.05	0.35 (0.65)
Source of labour	1.21	1.56	-0.36*** (0.08)

Significance level of mean difference is at *10%, **5% and ***1%, standard errors in parenthesis.

organic vegetable production system by aged population is expected as the general trend of farming in Kenya is by aging population while most of the youth go to towns to seek employment [14]. The preference of organic production by older generation can be said to relate to their preference for health benefits associated with consuming organic foods as observed by IFOAM (International Federation of Organic Agriculture Movements) [6].

Organic farming as a new technology is expected to attract more educated farmers and requires farmers to attend trainings to acquire skills. In addition, the organic cohort had more educated farmers who were less experienced but had attended more training compared to conventional cohort. This was in line with findings of other authors [13, 23] who found organic farmers to be new entrants in farming with less experience but with higher education level of post secondary level compared to conventional farmers who have more experience and lower education level. Organic farmers were also having bigger land sizes which were inform of many parcels contrary to expectation that organic farmers have small farms as observed by Cisilino and Madau [9].

The existence of significant difference between the two groups for selected variables suggests that they may have an influence on farmers decision whether to adopt organic vegetable production system. It is therefore important to use econometric analysis to understand motivation for adoption.

3.2 Impact of Organic Farming on Smallholder Vegetable Farm Profitability

3.2.1 Estimation of Propensity Scores

To establish whether the common support requirement was achieved, the distribution of propensity scores among the two cohorts was established across the three matching algorithms as shown below.

The Fig. 1 shows that density distribution of propensity scores for organic vegetable farmers and non organic vegetable farmers was almost similar in all the three matching algorithms as expected. Most of the individuals practicing organic production system were within the region of common support and could therefore find a suitable match of non organic

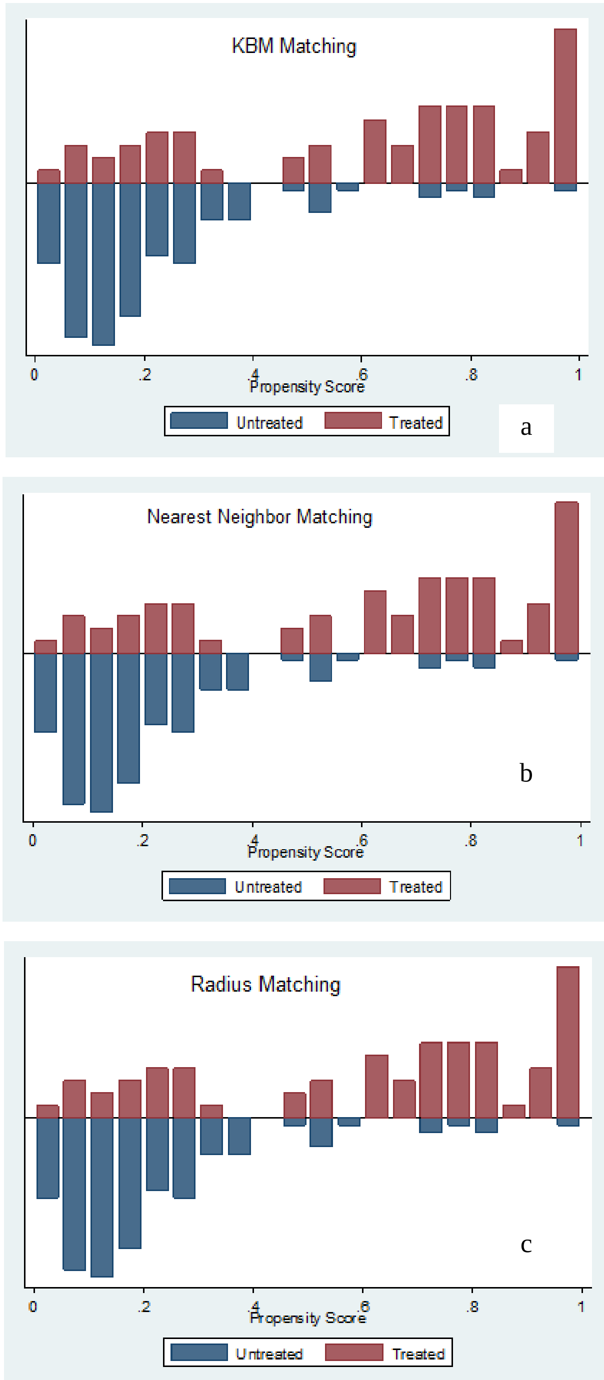

Fig. 1 Distribution of propensity scores on region of common support using (a) KBM, (b) nearest neighbour and (c) radius matching.

vegetable producers as shown by density distribution of propensity scores. The favourability of the match was confirmed across the three matching algorithms.

On identification of matches shown by the region of common support, propensity scores for different variables were analyzed across the three matching algorithms: nearest neighbor, KBM (kernel based matching) and radius matching as shown in Table 2.

The analysis of the three matching algorithms, KBM, radius based matching and nearest neighbour matching was similar. The likelihood ratio test of goodness of fit and high values of pseudo R^2 which were significant showed that the model fitted the regression estimators well. As shown in Table 2 above representing the three algorithms, the logit regression estimators of the propensity scores showed that county of residence, years of experience in farming, age and form of land ownership can significantly explain the gross margins earned by smallholder vegetable farmers. Residing county and years of experience negatively affected gross margins while age and land ownership affected gross margins positively. This meant that smallholder organic farmers and non organic farmers differed significantly in respect to observable characteristics as observed by other studies [7, 13, 23, 24]. The difference therefore means that there is a high potential for self selection bias. Comparing the two groups without correcting the self selection bias would have therefore lead to unsound results and hence the need to correct it using propensity scores.

3.2.2 Impact Evaluation

The impact of organic production on the grossmargin of smallholder production system was evaluated across the three matching logarithms. The ATT (average treatment of the treatment), ATU (average treatment of the untreated) and ATE (average treatment effect) were derived to establish the changes in grossmargin as a result of adopting organic production system as shown in Table 3.

Organic production system had a positive significant impact on the gross margin of vegetable production by smallholder producers in Kiambu and Kajiado Counties as shown by the average treatment effect of the treated (Table 3). From the impact evaluation it can be shown that the gross margin of organic vegetable farmers per acre when they adopt organic production system increase by 33.67 for nearest neighbor matching, 51.58 for KBM and 50.25 for radius matching. This represents an average 89.54% increase of gross margin when farmers adopt organic vegetable production system. When kernel and radius matching was used as matching logarithm, the impact was significant. Nearest neighbor matching however on

Table 2 Maximum likelihood estimators for factors impacting on profitability of organic vegetable production system.

	Kernel based matching		**Radius based matching**		**Nearest neighbor matching**	
Variable definition	Coefficient	Standard Error	Coefficient.	Standard Error	Coefficient	Standard Error
Land size	-0.152	0.133	-0.152	0.133	-0.152	0.133
County	-1.917***	0.665	-1.917***	0.665	-1.917***	0.665
Gender	-0.485	0.428	-0.485	0.428	-0.485	0.428
Age	0.088***	0.022	0.088***	0.022	0.088***	0.022
Occupation of household head	0.056	0.545	0.056	0.545	0.056	0.545
Years of farming experience	-0.111***	0.034	-0.111***	0.034	-0.111***	0.034
Number of land parcels	0.345	0.282	0.345	0.282	0.345	0.282
Availability of irrigation	1.621***	0.555	1.621***	0.555	1.621	0.555
Land ownership	1.123**	0.453	1.123**	0.453	1.123**	0.453
Constant	-4.337***	0.943	-4.337***	0.943	-4.337***	0.943

Number of observations 181; Likelihood Ratio chi^2 (9) 79.46; Probability > chi^2 0.001; Log likelihood—79.012; Pseudo R^2 0.335; Significance level of regression estimators: *0.1, **0.05, ***0.01.

Table 3 Impact of organic vegetable production system on profits.

Matching algorithm	Outcome variable	Treated	Control	Difference	St error	*t*-statistic
Nearest neighbor matching	ATT	95.60	61.93	33.67	3.03	1.11
	ATU	15.57	31.14	15.56		
	ATE			22.16		
Kernel matching	ATT	95.60	44.02	51.57	2.6	1.98**
	ATU	15.57	42.74	27.16		
	ATE			36.06		
Radius matching	ATT	95.60	45.34	50.25	2.4	2.05**
	ATU	15.57	46.85	31.28		
	ATE			38.20		

Significance level of regression estimators: *0.1, **0.05, ***0.01, caliper: 0.3.

the other hand returned non significant impact of organic production system on gross margin. To be able to offer explanation of the differences in gross margins, the comparative costs between organic and conventional system were analyzed as shown in Fig. 2.

The Fig. 2 demonstrates the comparative high cost of production of organic production system for the three vegetables. Comparatively, organic system had 43% higher transaction cost, 25% higher production cost for spinach, 9% higher production cost for kales and 2% higher production cost for cabbage. The findings compare with other studies which also show organic production system being costly compared to conventional production system [7, 9, 13, 15, 23-25]. The higher costs can be attributed to more labour requirements which made labour cost high for organic compared to conventional production system. Higher transaction cost in organic production system can be attributed to difficulties in sourcing important information such as on markets, training, certification and inputs.

Higher grossmargin for organic production can also be explained higher prices for organic vegetable farmers as shown by the Fig. 3.

The organic vegetable prices were found to be higher than conventional vegetable prices for all the vegetables, with the highest difference being in spinach represented by 71% premium, cabbages 46% and kales 28%. Most of the studies which have observed the difference between organic production and conventional markets show difference in prices due to organic premium. This price difference for the

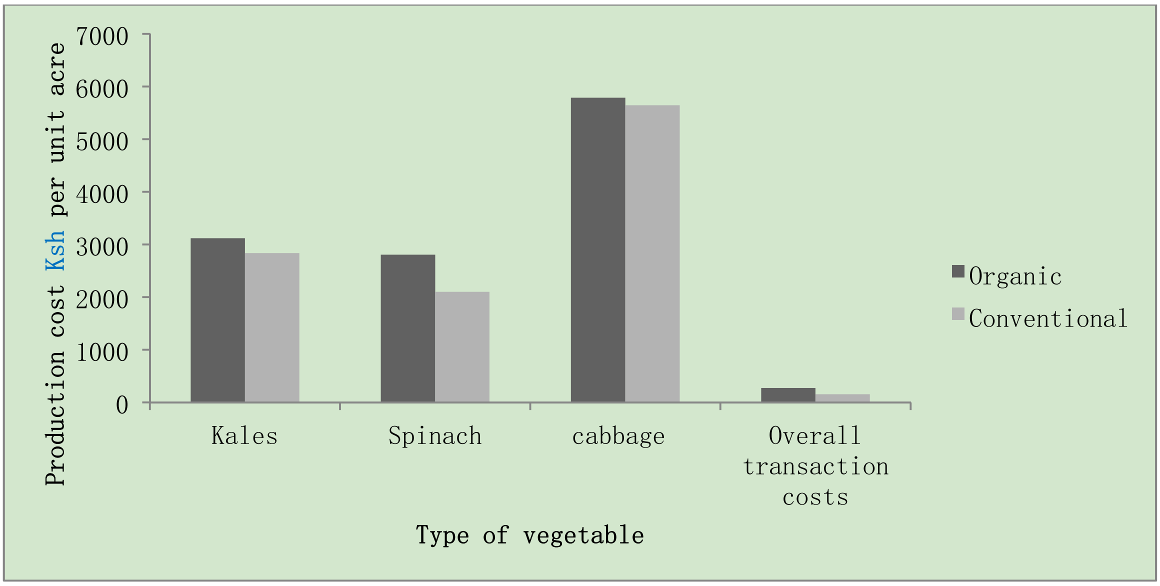

Fig. 2 Cost analysis for organic and conventional production system per unit acre.

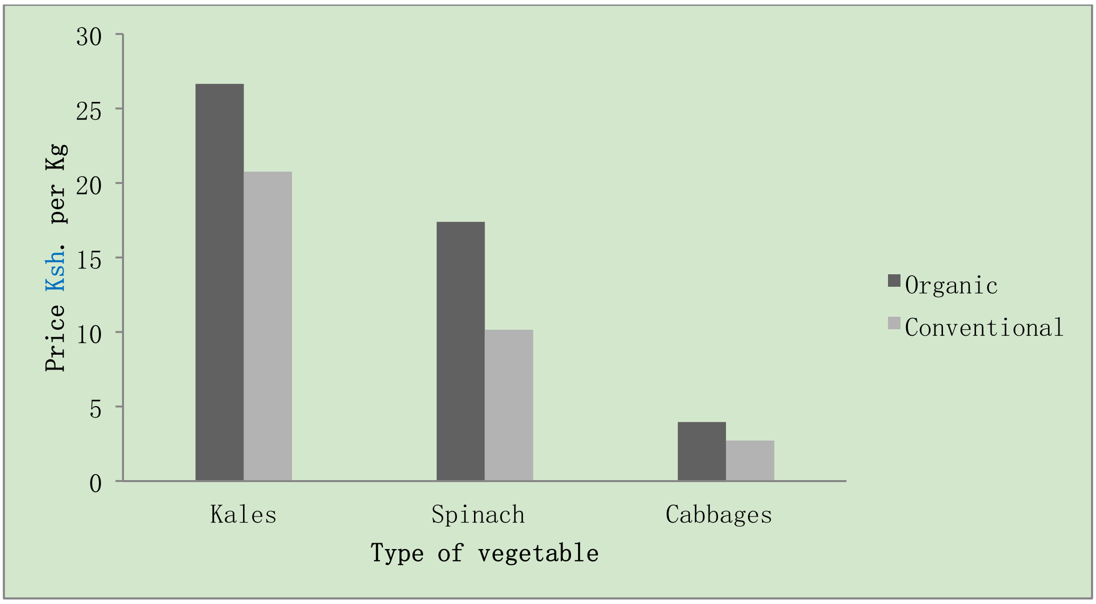

Fig. 3 Average farm gate prices for organic and conventional vegetables during the survey period.

different vegetables as observed by other authors Bolwig, et al. [7] on pineapples, coffee and cocoa, Reganold [26] on apples, Oxouzi and Papanagiotou [25] on grapes makes organic to be more profitable.

From the study, it was also shown that organic production system increased smallholder farmer's gross margins by 89.54%. In his study on transition to certified organic production for coffee and pineapples among small holder producers in Uganda, Bolwig, Gibbon and Jones [7] found 300% impact on profitability. Conversion to organic for smallholder vanilla producers in Uganda as documented by Agro Eco, et al.[27] gave 100% premium to smallholder farmers after going through three years conversion period. Other related study by Shadbolt et al. [28] on the effect of organic production system on smallholder producers supplying Bridges Organic Restaurant indicated a premium percentage on additional income of 100% for both kales and spinach. Other studies by Agriculture and Policy Research Centre [16] on vegetabels and Argiles and Brown [24] found organic production system having no significant effect on profitability of smallholder vegetable production system contrary to the study.

3.2.3 Evaluation of PSM Quality Indicators

The validity of these results are supported by the covariate balancing tests that were conducted and evaluation of PSM quality indicators before and after matching as shown in Table 4.

Usually after matching there should be no systematic differences in the distribution of covariates between both groups and therefore the pseudo—R^2 should be fairly low [17]. This was achieved as shown in Table 4.

Table 4 Quality indicators across matching algorithms.

Matching algorithm	Mean bias before matching	Mean bias after matching	% bias reduction	Pseudo R^2 unmatched	Pseudo R^2 matched	P value unmatched	P value matched
Nearest neighbor matching	44.26	18.70	57.75	0.331	0.059	0.001	0.293
Radius matching	44.26	14.12	68.10	0.331	0.050	0.001	0.416
Kernel matching	44.26	14.73	66.72	0.331	0.055	0.001	0.345

Covariate balancing tests showed a reduced mean bias after matching. The results of comparison of *P* values before and after matching showed reduction of biasness. the *P* value of unmatched showed significant levels biasness which was reduced by increased *P* values after matching. on the other hand, the mean biasness reduction after matching was by a percentage which ranged from 66.72% to 57.75% across the matching algorithms. The mean bias after matching ranged from 18.70 to 14.73. The percentage standardized mean difference therefore falls within the recommended range of 20% [19].

To establish whether the balancing procedure was able to establish balanced characteristics between covariates of organic and non organic cohorts, the pseudo R^2 and *P* values of likelihood ratio test were compared for matched and unmatched individuals. The low pseudo R^2 and insignificant rations shown by high *P* values in the matched individuals show proper balance was achieved.

3.2.4 Sensitivity Analysis

Mhbounds was used to compute Mantel-Haenszel bounds to check sensitivity of estimated average treatment effects and critical hidden bias [22], as shown in Table 5. The different level of bounds tells us at which degree of unobserved positive or negative selection the effect would become significant.

The Q_mh+ statistic adjusts the MH (Mantel-Haenszel) statistic downward for the case of positive (unobserved) selection while Q_mh- statistic adjusts the MH statistic downward for the case of negative (unobserved) selection. From the result above, under the assumption of no hidden bias ($\Gamma = 1$), the Q_mh+ and Q_mh- test-statistic gives a similar result, indicating a significant treatment effect. This is also the case for the different bound of odds of differential assignment due to unobserved factors. The negative values of Q_mh+ therefore indicate negative

Table 5 Mantel-Haenszel (1959) Bounds for gross margin

Gamma	Q_mh +	Q_mh -	P_mh +	P_mh -
1	0.001	0.001	0.001	0.001
1.05	0.1	-0. 091	0.1	0.536
1.1	-0.091	-0. 091	0.536	0.536
1.15	0.1	-0. 091	0.1	0.536
1.2	-0. 091	-0. 091	0.536	0.536
1.25	0.1	-0. 091	0.1	0.536
1.3	0.1	-0. 091	0.1	0.536
1.35	-0. 091	-0. 091	0.536	0.536
1.4	0.1	-0. 091	0.1	0.536
1.45	-0. 091	-0. 091	0.536	0.536
1.5	-0. 091	-0. 0919	0.536	0.536
1.55	-0. 091	0.1	0.536	0.1
1.6	-0. 091	-0. 091	0.536	0.536
1.65	-0. 091	-0. 091	0.536	0.536
1.7	-0. 091	-0. 091	0.536	0.536
1.75	-0. 091	-0. 091	0.536	0.536
1.85	-0. 091	0.1	0.536	0.1
1.9	-0. 091	-0. 091	0.536	0.536
1.95	-0. 091	-0. 091	0.536	0.536
2	0.1	-0. 091	0.1	0.536

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).

selection bias where the most likely adopters of organic farming system of vegetable production tends to have lower income even in the absence of participation. This therefore can be interpreted as downward bias in estimated treatment effects. This bias is however not significant at different bound levels both for likely underestimation of the treatment effects and overestimation of the treatment effects as indicated by P_mh + and P_mh - values. The table also shows that the study was insensitive to a bias that will double or triple the odds of change in gross margin as a result of the farming system selected. We can therefore conclude that the results are insensitive to possible deviations emanating from the identified unconfoundedness assumption and therefore it holds [22].

4. Conclusions

Organic production system has many documented benefits including economic and environmental. The motivation of any commercial oriented farmer is the profit made from farming activities. The study was undertaken to estimate the economic impact of organic vegetable production system in Kiambu and Kajiado Counties of Kenya. The study demonstrates that organic production system has a positive significant impact of increasing profitability of smallholder vegetable farmers by 89.54% in Kiambu and Kajiado Counties of Kenya. This can be attributed to higher prices (28%-71%). This is despite the fact that organic vegetable production system has higher transaction cost (43%) and higher production cost (2%-43%) and almost the same productivity as conventional system across the three vegetables. Organic system can therefore be used as livelihood improvement option to increase household incomes among farmers producing vegetables in Kiambu and Kajiado Counties.

5. Recommendations

Since organic vegetable production system has been shown to have a positive significant impact on profitability of organic production system, it should be promoted among smallholder producers as a way of improving their livelihoods. Organizations and government agencies involved in livelihood improvement projects in vegetable growing zones of Kajiado and Kiambu Counties should consider promoting organic systems as a way of improving incomes among rural communities. Strategies for reducing transaction costs such as availing production and market information should be adopted as a way of making organic vegetable production system cheaper and more competitive.

6. Areas for Further Study

Adoption of organic can be improved if other benefits such as environmental and health are quantified to make economic evaluation more holistic. A study analyzing differences in economic benefits between farmers who are in conversion and those that have full organic status can give insights on effects of investments during transition on overall farm incomes. Furthermore, studying the relationship between objectives of conversion to organic farming and achieved economic gains will reinforce the outcome especially where the objective of adopting organic production system is not economically motivated.

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