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Impact of improved indigenous chicken breeds on productivity. the case of smallholder farmers in makueni and kakamega counties, kenya.

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ABSTRACT

Indigenous chicken (IC) contributes significantly to the socio-economic development and nutritional requirements of rural and peri-urban households. Therefore, focusing on IC productivity remains crucial. Despite the IC potential, unimproved breeds are usually constrained by slow growth and maturity rate leading to low productivity. As an appropriate strategy to improve productivity, improved IC have been disseminated to smallholder IC farmers in Kenya. However, information on impact of improved IC breeds remained scanty thus necessitating this study. A total of 384 households were sampled using stratified random sampling procedure in Kakamega and Makueni. A structured questionnaire was used to collect primary data. Secondary data was accessed from Makueni and Kakamega livestock offices. Propensity score matching (PSM) econometric model was employed using STATA 13. Results from PSM estimates showed that the average egg production/hen/year of adopters was greater than for non-adopters. Education level, group membership, distance to the training point and non-farm activities positively and significantly influenced the impact of improved IC. On the other hand, gender of the household head negatively and significantly influenced adoption decision. Policies should target strengthening the IC farmer's access to frequent extension services. Moreover, formation of farmers groups is fundamental in enhancing information sharing on improved IC breeds. Further, policies should target more women in poultry production by developing programs in their favor.

Key words: Adoption**,** improved indigenous chicken, impact, training, propensity score matching, productivity

INTRODUCTION

Poultry production remains one of the key enterprises among the poor smallholder households in Kenya (Republic of Kenya, 2010). The enterprise has been recognized as an exit strategy in addressing poverty menace among rural poor households (Magothe *et al.,* 2012). The estimated population of chicken in Kenya is 29 million chickens where indigenous chicken (IC) constitute 75% of the total estimate (Olwande *et al.,* 2010; Republic of Kenya, 2010). The small-scale farmers contribute 80% of the national poultry production (Republic of Kenya, 2008). Over 70% (24 millions) of the Kenya's population residing in rural areas derive their livelihood from poultry production (Republic of Kenya, 2010; Ndegwa *et al.,* 2014. Thus, the industry remains vital towards playing a strategic role at achieving the socio-economic pillar by Vision 2030 (Republic of Kenya, 2010). Poultry products (eggs and meat) have been identified as the best source of cheap and quality protein especially for those suffering malnutrition in Sub-Saharan Africa (David, 2010). According to Mengesha (2012) deficits on availability of protein is a major concern in Africa. Other roles played by poultry include income generation, asset accumulation, cultural practices (Das *et al.,* 2008; Okello *et al.* 2010). However, it is worth noting that there exists an unmet demand of the poultry product in Kenya (WSPA, 2012).

Bett *et al.* (2012) asserts that demand for consumable IC table eggs have been on the increase resulting to supply deficit. The increased demand has been attributed to growth of urban areas, health consciousness, increased population and raised per capita disposable income thus boosting producer income (USAID, 2010). It is estimated that the mean annual poultry meat production is 20000 tonnes. On the other hand, the annual egg production is estimated at 1,255million eggs (Republic of Kenya, 2008). As revealed from the previous report, the country per capita poultry eggs and meat consumption is estimated at 36 and 0.65 kilograms respectively. These estimates are lower than the recommended consumption requirements by World Health Organization (WHO) on poultry eggs and meat (Republic of Kenya, 2010).

Most of the smallholder farmers prefer rearing IC for their ability to survive under harsh weather conditions, withstands feed fluctuation and are hardy (King'ori *et al*., 2010). Indigenous chicken products are generally preferred as compared to exotic breeds (USAID, 2010). The preferred attributes of IC products (meat and egg) include: leanness, tasty products and are recognized as organic products (WSPA, 2012). Moreover, Okello *et al.* (2010) affirmed that high demand of IC existed since consumers prefer to take its tasty and nutritious meat rather than exotic breed meat. Despite the capacity of IC to contribute to the economy and reduce poverty levels among the poor rural households, the enterprise is constrained by low productivity (KARI, 2011; King'ori *et al.,* 2010). Inappropriate breeds have however been identified as one of the major factors leading to low productivity (Magothe *et al.,* 2012; KARI, 2011). Therefore, advancing in improved genotypes of IC would enhance improved IC productivity. This would enhance intensification of IC production among smallholder farmers in Kenya (FAO, 2011).

In both Makueni and Kakamega Counties, IC has been recognized as an avenue to improve livelihoods of the rural households by increasing productivity (Republic of Kenya, 2010; USAID 2010). As a pertinent strategy to improve productivity, scientists and other poultry production stakeholders such as; KAPAP, KALRO and TechnoServe have pursued a vital role in improving the IC production through the dissemination of improved indigenous chicks (IIC) to the smallholder farmers in Kenya (KAPAP, 2012). Improved indigenous chicken is a superior crossbreed of different IC ecotypes from the various selected Kenyan communities. It was developed to serve a dual purpose (meat and eggs) and characterized by the ability to: produce more eggs, mature faster and meet market weight faster (KARI 2011). The strategy aims to transform IC industry into a profitable, commercially oriented and internationally and regionally competitive economic activity (Republic of Kenya, 2010). However, no studies have been done to assess the impact of such improved indigenous chicken ecotypes. Information from such studies if positive would help to come up with measures to promote dissemination and uptake of the improved technologies leading to higher productivity and incomes. Therefore, the aim of this paper aimed at quantifying the impact of improved IC among smallholder farmers in Makueni and Kakamega counties of Kenya.

Materials and Methods

Study area

Makueni County is located in Southern part of Eastern Kenya. It lies between latitude 1°35′, S and longitudes 37°10′ and 38°30′ E. This county comprises of an area of 8008.8 km^2. Temperatures in Makueni county ranges between 12-28 ºC and bimodal rainfall ranging from 150 mm to 650 mm per annum, which is typical of Arid and Semi-Arid Lands (ASALs) in Kenya (Republic of Kenya, 2010). Low rainfall and high temperatures in this county hinder crop production thus livestock production remains a priority. On other hand, Kakamega county is located in Western Kenya and lies between longitudes 34º 32’’ and 35º 57’30 E of the prime meridian and latitudes 0º 07’30’’ N and 0º 15’’ N of the equator. It covers a total area of 1394.8 km^2. Annual rainfall ranges between 1250–1750mm (Republic of Kenya, 2010). There was a rapid dissemination of improved indigenous as one of the major components of poultry production technologies by the various stakeholders such as KAPAP, KALRO and Technoserve in the two counties which are known to be main producers of IC (Muthee, 2009; KARI, 2011). Consequently, the two counties are located in areas that have favorable agro-ecological conditions that are required for the production of IC and are listed as leading areas in IC production (MoLD, 2011).

Sampling procedure and data collection

A multi-stage sampling procedure was used for the study. The first stage used purposive sampling of Kakamega and Makueni County which has a large population of small-scale farmers practicing IC production. The two counties had rapid dissemination of the improved poultry production technologies. The second stage used stratified random sampling to select regions within the sub counties located in Kakamega and Makueni counties. The random stratified sampling was preferred since it was able to reduce the biases associated with sampling. This ensured that there was no over presentation or under presentation of the smallholder farmers in the different strata. Subsequently, the researcher randomly picked Lugari, Shinyalu and Lurambi districts from Kakamega County. Furthermore, the researchers randomly sampled Makueni and Kaiti from Makueni County**.** The total sample of 384 households included adopters and non-adopters of IIC technology from Kakamega and Makueni counties, Kenya. Data was collected from the selected households on various explanatory variables (Table 1) using a structured questionnaire Further, secondary information was accessed from the county agricultural offices located in Kakamega and Makueni.

Specification of the model

The study adopted the approach used by Rosenbaum & Rubin (1983) assessment on impact aimed at comparing performance from the households that adopt the IIC with counterfactual. Therefore, Propensity Score Matching (PSM) was estimated through use of STATA version 13. The equation is expressed as:

$$P(X) \stackrel{\text{def}}{=} \Pr(T = \frac{1}{X} = X) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(1)}$$

Also simplified as;

$$P(X) = Pr\,(T=1/X) = E\,(T/X) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where; P= propensity score; Pr = the probability

T= Binary treatment showing the indicator of exposure to treatment where if adoption (T=1, otherwise, T=0);

X= Background variable such as age, farm size

E = Expected outcomes

Average treatments effects were computed for the adopters and non-adopters and included: the Average Treatment Effect on the Treated (ATT), Average Treatment effect on the Untreated (ATU) and Average Treatment Effect (ATE). The average treatment effect was expressed as;

$$ATE = E\,(Y_1\text{-}Y_0) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where, the subscripts 1 and 0 denote adopters and non-adopters, respectively.

Becker & Caliendo (2007) identified that matching technique using propensity score has gained popularity in estimation of average treatment effect. Mendola (2007) asserts that while estimating impact of adopting a given technology, its remains appropriate to use Logit model to derive at propensity scores. However, PSM depends on two assumptions; conditional independence and common support. Conditional independence assumption allowed the researcher to observe all the variables influencing adoption of improved indigenous chicken. Thus, the value of outcome variable remains independent on receiving the treatment. Wooldgridge (2002) asserts that conditional independence assumption is based on decision to adopt a technology and it's random, conditional on observed variables. This can be expressed as:

$$E\,(Y_0|X, T=1) = E\,(Y_0|X, T=0) = E\,(Y_0|\,X) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where in this case, $E\,(Y_1|T=1)$ represented the observations of outcome variable for the adopters. Thus, the matching estimation for the study assumed counterfactual analysis by matching the outcome for adopters and non-adopters of the improved indigenous chicken. The conditional independence assumption (CIA) depicted the counterfactual outcome for the treated group is similar to the outcome parameter for the control

On the other hand, the common support assumption (CSA) is considered since the average treatment effect of the treated (ATET) is defined within the region of common support. This assumption on common support assumes that there is no independent variable that can predict the treatment perfectly.

It can be expressed as; $0< P\,(Y= \,|\, X) <1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$

Where P is the i^{th} farmer propensity score estimate to adopt the technology

Therefore based on the two assumptions above; CIA and CSA, ATT was computed as follows;

$$ATT= E\,(Y_1\text{-}Y_0|X, T=1) =E\,(Y_1|\,X, T=1) - E\,(Y_0|X=1) \ldots\ldots\ldots\ldots \ldots\ldots \quad (6)$$

Where; Y_1- is the treated outcome (number of eggs/hen/year); Y_0 is the untreated outcome (for the non-adopters). T indicates the treatment status where if the respondent received treatment = 1 and 0 otherwise.

Table 1 : Description of dependent and independent variables (N=384)

Variable	Type	Measurement
Adoption decision (Improved IC)	Dummy	Yes = 1, No = 0
Age of the household head	Continuous	Years
Sex of the household head	Dummy	Male = 0, Female = 1
Level of education head	Continuous	No. of years in school
Household size	Continuous	No. of persons residing
Farm size	Continuous	Acres
Social group	Dummy	Yes = 1 , No = 0
Type of social group	Continuous	Main activities
Source of information on IC	Continuous	Number
Training on poultry production	Dummy	Yes = 1, No = 0
Number of times trained	Continuous	Number
Distance to training center	Continuous	Kilometers
Access to credit	Dummy	Yes = 1, No = 0
Other off-farm activities	Dummy	Yes = 1, No = 0
Awareness on IIC	Dummy	Yes = 1, No = 0

IC: Indigenous chicken. IIC: Improved indigenous chicken.

Results and discussion

Descriptive statistics

Table 2 presents the descriptive statistics used to achieve a clear phenomenon of the sampled households.

Table 2: Distribution of Adopters and Non-adopters in both Kakamega and Makueni (N=384)

	Pooled (N=384)		Adopters (N=231)		Non-adopters (N=153)	
Variable	Mean	SE	Mean	SE	Mean	SE
Age	47.45	0.57	47.78	0.71	46.94	0.97
Sex of household head	0.27	0.02	0.23	0.03	0.33	0.04
Level of education	2.04	0.04	2.12	0.06	1.91	0.07
Household size	7	0.04	2.75	0.06	2.69	0.07
Size of the farm	2.34	0.045	2.35	0.06	2.32	0.07
Flock size	81.60	4.33	91.74	6.06	66.30	5.68
Social group	0.82	0.02	0.91	0.02	0.68	0.04
Type of social group	2.12	0.10	2.46	0.13	1.60	0.14
Source of information	9.59	0.26	9.68	0.31	9.47	0.47
Training on poultry production	0.86	0.02	0.94	0.02	0.74	0.04
Number of times trained	2.89	0.09	3.16	0.10	2.48	0.16
Distance to the center	1.96	0.07	2.27	0.08	1.49	0.10
Access to credit	0.32	0.02	0.39	0.03	0.20	0.03
Off-farm activities	0.46	0.03	0.49	0.032	0.41	0.04
Awareness on IC	0.96	0.01	0.99	0.00	0.92	0.02

IC: Indigenous chicken. SE: Standard Error.

The survey results reveal that approximately 60% of the sampled households had adopted the improved indigenous chicken (IIC). The mean age of the household head was 47 years and out of the sampled households, 72.66% were male headed (Table 2). Results revealed that majority (46.09%) had attained secondary education and worth noting that a good proportion of respondents had accessed formal education (Table 2). The average household size of the sampled households was 7 members whereas farm size owned by the majority ranged from 1-3 acres (0.405-1.215 ha). The average mean of the flock size was 81 chickens. On the other hand, majority of the respondents participated in social groups which included farmers group, common interest group (CIG). Chicken production and marketing were main activities by these groups. Farmers in the study area accessed information on IC from the extension officers, radios, mobile phones and through Internet access. Majority (85.67%) of the sampled households had been trained on poultry production. Results also revealed that 31.51% of the sampled households had access to credit whereas 45.57% of the sampled households generated incomes from other off farm activities estimated at an average of Ksh. 16,257 per month ($163USD/month). However, only 46% of the farmers had access to credit for both counties whereas majority (96%) was aware of the improved indigenous chicken (Table 2).

Results on performance of both improved indigenous chicken and the unimproved indigenous chicken (local indigenous chicken) are presented in Table 3. Parameters used to measure productive performance included: age at onset lay, number of clutches, size of the clutch, size of the egg, hatchability, weaning stage and survivability. The variable on size of clutch was found to be significant.

Table 3: **Performance of Improved Indigenous Chicken among the smallholder farmers (N=384)**

	Pooled		Treated (IIC)		Control (LIC)		
Parameters	Mean	SE	Mean	SE	Mean	SE	p-value
Age at first egg lay (weeks)	21.65	0.43	21.27	0.43	21.99	0.71	0.404
Number of clutches (counts)	2.87	0.04	2.94	0.05	2.82	0.07	0.174
Size of clutch (no. of eggs)	25.81	1.08	33.51	1.77	18.76	1.00	<0.001
Size of the egg	2.88	0.11	2.97	0.14	2.80	0.17	0.437
Hatchability (%)	78.97	1.39	78.52	2.19	79.38	1.76	0.758
Weaning stage (%)	79.40	1.56	79.51	2.33	79.30	2.10	0.947
Survivability (%)	68.65	1.58	69.86	2.30	67.55	2.19	0.468

IIC: Improved indigenous chicken: - a superior crossbreed of different IC ecotypes from the various selected Kenyan communities which was developed to serve a dual purpose (meat and eggs). It was developed through the joint initiative of the Ministry of Livestock and Development and the Kenya Agricultural Research Institute (KARI), currently known as Kenya Agricultural and Livestock Research Organization (KALRO). LIC: Local indigenous chicken: Refers to the typical indigenous chicken in which no attempts have been made by any agricultural stakeholder in order to improve on its genotype. Hatchability: Percentage of eggs hatched divided by the eggs set for each hen multiplied by 100. Survivability: Percentage by dividing the number of chicks that survived to the weaning stage (8weeks) by the number of chicks hatched and multiplied by 100. SE: Standard error.

The mean of age at first egg lay for IIC was 21 weeks while the LIC was 22 weeks respectively (Table 3). The improved IC took shorter period to lay first egg compared to the overall mean of 21.65 ± 0.43 for both the ecotypes though the difference was insignificant. The findings contradict those of Magothe *et al.* (2012) where age at first egg lay was higher compared to the IC in the area of study. However, the results are in line with those of Melesse *et al.,* (2013) who reported that Fayoumi (improved IC) breed took 154 days for the first egg lay though with some variance with other types of IC breeds. Additionally, Mengesha (2012) findings on first egg lay ranged between 151 to 167 days.

The pooled average clutch number per chicken in the area of study was 2.87/hen/year (Table 2). This was lower compared to the IIC (2.94 ± 0.05) clutches and higher for LIC (2.82 ± 0.07) though the difference was not statistically significant. On the other hand, egg size for both ecotypes was large weighing at 50-55g. Various studies reported that IC had an average of 3 clutches/hen/year (Adomako *et al.,* 2010; Addisu *et al.,* 2013; Hagan *et al.,* 2013).

The average clutch size for IIC and LIC was 34 and 19 eggs, respectively. The results revealed that there was significant difference ($p<=0.05$) in average number of eggs/clutch/hen. This depicts that IIC laid more eggs compared to LIC per clutch. Therefore this increased egg production/hen/year given the average number of clutches/hen/year. This could be attributed to the genetic potential and the different feeding management used for egg production. Findings on average number of eggs per clutch/hen deviate from those of Addisu *et al.,* (2013) which revealed an average of 13eggs/hen/clutch.

The mean hatchability values for the adopters were approximately 79% and non-adopters 79% respectively. However, the parameter results among the two groups were not statistically significant. It's worth noting that the pooled mean on hatchability was lower compared to reports by Fisseha *et al.* (2010) and Hossen (2010) whose findings revealed 81.7 and 84%, respectively, on hatchability rate. However, findings by Ndegwa *et al.* (2014), Magothe *et al.* (2012) and Melesse *et al.* (2013) reported lower hatchability rate at 69, 70 and 69.7%, respectively. As shown in the Table 2, 79.4% of the chicks hatched reached the weaning stage (8weeks). The results depicts that weaning for the non-adopters was lower (79.30%) compared to the adopters (79.51%) though statistically it was not significant. The results obtained indicate that 68.65% of the overall number of chicks survived to adulthood categories (more than 8 weeks).

The results revealed that survivability mean for adopters was 69.68% and for non-adopters at 67.55% (Table 2). However the differences were not statistically significant and may be attributed to the proper controls on diseases, feeding, handling and predation which are as a result of utilizing brooding technologies. Report on pooled mean on survivability rate contradicts findings of Hossen (2010) who reported a survivability rate of 87%. However, Fisseha *et al.* (2010) reported a lower survivability rate of 61%.

The results of the analysis of factors that impacting on egg productivity of IIC are presented on Table 3. There were five independent variables that were found to significantly impact on egg productivity.

Table 3: Factors impacting on egg productivity of improved indigenous chicken per hen/year (N=384)

Variable	Coefficient	SE	Z	p-value
Age of the household head	-0.0041	0.0135	-0.3	0.761
Gender of household head	-0.8370	0.3101	-2.7	0.007
Level of education	0.3040	0.1701	1.79	0.074
Household size	-0.0187	0.1695	-0.11	0.912
Size of the farm	0.0004	0.1724	0	0.998
Social group	0.9881	0.5134	1.92	0.054
Type of social group	0.1074	0.0885	1.21	0.225
Source of information on IC	-0.0123	0.0279	-0.44	0.658
Training on poultry production	-0.1158	0.7075	-0.16	0.87
Number of times trained	0.1511	0.1065	1.42	0.156
Distance to the training center	0.3342	0.1486	2.25	0.024
Access to credit	0.3068	0.3186	0.96	0.336
Other off-farm activities	0.6141	0.2977	2.06	0.039
Awareness on IIC	0.1234	0.8308	1.35	0.176

IC: Indigenous chicken. IIC: Improved indigenous chicken. SE: Standard error.

The various matching algorithms that were used included; Nearest Neighbor (1), Nearest Neighbor (5), Caliper and Kernel based (Table 3). Further the likelihood test of goodness of fit and values of Pseudo R^2 for the matched sample were analyzed and found to be significant. This is a depiction that the Logit model used fitted the regression estimator. Five variables were found significant at various levels of statistical significance. They included; gender of the household head negatively affected the egg production while; level of education, participation in social group, distance to the training point and other off-farm activities affected the egg production positively.

Table 4 presents the results on average treatment effect of the treated (ATT) estimation based on their propensity score using various matching algorithms.

Table 4: Estimating the impact of improved indigenous chicken on egg production/hen/year

Matching Algorithm	Outcome variable	Treated	Controls	Difference	Std. Err.	T-stat
Nearest	ATT	98.06	70.78	**27.29**	9.05	3.01***
Neighbor	ATU	55.29	98.47	43.18		
Matching(1)	ATE			35.59		
Neighbor	ATT	98.06	62.75	**35.31**	6.92	5.10***
Neighbor	ATU	55.29	95.39	40.10		
Matching(5)	ATE			37.81		
Kernel	ATT	98.06	66.17	**31.90**	6.64	4.81***
Based	ATU	55.29	93.76	38.47		
Matching(KBM)	ATE			35.33		
Caliper	ATT	98.06	70.78	**27.29**	9.05	3.01***
Based	ATU	55.29	98.47	43.18		
Matching(CBM)	ATE			35.59		

ATT: Average Treatment effect of the Treated; ATU: Average Treatment effect of Untreated; ATE: Average Treatment Effect; Propensity Score: Refers to the probability that a household might be exposed to the treatment (adoption of IIC). *** Significant at 1% (Highly significant)

Table 4 shows the ATT estimation on impact of the IIC chicken on the total egg production /hen/year based on propensity scores. The outcome variable was analyzed for the average treatment of the treated, average treatment of the untreated and average treatment/causal effect to determine the impact of egg production on adopting the improved indigenous chicken. Results revealed that adopting IIC had a positive impact on egg productivity among the smallholder farmers in Kakamega and Makueni Counties. Adoption of IIC increased eggs production by; 27.29 for Nearest Neighbor (N1), 35.31 for Nearest Neighbor (NN5), 31.90 for Kernel based matching (KBM) and 27.29 for caliper based matching (CBM) where the impact for both groups were significant (Table 4). This is an implication that that the results based on the four matching algorithms revealed that the ATT estimate was robust. The overall average gain of the total number of eggs produced ranged from 27.29 to 35.31 which were significant at 95% confidence level for all the matching (Table 4). The implication was that assuming there was no selection bias due to unobservable characteristics; egg production/hen/year for farmers who adopted the improved indigenous chicken was significantly higher than of the non-adopters.

Balancing Tests for the Propensity Score Matching quality indicators

Results on evaluation of PSM quality indicators are as shown in Table 5. Results revealed that Pseudo R^2 was low and depicted that there were no systematic difference in the distribution of the covariates between the treated and the control group. Sianesi (2004) opines that the Pseudo

R2 should be lower whereas P-value of the likelihood ratio tested in the study should be insignificant to confirm a successful match.

Table 5: Evaluation of Propensity Score Matching quality indicators

Matching	Pseudo R^2 Unmatched	Pseudo R^2 Matched	P-value Unmatched	P-value Matched	Mean Bias before match	Mean Bias after matching	%bias reduction
NN1	0.180	0.046	0.000	0.214	35.30	9.30	73.65
NN5	0.180	0.021	0.000	0.878	35.30	6.20	82.43
Kernel	0.180	0.016	0.000	0.961	35.30	6.30	82.15
Caliper	0.180	0.046	0.000	0.214	35.30	9.30	73.65

Nearest Neighbor 1, 5: Refers to matching algorithm that compares propensity score of an adopter of a given treatment (IIC) with the non-adopter who has a similar or closest propensity score during impact assessment. It was preferred since all treated matches found a match. Kernel Matching: It was preferred to improve the quality of matching since it matched all the adopters of IIC with a weighted average of all non-adopters with weights that were inversely proportional to the distance between the propensity scores of the adopters and non-adopters.

The unmatched P-values were significant levels before matching of biasness which reduced after matching to become insignificant (Table 5). The mean biasness reduction after matching ranged 82.15 to 73.65% across the matching algorithms. The mean bias after matching ranged from 9.30 to 6.20.

Sensitivity analysis for Estimated Average Treatment Effects (ATT)

The concept of sensitivity analysis of the study is as shown in Table 6. The results in the Table 6 revealed that when Γ=1, the p-value is quite close to the one estimated in the matching analysis. This is a depiction that the p-value holds assuming that there is no hidden bias due to unobserved confounder. Additionally, there were no prospects of outliers on the estimated parameters.

Table 6: Sensitivity test for Estimated Average Treatment Effects (ATT)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0.000315	0.000315	12.4296	12.4296	5.22509	19.1253
1.05	0.001112	0.000078	11.1561	13.7284	3.8988	20.537
1.1	0.003291	0.000018	9.92684	14.8432	2.60425	21.7395
1.15	0.008367	4.10E-06	8.71093	16.0078	1.48352	22.8339
1.2	0.01864	8.70E-07	7.53231	17.1081	0.421789	23.9638
1.25	0.037015	1.80E-07	6.37265	18.0621	-0.65523	24.9329
1.3	0.066487	3.50E-08	5.33547	19.0047	-1.65238	25.918
1.35	0.109386	6.60E-09	4.35767	20.0041	-2.54521	26.7824
1.4	0.166659	1.20E-09	3.32169	21.0108	-3.448	27.5923
1.45	0.237423	2.20E-10	2.41178	21.88	-4.27916	28.4351
1.5	0.318977	3.80E-11	1.59295	22.7407	-5.1713	29.2213

Gamma: Represents the log odds of differential assignment due to unobserved factors
Sig+: Upper bound significance level
Sig-: Lower bound significance level

t-hat+: Upper bound Hodges-Lehmann point estimate
t-hat-: Lower bound Hodges-Lehmann point estimate
CI+: Upper bound confidence interval (a= .95)
CI-: Lower bound confidence interval (a= .95)

As per the results, a small increase of 0.05 in gamma, the p-value increases to 0.001 which is below the usual threshold of 0.05. This suggests that the odds are only 1.05 higher which might be attributed to different values on an unobserved covariate despite being identical on the matched covariates. However, the inference made would not change. Hodges point estimate suggests that the median differences in output should have a value of 12 if there is no hidden bias. As shown in the, the gamma level at which insignificant level is noted is at 1.35. This finding is above 1 which is the threshold for sensitivity tests. The critical levels greater than 1.00 indicate a more robust estimate against hidden bias (Rosenbaum and Rubin, 1983; Becker & Ichino, 2002). The implication is that the results are insensitive to possible hidden biases due to unobserved confounders. Hence, the conclusion and interpretation on impact can be made with some level of caution. However, at higher level the results revealed that sensitivity to bias is greatly reduced and conclusions can be made with confidence. Becker and Caliendo, (2007) asserts that sensitivity checks on estimated results remains vital and it's a strong identifying assumption thereby appropriate to justify.

CONCLUSION AND POLICY IMPLICATION

The study identifies the performance and impact of IIC on productivity in Makueni and Kakamega counties, Kenya. Results from the propensity score matching estimates revealed that the average egg production/hen/year of adopters of improved IC was greater than that of the non-adopters. Five variables were found significant which include; education level, group membership, distance to the training point and non-farm activities which positively and significantly influenced adoption of improved IC. On the other hand, gender of the household head negatively and significantly influenced adoption decision. More extension service agents should be deployed and infrastructures facilitating transport improved. This will help to reduce the distance covered by majority of the farmers seeking for training on improved poultry production. Frequent extension service contact which will aid at acceptance and dissemination of information on improved poultry production technologies. The stakeholders should also prioritize on formation of social groups among the smallholder farmers. This would encourage collective actions in both IC production and marketing leading them to achieve economies of scales on commercialization. Further, policies should focus more on women in poultry production by developing programs in their favour in attempt to promote IC production.

CONFLICT OF INTEREST STATEMENT

The authors certify that they have no affiliations with or involvement in any organization or entity in the subject matter or materials discussed in this manuscript. Therefore, we declare that we have no competing interests.

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About the author

Christopher Njuguna Kamau holds a Master of Science in Agribusiness Management and Trade of Kenyatta University. He graduated with a Bachelor of Agribusiness Management from Egerton University (GPA-69%). He has an extensive research experience with Kenya Agricultural Productivity and Agribusiness Project (KAPAP) under the subcomponent on Promotion of Indigenous Chicken Value Chain (ICVC) in Makueni and Kakamega Counties funded by World Bank and implemented by Kenyatta University. He is also an independent contractor with USAID-AHADI (Agile Harmonized Assistance for Devolved Institutions) in collaboration with The Research Foundation for the State University of New York (SUNY). Other research organizations worked include; African Agricultural Technologies Foundation (AATF); Institute of Development Studies (IDS), University of Nairobi. He worked as an intern with Kenya Agricultural & Livestock Research Organization – Thika. Prior to that, his professional interest focuses on; agricultural economics and impact assessment of agricultural production technologies.

Public Interest Statement

Improved indigenous chicken (IIC) is a superior crossbreed of different IC ecotypes from various selected Kenyan localities and widely known as KARI-Kienyeji. It was developed through the joint initiative of the Ministry of Livestock and Development and the Kenya Agricultural Research Institute (KARI), currently known as Kenya Agricultural and Livestock Research Organization (KALRO) to serve a dual purpose (meat and eggs) and characterized by the ability to; produce more eggs, mature faster and meet market weight faster. The strategy aims to transform IC industry into a profitable, commercially oriented and internationally and regionally competitive economic activity. We found that rearing improved indigenous chicken breeds had a positive significant impact on egg productivity. Venturing in improved IIC also proved to be more profitable as compared to local breeds. Therefore, policies should focus more on women in poultry production by developing programs for them in attempt to promote IC production.