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.

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PUBLIC INTEREST STATEMENT
Improved indigenous chicken (IIC) is a superior cross-breed 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 IIC 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.
sampling procedure in Kakamega and Makueni. A structured questionnaire was used to collect primary data. Secondary data were 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.

Subjects: Environment & Agriculture; Agriculture & Environmental Sciences; Plant & Animal Ecology
Keywords: adoption; improved indigenous chicken; impact; training; propensity score matching; productivity

1. 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, Okeno, Muhuyi, & Kahi, 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 (Ndegwa et al., 2014; Republic of Kenya, 2010). 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, Chowdhury, Khatun, Nishibori, & Yoshimuray, 2008; Okello et al., 2010). However, it is worth noting that there exists an unmet demand of the poultry product in Kenya (World Society for the Protection of Animals [WSPA], 2012).

Bett, Musyoka, Peters, and Bokelmann (2012) assert 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 (United States Agency for International Development [USAID], 2010). It is estimated that the mean annual poultry meat production is 20,000 tonnes. On the other hand, the annual egg production is estimated at 1255 million 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 kg 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 (Kingori, Wachira, & Tuitoek, 2010). IC 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.
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; Kingori et al., 2010). Inappropriate breeds have however been identified as one of the major factors leading to low productivity (KARI, 2011; Magothe et al., 2012). Therefore, advancing in improved genotypes of IC would enhance improved IC productivity. This would enhance intensification of IC production among smallholder farmers in Kenya (Food and Agriculture Organization for United Nations [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 IIC to the smallholder farmers in Kenya (KAPAP, 2012). IIC is a superior cross-breed 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 IIC 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 IIC among smallholder farmers in Makueni and Kakamega counties of Kenya.

2. Materials and methods

2.1. 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 km². Temperatures in Makueni county ranges between 12 and –28°C 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 34° 32″ and 35° 57′ 30″ E of the prime meridian and latitudes 0° 07′ 30″ N and 0° 15″ N of the equator. It covers a total area of 1394.8 km². Annual rainfall ranges between 1250 and 1750 mm (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 (KARI, 2011; Muthee, 2009). 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 (Ministry of Livestock and Fisheries Development [MoLD], 2011).

2.2. 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 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 were 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.

2.3. Specification of the model

The study adopted the approach used by Rosenbaum and 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:

$$ATT = E(Y_1 - Y_0 | X, T = 1) = E(Y_1 | X, T = 1) - E(Y_0 | X = 1)$$  (1)

Also simplified as;

$$P(X) = Pr(T = 1 | X) = E(T | X)$$  (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:

$$ATE = E(Y_1 - Y_0)$$  (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 IIC. Thus, the value of outcome variable remains independent on receiving the treatment.

| 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              |

Notes: IC: Indigenous chicken. IIC: Improved indigenous chicken.
Wooldridge (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:

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

where in this case, $E(Y_0|T = 1)$ 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 IIC. 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; $0 < p(Y = |X) < 1 \quad (5)$

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;

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

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.

| Variable                  | Pooled (N = 384) | Adopters (N = 231) | Non-adopters (N = 153) |
|---------------------------|------------------|--------------------|------------------------|
|                           | 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 |

Notes: IC: Indigenous chicken. SE: Standard Error.
3. Results and discussion

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

The survey results reveal that approximately 60% of the sampled households had adopted the 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 to 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 ($163 USD/month). However, only 46% of the farmers had access to credit for both counties whereas majority (96%) was aware of the IIC (Table 2).

Results on performance of both IIC and the unimproved IC (local IC) 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.

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, Alewi, and Teklegiorsis (2013) who

| Parameters                             | Pooled       | Treated (IIC) | Control (LIC) | p-Value |
|----------------------------------------|--------------|---------------|---------------|---------|
|                                        | Mean | SE   | Mean | SE  | Mean | SE  |         |
| 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   |

Notes: 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 IC 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 (eight weeks) by the number of chicks hatched and multiplied by 100. SE: Standard error.
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 and 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 50–55 g. Various studies reported that IC had an average of 3 clutches/hen/year (Addisu, Hailu, & Zewdu, 2013; Adomako, Hagan, & Olympio, 2010; Hagan, Bosompem, & Adjei, 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/clutch deviate from those of Addisu et al. (2013) which revealed an average of 13 eggs/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, Azage, and Dessie (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 Table 2, 79.4% of the chicks hatched reached the weaning stage (eight weeks). The results depicts that weaning for the non-adopters was lower (79.30%)

### Table 4. 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   |

Notes: IC: Indigenous chicken. IIC: Improved indigenous chicken. SE: Standard error.
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 eight 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 4. There were five independent variables that were found to significantly impact on egg productivity.

The various matching algorithms that were used included; Nearest Neighbor (1), Nearest Neighbor (5), Caliper and Kernel based (Table 4). 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 5 presents the results on average treatment effect of the treated (ATT) estimation based on their propensity score using various matching algorithms.

Table 5 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 IIC. 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

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

Notes: 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).
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 5). This is an implication 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 5). The implication was that assuming there was no selection bias due to unobservable characteristics; egg production/hen/year for farmers who adopted the IIC was significantly higher than of the non-adopters.

### 3.2. Balancing tests for the propensity score matching quality indicators

Results on evaluation of PSM quality indicators are as shown in Table 6. 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 $R^2$ should be lower whereas $p$-value of the likelihood ratio tested in the study should be insignificant to confirm a successful match.

The unmatched $p$-values were significant levels before matching of biasness which reduced after matching to become insignificant (Table 6). The mean biasness reduction after matching ranged 82.15–73.65% across the matching algorithms. The mean bias after matching ranged from 9.30 to 6.20.

### Table 6. Evaluation of propensity score matching quality indicators

| Matching | Pseudo $R^2$  | Pseudo $R^2$  | $p$-value | $p$-value | Mean Bias Before matching | 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           |

Notes: 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.

### Table 7. 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   | 0.166599 | 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 |

Notes: 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).
3.3. Sensitivity analysis for Estimated Average Treatment Effects (ATT)

The concept of sensitivity analysis of the study is as shown in Table 7. The results in the Table 7 revealed that when $\gamma = 1$, 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.

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 (Becker & Ichino, 2002; Rosenbaum & Rubin, 1983). 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.

4. 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 favor in attempt to promote IC production.

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Competing interests

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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References

Addisu, H., Hailu, M., & Zewdu, W. (2013). Indigenous chicken production system and breeding practice in North Wollo, Amhara Region, Ethiopia. Journal of Agricultural Science, 3(10), 433-444.

Adomako, K., Hogan, J. K., & Olympio, O. S. (2010). The productivity of local chicken in the Ashanti Region of Ghana. Ghanaian Journal of Animal Sciences, 5(2), 113–118.
Becker, S. O., & Caliendo, M. (2007). Sensitivity analysis for average treatment effects. The Stata Journal, 7(1), 71–83.

Becker, S. O., & Ichino, A. (2002). Estimation of average treatment effects based on propensity scores. The Stata Journal, 2(4) 358–377.

Bett, H. K., Musyoka, M. P., Peters, K. J., & Bokelman, W. (2012). Demand for meat in the rural and urban areas of Kenya: A focus on the indigenous chicken. Economics Research International, 2012, 1–10. doi:10.1155/2012/401472

Das, S. C., Chowdhury, S. D., Khatun, M. A., Nishibori, M. N., & Yoshimuray, Y. (2008). Poultry production profile and expected future projection in Bangladesh. World’s Poultry Science Journal, 64, 99–118. doi:10.1017/S0043933907001754

David, F. (2010). The role of poultry in human nutrition. Poultry Development Review, 90–104. www.fao.org/docrep/019/i3531e/i3531e02.pdf

Fisseha, M., Azage, T., & Dessie, T. (2010). Indigenous chicken production and marketing systems in Ethiopia: Characteristics and opp ortunities for market-oriented development (IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 24). Nairobi: ILRI.

Food and Agriculture Organization for United Nations. (2011). State of food and agriculture report. Retrieved from http://iriclippings.wordpress.com/category/poultry

Hagam, J. K., Bosompem, M., & Adjei, I. A. (2013). The productive performance of local chickens in three ecological zones of Ghana. ARPN Journal of Agricultural and Biological Science, 8(1), 51–56.

Hossen, M. J. (2010). Effect of management intervention on the productivity and profitability of indigenous chicken under rural condition in Bangladesh. Livestock Research for Rural Development, 22(10), 73–81.

KAPAP. (2012). A baseline survey of indigenous chicken value chain in Makueni district, Kenya (Unpublished Report). Nairobi.

KARI. (2011). Kenya Agricultural Research Institute annual report. KARI, Nairobi.

Kingori, A., Wachira, A., & Tuitoek, J. (2010). Indigenous chicken production in Kenya: A review. International Journal of Poultry Science, 9(4), 309–316. doi:10.3923/ijps.2010.309.316

Magato, T. M., Okeno, T. O., Muhuyi, W. B., & Kahi, A. K. (2012). Indigenous chicken production in Kenya: I. Current status. World’s Poultry Science Journal, 68, 119–132. doi:10.1017/S0043933912000128

Melesse, A., Alewi, M., & Teklegioris, T. (2013). Evaluating the reproductive an egg productive traits of local chickens and their F1 crosses with Rhode Island Red and Fayoumi. Iranian Journal of Applied Animal Sciences, 3(2), 379–385.

Mendola, M. (2007). Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh. Food Policy, 32, 372–393. doi:10.1016/j.foodpol.2006.07.003

Mengesha, M. (2012). Indigenous chicken production and the innate characteristics. Asian Journal of Poultry Science, 6(2), 56–64. doi:10.3923/ajpsj.2012.56.64

Ministry of Livestock and Fisheries Development. (2011). Animal production annual report. Nairobi: Government Press.

Muthie, A. (2009). Poultry value chain assessment and situational analysis with girls lens in Suba and Bunuvala District. Nairobi: Nike Foundation.

Ndewu, J. M., Mead, R., Norrish, P., Shephered, D. D., Kimani, C. W., Wachira, A. M., & Siamba, D. N. (2014). Investigating eggs hatchability in indigenous chicken system with smallholder farms in Kenya in a participatory research using analysis of variation. Journal of Applied Biosciences, 80, 7000–7013. doi:10.4314/job.v8i01.6

Okello, J. J., Gitonga, Z., Mutune, J., Okelo, R. M., Afande, M., & Rich, K. M. (2010). Value chain analysis of the Kenyan poultry industry. The case of Kiambu, Kilifi, Vihiga, and Nakuru districts [HPAI Working Paper 24]. Washington, DC: IFPRI.

Olwande, P. O., Ogar, W. O., Okuthe, S. O., Muchemi, G., Okoth, E., Odindo, M. O., & Adhiambro, R. F. (2010). Assessing the productivity of indigenous chickens in an extensive management system in Southern Nyanza, Kenya. Tropical Animal Health and Production, 42, 283–288. doi:10.1007/s11250-009-9418-4

Republic of Kenya. (2008). Session Paper No. 2 of 2010 on National Poultry Policy. Ministry of Livestock Development. Government Printers, Nairobi. Kenya

Republic of Kenya. (2010). Agriculture development strategy (ASDS) 2010-2020. Nairobi: Government Printers.

Rosenbaum, P. R., & Rubin, D. B. (1983). Reducing bias on observational studies using subclassification on propensity score. Journal of the American Statistical Association, 79(387), 516–524.

Siamesi, B. (2006). An evaluation of the Swedish system of active labour market programmes in the 1990s. Review of Economics and Statistics, 86(1), 133–155. doi:10.1162/00346530423023723

United States Agency for International Development. (2010). Value chain analysis of poultry. Partnership for safe poultry in Kenya (PSPK) program, Winrock International, USA

Wooldridge, J. M. (2002). Econometric analysis of cross section and panel data. Cambridge: The MIT Press.

World Society for the Protection of Animals. (2012). Livestock production and climate change. Retrieved from http://unfccc.int/resource/docs/2012/smsn/ngo/194.pdf
