Is the type of agricultural extension services a determinant of farm diversity? Evidence from Kenya

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ABSTRACT
An understanding of the determinants of farm diversity is important in dealing with food and nutrition security concerns. Access to extension is a key determinant of farm diversity through technology adoption. However, limited empirical evidence exists on the effects of different types of extension services on farm diversity. A truncated Poisson regression was used on data collected from 744 households that were selected using a multi-stage sampling technique. Results show that access to government and private extension services increased farm diversity by 81 and 95 percentage points, respectively. The policy implications are that first, government extension services should be focused on farmers who may not afford private extension services given that the least diversified farms are significantly different from the most diversified farms. Second, policies should incentivize the private sector to invest more resources in the development and dissemination of extension services as a complement to government extension and lastly, there is need for policies that guide privatization of extension services especially in the current devolved system of governance in Kenya.

1. Introduction
In an attempt to mitigate the risks inherent in smallholder agriculture, farmers employ several options including livelihood diversification (Kelemu et al. 2017; Amine and Fatima 2016). Livelihood diversification is the process of managing multiple activities and engaging in diverse portfolio of social support for survival and enhanced living standards. Livelihood diversification can be classified into on-farm diversification, off-farm diversification and non-farm diversification (Kassie 2017; Ellis 1998). On-farm diversification occurs when a household manages multiple enterprises (crops and livestock) concurrently (Ellis 2000). Off-farm diversification refers to labor compensation from other farms whereas non-farm diversification is gained from non-agricultural sources like rental income (Ellis 1998). This study focusses on understanding the drivers of farm diversity and not the other two forms of livelihood diversification because agricultural extension (the explanatory variable of interest in this paper) promotes on-farm activities.

On-farm diversification (hereinafter farm diversity) is the allocation of productive resources to a wider range of farm activities and can be categorized into horizontal or vertical diversification (Kankwamba, Mapila, and Pauw 2012). Horizontal diversification occurs when a farmer adds a new enterprise to existing ones while vertical diversification occurs when a farmer adds value to existing farm produce through processing (Kankwamba, Mapila, and Pauw 2012). In addition to managing risk, farm diversity is beneficial to farmers in several other ways including enhancing crop productivity, increasing farm income, boosting food and nutrition security (Demeke et al. 2017; Makate et al. 2016; Sibhatu, Krishna, and Qaim 2015; Jones, Shrinivas, and Bezner-Kerr 2014 and Barbieri and Mahoney 2009).

Even though the effect of livelihood diversification on farmers’ welfare is well documented (Kassie 2017; Kassie et al. 2017; Birthal, Roy, and Negi 2015), there is hardly any focus on its drivers. Studies on the effect of the different types of agricultural extension services accessed by farmers on farm diversity are also not readily available. This paper attempts to fill the identified gap in knowledge by assessing the effect of different types of agricultural extension services on farm diversity.

Several factors significantly influence farm diversity including age and education of the household head, household income, access to markets and access to extension services (Kankwamba, Kadzamira, and Pauw 2012). Horizontal diversification occurs when a farmer adds a new enterprise to existing ones while vertical diversification occurs when a farmer adds value to existing farm produce through processing (Kankwamba, Mapila, and Pauw 2012). In addition to managing risk, farm diversity is beneficial to farmers in several other ways including enhancing crop productivity, increasing farm income, boosting food and nutrition security (Demeke et al. 2017; Makate et al. 2016; Sibhatu, Krishna, and Qaim 2015; Jones, Shrinivas, and Bezner-Kerr 2014 and Barbieri and Mahoney 2009).

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Mussema (2018; Kankwamba, Mapila, and Pauw 2012) found that access to extension services increased the probability of diversification by 22 percentage points in Ethiopia. In Kenya, McCord et al. (2015) found that access to extension services increased crop diversity by 0.27 units. On the contrary, Abay, Bjørnstad, and Smale (2009) found a negative association between access to extension services and farm diversity among barley farmers in Ethiopia. However, these studies used a single dummy to measure access to extension services even though it is well known that several types of extension services exist.

Muyanga and Jayne (2008) and Schwartz (1994) categorize extension services into three types based on the service provider: Government, private and non-governmental Organizations (NGOs) extension services. Government extension services are provided by public agencies and are deemed to be relatively affordable because the cost of accessing them is almost entirely borne by the providing agency. According to Muyanga and Jayne (2008) government extension services are long term in nature and reach many farmers enhancing their impact (Muyanga and Jayne 2008). However, they are sometimes unreliable because they are constrained by bureaucracy and inadequate funds.

Private extension services are provided by commercial companies for profit. They often target literate farmers with relatively high income because they can afford them. Consequently, these services are well funded and efficient compared to those provided by Government. Nevertheless, they only cover limited geographic area and reach few selected farmers leaving out poor farmers (who are the majority and equally need extension services) unattended.

Schwartz (1994) considers NGOs extension services as a separate type but Muyanga and Jayne (2008) argue that they are part of private extension. Farmers in this study reported that they accessed the three types of extension services. Thus, it was logical to view them as different. The main strength of the NGO extension services is that they are affordable and cover a wider geographic area compared to the private extension services. Nonetheless, NGO extension services are based on short term projects limiting their impact on target farmers (Muyanga and Jayne 2008).

This study contributes to existing literature by assessing the effects of the type of extension services accessed by farmers on farm diversity while controlling for government, private and NGOs extension services variables. In addition, we include livestock diversity as an outcome variable given that, often farms manage both crop and livestock enterprises, and noting that, most previous studies have only focused on the determinants of crop diversity as a proxy for farm diversity. Thus, we evaluate the effects of the type of extension services on farm diversity by answering the question ‘Is the type of agricultural extension a driver of farm diversity?’

The rest of this paper is organized as follows: section two presents the theoretical basis of the study while section three discusses the study methods. The results are discussed in section four and section five concludes by providing policy implications of the findings.

2. Analytical framework

Supposing that the expected utility from existing farm enterprises is represented by $U_{di}$ while the expected utility from introducing a new enterprise (diversification) is represented by $U_{di}$, the decision by the $ith$ farmer to diversify ($D_i$) can be modeled following Greene (2012) as follows:

$$D_i = \begin{cases} \text{if } U_{bi} > U_{ai}, \text{ the farmer diversifies,} \\ \text{if } U_{bi} \leq U_{ai}, \text{ the farmer does not diversify} \end{cases} \quad (1)$$

If the expected utility from the introduction of a new enterprise is greater than that of the existing enterprise, a farmer diversifies further otherwise, they do not.

Farm diversification occurs in two successive stages. In the first stage, a farmer decides whether to diversify or not. This stage can be modeled as the probability that the $ith$ farmer diversifies. Following Rahm and Huffman (1984), the probability that the $ith$ farmer diversifies can be specified as follows:

$$P_i(D_i|1) = \begin{cases} X \beta = \frac{e_{bi} - e_{ai}}{\alpha_0 - \alpha_0} \\ \alpha_0(X_i - \alpha_0) \end{cases} \quad (2)$$

Where $P_i(D_i|1)$ is the probability function, $\mu_i = e_{bi} - e_{ai}$ is a random term with mean zero, $\beta = \frac{\alpha_0 - \alpha_0}{\alpha_0 - \alpha_0}$ is a vector of parameters to be estimated, and $F(X_i, \beta)$ is the cumulative distribution function for $\mu_i$ evaluated at $(X_i, \beta)$. Therefore, the probability that the $ith$ farmer diversifies is the probability that the benefits due to diversification are greater than benefits of failing to diversify.

The second stage of the diversification process involves a decision on the intensity of diversification (the number of enterprises a farmer manages). Following Sichoongwe et al. (2014), the intensity of diversification can be specified as follows:

$$U_{ij} = \alpha_j (X_i) + e_{ij} \quad (3)$$
Where $U_{ij}$ is the unobservable random utility of the $i$th farmer from the $j$th diversification decision, $X_{ij}$ are the observable demographic characteristics associated with the $i$th farmer including access to extension, $\alpha_i$ is a vector of parameters to be estimated and $e_{ij}$ is the error term.

3. Study methods
3.1. Sample selection
Farm diversification is common in high agricultural potential zones of Kenya. Two counties in these zones, Kisii and Nyamira, were identified with the help of Africa Harvest International, a local NGO working with farmers in the study area. The NGO had registered 71 farmer groups in Kisii and 23 in Nyamira. A random sample of these groups, proportionate to the number of groups per county, was selected resulting in 32 groups from Kisii and 16 from Nyamira. Subsequently, 20 farmers were randomly selected from each group. Where a group had 20 or less than 20 active members, a group census was conducted. Since most groups had less than 20 active members, the effective sample size for this study was 744 against a target of 960.

3.2. Measurement of key variables
3.2.1. Farm diversity
The dependent variable in this study is farm diversity. According to Tung (2017) and Sibhatu, Krishna, and Qaim (2015), there are two common methods of measuring farm diversity: (i) use of indices, and (ii) use of crop and livestock count. The use of indices as a measure of farm diversity is limited to measuring crop diversity and requires that data on the land share for each of the crop species grown is available. Given that intercropping is the main farming system in Kisii and Nyamira counties, it was not possible to use the index approach because the data on land that were available for crops grown was not disaggregated by species. This study therefore adopted the count approach and measured farm diversity in three ways: (i) a count of existing crop species; (ii) a count of livestock breeds and (iii) sum of the number of crop species and livestock breeds as a measure of total farm diversity.

3.2.2. Type of extension service
To measure access to different types of extension services, farmers were asked two successive questions. The first question was ‘did you access extension services in the year preceding this survey?’ The response was ‘yes’ or ‘no’. All the farmers had accessed extension services during the reference period and therefore were asked the follow-up question ‘which type of extension service did you access?’ Allowing for multiple choices, the farmers had to choose from the three types of extension services (government, private and NGO extension services).

3.2.3. Computation of wealth index
Principal Component Analysis (PCA) was used to compute the wealth index of farmers based on 34 household assets. The Kaiser-Meyer-Olkin Measure Sampling Adequacy (KMO-MSA) statistic was employed to assess the suitability of the PCA. According to Gyau, Mbugua, and Oduol (2016), a KMO-MSA value equal to or greater than 0.5 is acceptable which was the case in this study. The wealth index was then computed in two stages. In the first stage, the asset values were normalized (scaled to values between 0 and 1) to enable them to be comparable following Langyintuo (2008) as follows.

$$i = \frac{x_i - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}}$$

Where $i$ is the normalized asset value, $x_i$ is the actual asset value and $x_{\text{min}}$ and $x_{\text{max}}$ are the minimum and maximum values of $x$, respectively.

In the second stage, a weight for each asset was calculated and used as the criterion for selecting the assets that significantly contributed to farmers’ wealth. Only those assets with a weight equal to or greater than 0.5 were deemed significant in contributing to a farmer’s wealth (Gyau, Mbugua, and Oduol 2016). Following Langyintuo (2008), the wealth index was then computed as shown.

$$W_j = \sum_{i=1}^{k} b_i(a_{ij} - x_i)/s_i$$

Where $W_j$ is the wealth index for each household; $b_i$ represents the weight assigned to the $i$th asset; $a_{ij}$ is the value for each household on each of the $k$ asset; $x_i$ is the mean of each of the $k$ asset and $s_i$ is the standard deviation.

3.2.4. Shocks
Respondents were presented with a list of three categories of shocks: (i) climatic shocks (drought, flood, frost and hailstorm); (ii) biological shocks (pests, diseases and loss of livestock), and iii) economic shocks (large increase in input prices, large decrease in output prices and large increase in food prices). They were then asked ‘did you experience [NAME OF SHOCK] in the last 12 months’ for all the shocks and allowing for multiple choices. Those who chose at least one shock were considered as having experienced shocks in the reference period. To ensure independence of the effect of each...
Table 1. Definition of other variables included in the truncated Poisson model.

| Variable         | Description                                      | Hypothesized effect |
|------------------|--------------------------------------------------|---------------------|
| Farm size        | Land available for cultivation, acres            | ±                   |
| Credit           | Access to credit, 1 = yes; 0 = no                | –                   |
| Household size   | Number of members in a household                 | +                   |
| Age              | Age of the household head, years                 | –                   |
| Education        | Education of the household head, years           | –                   |
| Distance to tarmac | Distance to nearest tarmacked road, km         | –                   |
| Shocks           | Experienced shocks? Dummy, 1 = yes; 0 = no       | +                   |
| Group official   | Dummy, 1 = yes; 0 = otherwise                    | +                   |
| Gender           | Gender of household head, 1 = male; 0 = otherwise | –                   |

Type of extension service on farm diversity, we controlled for other confounding covariates as shown in Table 1.

3.3. Empirical model

The outcome variable in this study is a count taking a value greater than ‘1’ if the ith farmer diversified (managed more than 1 enterprise) and a value of ‘1’ if the ith farmer managed a single enterprise. Non-negative dependent variable is negatively skewed implying that OLS parameter estimates would be inefficient (Maddala 1983). The most appropriate techniques of analyzing count data are Poisson model, negative binomial model, zero-inflated Poisson model and zero-inflated negative binomial model (Okello et al. 2011).

The zero-inflated Poisson and the zero-inflated negative binomial models are applicable when data sets exhibit unequal dispersion (Yusuf, Bello, and Gureje 2017). In zero-inflated Poisson regression, the response \( Y = Y_0 \) is independent and with probability \( p \), the only possible observation is 0, whereas with probability \( (1-p) \), a Poisson \( (\lambda) \) random variable is observed in \( Y \) (Lambert 1992). Zero-inflated negative binomial model assumes that there are two distinct data generation processes. Yusuf, Bello, and Gureje (2017) argue that for the ith observation with probability \( p_i \), the only possible response of the first process is a zero count and with probability \( 1-p_i \), the response observed in the second process is governed by a negative binomial with mean \( \lambda_i \).

The Poisson and negative binomial models apply when the outcome variable is non-negative (Greene 2008; Winkelmann and Zimmermann 1995). Winkelmann and Zimmermann (1995) further state that the merits of the Poisson regression model are that, it captures the non-negative and discrete nature of count outcome variable and allows inference to be drawn based on probabilities of an occurrence. Moreover, the equal dispersion assumption of the model accounts for heteroscedasticity and skewed nature of count data. In cases where the outcome variable does not have zeros but exhibits unequal dispersion, the Poisson estimator is inefficient (Rodriguez 2013).

To correct for unequal dispersion, the negative binomial model is used. The outcome variable in this study does not have zeros and therefore the zero-inflated Poisson and the zero-inflated negative binomial models are inappropriate. Moreover, tests for unequal dispersion showed that the assumption was not violated (the mean to variance ratio was one and the Pearson statistic was insignificant) making the Poisson model appropriate. Following Greene (2012), the Poisson model is specified such that each \( y_i \) is drawn from a Poisson population with parameter \( \lambda_i \), which is related to a set of regressors \( X_i \), as shown.

\[
P_r(y_i|x_i) = \frac{e^{-\lambda_i} \lambda_i^{y_i}}{y_i!}, \quad y_i = 0, 1, 2, \ldots, n \tag{6}
\]

Where \( P_r(y_i|x_i) \) is the probability that a farmer diversifies, \( y_i = 0, 1, 2 \ldots n \) is a set of all possible farm enterprises the ith farmer can manage and \( x_i \) is a vector of predictor variables. Wooldridge (2002) shows that the expected number of enterprises is given by:

\[
E(y_i|x_i) = \text{var}(y_i|x_i) = \lambda_i = \exp (\alpha + X_i' \beta)
\]

for \( i = 0, 1, 2, \ldots, n \) \tag{7}

Where \( E(y_i|x_i) = \lambda_i \) is the log-linear mean condition and \( \text{var}(y_i|x_i) = \lambda_i \) captures the equal dispersion assumption. The log-linear function accounts for the non-negative restriction imposed by the Poisson model on the dependent variable.

Since the outcome variable in this study is truncated, only positive count was included in the analysis, the model used was the truncated Poisson (tpossoin) regression that uses maximum likelihood estimator (MLE). As with other MLE models, the estimated coefficients are not the direct effect of change of the independent variables on the dependent variable. As a result, the marginal effects were computed.

4. Results

4.1. Descriptive results

Table 2 presents the descriptive statistics of the farmer demographics disaggregated by their level of farm diversity. The 25 percent least diversified farms (25% LDF) were compared with the 25 percent most diversified farms (25% MDF). We found that the two categories of farms were significantly different considering total farm diversity, age and education of the household head,
farm size, access to credit and access to extension services. This finding suggests that extension services should target smallholder farms based on these differences.

### 4.2. Econometric results

Table 3 presents the results of the truncated Poisson regression model. The Wald statistic was significant at the one percent level suggesting a high prediction power of the model. The partial correlation coefficients for all the explanatory variables were less than 0.5 while the Variance Inflation Vectors (VIF) were less than 10 implying that multi-collinearity of the independent variables was not a problem (O’Brien 2007; Kennedy 1985). Moreover, the Pearson and deviance tests for unequal dispersion were not significant \( (p > 0.05) \) indicating that the truncated Poisson model fitted the data well. Table 3 is the abridged version presenting the independent variables of interest only. Complete models with other confounding variables are presented in Appendices 1–7.

Access to government and private extension services increased total farm diversity by 84.9 and 90.7 percentage points respectively (Table 3). This finding implies that farmers who accessed government and private extension services managed more diversified farms. This finding is plausible because access to extension services encourages technology adoption through creation of awareness about new and existing technologies and improving knowledge on their management.

Overall, the type of extension service accessed by farmers is an important driver of farm diversity. The results further show that crop diversification is more important in accounting for farm diversity, probably explaining the reason why crop diversity is widely studied (Kankwamba, Kadzamira, and Pauw 2018; Demke et al. 2017; Makate et al. 2016) as opposed to livestock diversity (Asante et al. 2018). This explanation to this observation is twofold. One, the study area is high potential agricultural zone characterized by conducive weather conditions that are ideal for crop production. Two, naturally there are more crop species available for farmers to choose from compared to livestock breeds.

In practice, providers of agricultural extension services do not operate in isolation but target the same farmers. We estimated the effect of accessing multiple extension services concurrently on farm diversity by interacting the dummy variables that measured access to extension services. It was only the access to government and NGO extension services that increased farm diversity marginally by 17.8 percentage points (Table 3). This finding suggests that there may be no added benefits of using multiple types of extension services concurrently possibly because they disseminate similar information.

### 5. Conclusions and policy implications

Smallholder agriculture in SSA remains a risky undertaking due to the ever reliance on rain-fed production and limited use of improved technologies among other factors. These risks call for coping strategies such as farm diversification. Consequently, the drivers of farm diversification need to be understood better in order to ensure its successful promotion. This paper assesses...
the effect of different types of agricultural extension services on farm diversity.

We found that the least diversified farms were significantly different from the most diversified farms. We also found that the type of extension service accessed by farmers was an important driver of farm diversity. In particular, private and government extension services were the most important drivers of farm diversity. Also, crop diversity accounted for farm diversity more than livestock diversification. Thus, providers of private and government extension services should promote crop technologies in order to boost farm diversity among smallholder farmers. Against expectation, access to multiple sources of extension services did not have added effect on diversification.

Given that the least diversified farms are significantly different from the most diversified farms, there is need for improved targeting for government extension services to focus on farmers who may not afford private extension services. Similarly, government should explore incentives aimed at supporting providers of private extension services to invest more in the development and dissemination of extension services. Lastly, the observation that private extension services are an important driver of farm diversity is of particular interest considering the ongoing privatization of extension services in Kenya. This requires the development and implementation of policies that guide the privatization process especially in the current devolved system of governance in Kenya.

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