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Research article

Land tenure and property rights, and household food security among rice farmers in Northern Nigeria

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ABSTRACT

There are growing campaigns to promote land titling to secure Land Tenure and Property Rights (LTPRs) in African agriculture. Theoretically, deed registration should reduce land disputes, facilitate land use as collateral for loans, and stimulate investment in land improvement for increased productivity, income and food security. Empirical evidence in these regards, however, remains anecdotal, and sometimes conflicting. This paper reports a study that examined LTPRs' among smallholder rice farmers in Northern Nigeria and the influence on household food security (HFS). It used cross-section data obtained from 549 rice farmers, selected by multistage sampling across 84 rice-growing communities, seven (7) States and the three (3) geopolitical zones in northern Nigeria. Data collection was by personal interviews of adult members of the farmers' households, focusing on the households' socio-economics, livelihoods, and LTPRs on farmland cultivated during the 2016/17 farming season. HFS was assessed within the framework of the United States Department of Agriculture' HFS Survey Module. LTPRs assessment was in terms of the type (source) and registration of titles to farmlands. HFS modelling was within the framework of Poisson, Instrumental Variable Poisson (IVP) and Zero-inflated Poisson (ZIP) regression methods, with endogeneity concerns and choice of specification addressed within Hausman specification tests. The results show that land titling is not endogenous in the estimated models; and that HFS is significantly ($p < 0.01$) enhanced with an increase in shares of freehold and leasehold in the households' farmlands, as against reliance on communal holdings. Holding *de jure* secure title to farmlands, however, had no significant influence on HFS. The evidence supports the need to develop land markets to enhance the ease of land transfer, as part of measures to enhance HFS in northern Nigeria.

1. Introduction

Land tilting to enhance the security of Land Tenure and Property Rights (LTPRs) in agriculture is increasingly considered crucial for sustainable development, particularly in sub-Saharan Africa (Bennett and Alemie, 2016; Borras and Franco, 2010; Deininger et al., 2008). By LTPRs, reference is made to – the rights that individuals, communities, families, firms, and other community structures hold in land and associated natural resources. LTPRs are secure (*de facto* or *de jure*) if clearly defined, exclusive, enforceable and transferable as well as recognized by relevant authorities (Feder and Feeny, 1991). In Nigeria, a State Governor grants official recognition of a landholder's LTPRs through the issuance of a Certificate of Occupancy, which is granted after following some due process that includes boundary survey and submission of a duly verified deed of transfer (Shittu et al., 2018). Local government councils may also grant customary rights of occupancy to individuals, firms, and communities (Laws of the Federation of Nigeria [LFN], 2004). The customary right of occupancy is, however, considered *de facto* held by holders of agricultural lands in non-urban areas that have been under use for agricultural purposes prior to the enactment of the Land Use Act of 1979 (Shittu et al., 2018; LFN, 2004: Section 36 [2 & 3]). This practically leaves the control of most rural (agricultural) lands in Nigeria within the purview of the informal customary tenure systems at various localities. However, registration of such titles, especially when transferred from one party to another, are commonly registered at the affected State's land registry upon submission of the approved perimeter survey plan, the deed of transfer, and payment of stamp duty fees (Shittu et al., 2018).

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Ideally, title deed registration should help countries to minimize incidences of land disputes, prevent unfair land expropriation, facilitate land use as collateral for loans, and promote long-term investments in land improvement that can enhance agricultural productivity and income (Fenske, 2011; Place, 2009; Brasselle et al., 2002; Feder and Feeny, 1991). Land titling could also facilitate the emergence of efficient land markets that allows land transfer from less efficient to more efficient users, thereby enhancing the efficiency of land and associated natural resources use. As noted by World Bank (2017), LTPRs are fundamental to stimulating agricultural investment and growth, and for building countries and their people's resilience against unfair land expropriation as well as forced migration: as such, "improving tenure security for both women and men [in farm households] can have a great impact on household income, food security, and equity".

While the expected positive link between secure LTPRs and livelihood outcomes, including food security is quite plausible, empirical evidence in these regards remains anecdotal and sometimes conflicting (Payne et al., 2009). Some studies (e.g. Abdulai et al., 2011; Deininger and Ali, 2008) reported a significant positive link between land titling and some livelihood outcomes, particularly investment in land improvement and/or agricultural productivity. Similarly, Galiani and Schargrodsky (2010) found that land titling could be an important tool for poverty reduction in the long-run as it enhanced investment in physical and human capital among Argentine households. However, a number of other studies seem to suggest otherwise. For instance, a review by Payne et al. (2009) led to the conclusion that most land titling programmes generally failed to live up to expectations. Evidence in Brasselle et al. (2002) had also suggested that some of the commonly taunted positive outcomes might be due to endogeneity bias! It is instructive to note that certain investments in land improvements like tree planting and fencing may actually be a pursuit to secure LTPRs (Place and Otsuka, 2002). Moreover, Deininger and Ali (2008), while providing support for enhancing LTPRs, noted that title registration, *per se*, has no investment effects, and thus called for context-specific considerations in pursuits of programmes to enhance LTPRs in pursuit of development objectives.

For sub-Saharan Africa and many developing countries, pursuits of secure LTPRs in agriculture appear compelling, even though context-specific considerations are important to determine how best to achieve this for women, men, youths, and smallholder farmers. There is growing evidence (e.g. World Bank, 2017; FAO, 2010) that both statutory and customary tenure systems are under stress in the face of global demographic growth, rapid urbanization, environmental degradation, and climate change. A major consequence has been rising cases of land-related conflicts (Berry, 2017; Bottazzi et al., 2016). In Nigeria, for example, rivalry over land use is the root cause of farmers-herdsmen conflicts and many communal clashes that are now almost endemic in the country, and causing massive loss of livelihoods, properties and lives across the nation's landscape (Akov, 2017; Higazi, 2016; Adisa and Adekunle, 2010). The land-related conflicts persist because rural land governance in Nigeria remains largely within the purview of the informal - customary tenure systems at various localities (Shittu et al., 2018; LFN, 2004). Effectively addressing the challenge, therefore, would suggest the need for some review of the land use act to strengthen and possibly formalise the customary rights of occupancy in Nigeria.

Against the above background, this paper presents the report of a study that examined the LTPRs of smallholder rice farmers in Northern Nigeria and the influence on HFS. The study was considered necessary for Nigeria and other developing countries with similar land tenure systems, to empirically ascertain how customary versus statutory rights of occupancy affects livelihood outcomes in view of the rising call for a review of the land use act. The paper contributes to the ongoing debates on LTPRs and livelihood outcomes in Africa's smallholder agriculture in a number of ways. First, it updates empirical evidence on the forms of LTPRs that operate for agricultural lands in Northern Nigeria. Second, it provides empirical evidence on how tenure types and titling as well as other control variables, affect HFS among smallholder rice farmers in Northern Nigeria. The analyses were within the framework of Poisson, Instrumental Variable Poisson (IVP), and Zero-inflated Poisson (ZIP) regression methods, with endogeneity concerns as well as a choice of specification addressed with the framework of Hausman (1978) specification test. The approach supported the provision of answers to three (3) pertinent research questions, including:

1) Which of the hypothesised determinants [including LTPRs] are most likely to guarantee that a farm household will not fall into any of the food insecurity situations [that is, will achieve HFS score of zero]?
2) Which of the hypothesised determinants contributes to the severity of food insecurity among households of the rice farmers?
3) To what extent do the significant variables contribute to the severity of food insecurity among households of the rice farmers?

The rest of the paper is organised as follows. The next section provides some review of recent evidence on HFS in Nigeria. The third section presents the study methodology, including the measurement of household food security status and LTPRs, description of the study area, the research design and the econometric approach of the ZIP model. The fourth presents and discusses the results, while the final section presents the main conclusions and the policy implications.

2. Empirical review on LTPRs and food security in Nigeria

Secure land tenure is a critical factor in achieving poverty reduction, household food security, and improved nutritional status for those who reside in rural areas and depend on agriculture for their livelihoods (Holden and Ghebru 2016; Ariana, 2014; IFAD, 2010). Empirical evidence (Espinosa, 2020; Chirwa, 2008) from the Malawi land redistribution program based on a willing buyer and/or seller model showed that there was a substantial increase in food availability when the erstwhile landless or near landless households acquire land or substantially more land. Meanwhile, a study from Zambia that compared caloric intake among children whose families had access to land and those that did not found that under 10 children in households who lost access to agricultural land within the last five years received 11% fewer daily calories compared to their counterparts whose households did not lose access to farmland within the same period.

On the contrary, LTPR variables, except farm size, rarely feature as regressors in most HFS studies on Nigeria. An exception was Bamire (2010), who considered the influence of *de facto* tenure security in his model. He introduced a dummy variable that took on the value of one (1) for inherited/purchased land and zero if otherwise into the HFS model as a measure of tenure security. The study, however, did not find any significant relationship between the measure of tenure security and HFS. Most past HFS studies on Nigeria modelled HFS within some limited dependent variable modelling framework: logit, probit, ordered probit, multinomial logit, etc. Common regressors in such models included household socio-economic, demographic, and locational variables.

Considerable research attention has been focused on understanding the challenge of food insecurity in Nigeria. Common emphases of these studies (e.g. Ogundari, 2017; Ahmed et al., 2015; Akerele et al., 2013; Obayelu, 2012; Babatunde and Qaim, 2010; Okuneye, 2002) include assessment of the prevalence or dimensions of food insecurity among Nigerian households, the households' coping strategies, and/or the influence of various socio-economic factors in explaining the phenomenon. Most of the studies assessed HFS by measures such as cost of calories, food expenditure, and dietary diversity scores/index, based on household consumption data over a rather short period, typically 7–30 days. A number of studies (e.g. Babatunde and Qaim, 2010; Owoo, 2018) tried to circumvent this shortcoming by complementing their expenditure measure with anthropometric measures (e.g. stunting and wasting among children in the households) to accommodate the long-term as well as individual household members' dimensions of HFS. A growing number of recent studies (e.g. Obayelu, 2012), particularly those using the World

Bank Sponsored Living Standard Measurement Survey (LSMS) – Panel data embraced the USDA Household Food Security Survey Modules in HFS assessment in Nigeria. A key challenge, however, has been that many of these recent studies, identified through google scholars search, were published in low-quality journals.

Another key challenge with most HFS studies on Nigeria was a general failure to test and correct the endogeneity problem in the estimated models. Some exceptions include Ogundari (2017) and Babatunde and Qaim (2010). These adopted the Durbin–Wu–Hausman (DWH) test to establish the endogeneity of variables such as farm and off-farm income, and total expenditure (a proxy for income) respectively in their HFS models. These would suggest that HFS models that included variables such as income and possibly LTPRs among other variables, and failed to explicitly test and confirm exogeneity of such variables might suffer from endogeneity problems. In the presence of endogenous regressors, the estimates are not just biased in finite samples; they are inconsistent, and thus not appropriate for policy analysis.

Evidence from Ogundari (2017) showed that the probability of a household falling into any of the food insecurity categories as against being food-secure decreases significantly and consistently with income, household size, whether households consumed only purchased food, and the geographical region of the household. This probability, however, increased if the household consumed only home-produced food. Dietary diversity was also found to increase with household income and household size, whether the household head was a farmer, whether households consumed only purchased food, and whether households resided in the rural areas. He, however, found that educated household heads and those consuming only home-produced food consumed a less diverse diet.

Focusing on some of the well-conducted recent studies, evidence from Babatunde and Qaim (2010) showed that off-farm income has a positive net effect on food security and nutrition. They also found that the prevalence of child stunting, underweight, and wasting was lower in households with off-farm income than in households without. The results further show that calorie consumption is significantly lower among female-headed households than among male-headed ones. They also found that the age of the household head had a negative and significant influence on HFS.

In summary, while the roles of various socio-economic and locational factors on HFS in Nigeria seem to be well established, there remains a dearth of studies examining the nexus between land tenure and property rights and household food security in Nigeria. The very few studies that attempted to examine the issues also did so using suspicious methodology: particularly, the failure to examine the likely endogeneity of LTPRs, income, and other variables in the HFS model. This study is an attempt to address these lacunae.

3. Methodology

3.1. The study area

The study was carried out in selected farming communities across the three geopolitical zones in Northern Nigeria. The study area is located between longitudes 3° and 15° East and latitudes 9° and 14° North. It shares land borders with the Republic of Benin in the West, Chad, and Cameroon in the East, the Niger Republic in the North, and Southern Nigeria in the South. It is made up of 19 out of the 36 states of Nigeria as well as the FCT, grouped into three geopolitical zones (GPZ): Northeast, Northwest, and Northcentral. The region also has six out of the seven agro-ecological zones (AEZ) in Nigeria, ranging from the Derived to the Sahel Savannahs. Eleven of the States in northern Nigeria are among the 12 leading rice-producing States in Nigeria. With respect to food insecurity situations of the rural households in Northern Nigeria, the northeast seems to have the highest incidences (56%) in Nigeria, followed by north central (48%) and northwest (47%) (Adepoju and Adejare, 2013). It is important to note that land ownership and control in Nigeria is *de jure* governed by the Land Use Act of the 1979 constitution (LFN, 2004).

3.2. The study design

The study was part of the FUNAAB-RAAF-PASANAO project implemented by the Federal University of Agriculture, Abeokuta (FUNAAB) in partnership with the National Cereals Research Institute (NCRI), Baddegi, and funded by the Economic Community of West African States (ECOWAS). The central focus was on Incentivising Adoption of Climate-Smart Agricultural Practices in Cereals Production in Nigeria. The data were collected in a Nation-wide Farm Household Survey conducted across the six geopolitical zones in Nigeria, focusing on maize and rice farmers: see Shittu et al. (2018) for some description of the main study. The sub-set of the study data used in this study was from smallholder rice farmers in Northern Nigeria. The respondents were selected in a three-stage sampling process, described as follows:

Stage I: Purposive selection of seven States that have been the leading rice producers in Northern Nigeria (excluding conflict-prone areas), based on production statistics from [National Bureau of Statistics (NBS), 2016].

Stage II: Purposive selection of six Agricultural Blocks per State from the main rice-producing areas of the State, and two Extension Cells per block - that is, 12 Cells per State and 84 Cells in all.

Stage III: Proportionate stratified random selection of five to 10 rice farmers from the list of rice farmers in the selected cells.

This process yielded 549 households of rice farmers, from which a complete dataset was collected through personal interviews of the household heads and other farming members of their households. Data were collected on a wide range of issues, including the households' socio-economics, livelihoods, and LTPRs on farmland cultivated during the 2016/17 farming season.

3.3. Measurement of household food security

The main outcome variable for this study is Household's Food Security (HFS) while Land Tenure and Property Rights (LTPRs) and a number of traditional socio-economic predictors of HFS were the explanatory variables. HFS was assessed within the framework of the United States Department of Agriculture's (USDA's) – 18 questions HFS modules (Appendix Table A1). This approach has the advantage of having been tested, validated and consistently used by USDA in HFS monitoring in the USA, over the years. It is particularly suitable for capturing both the incidence and severity of food insecurity, and adaptable to many climes. The experiences the 18 questions seek to elicit are such that households can easily recall over a period up to 12 months than actual expenditure. It thus tends to be a much more reliable measure of food security in settings such as Nigeria, where most households do not keep records of their consumption.

There are three items in the USDA HFS survey modules that ask about experiences of the entire household. Seven items ask about experiences and behaviour of the adult members of the household, and eight items ask about experiences and conditions of the children in the household. An affirmative response to each of these questions is score one (1) while households that did not experience each of the food insecurity situations are scored zero (0). The scores are summed-up across all questions to determine HFS Scores of a household. This could add-up to a maximum of 18 for households with at least a child and maximum of 10 for households without children. Appendix Table A2 shows how households may be categorised into four mutually exclusive HFS categories based on the HFS Scores, following USDA (2016). The categories include high food security, marginal food security, low food security, and very low food security.

3.4. LTPRs' measurement

Two key indicators were employed in assessing Land Tenure and Property Rights of farmers in this study. They include:

3.4.1. Tenure type

This depicts the mode of land acquisition, categorised into three – Freehold (including personally inherited and/or purchased lands to which exclusive use and transfer rights apply), Leasehold (land leased from a third-party), and Communal (land jointly owned/controlled by extended family or other community members, to which only use right is accorded). These were represented in the study models in terms of the proportion of the farmlands cultivated by all members of the households that fall under each of the three categories. Meanwhile, the share of communally owned/controlled land was dropped as the reference tenure-type variable.

3.4.2. Tenure security (legal)

In view of provisions of Nigeria's Land Use Act (LFN, 2004), a tenure is *de jure* secure, if it is duly registered with the land registry and/or the holder is issued a statutory Certificate of Occupancy by the Governor of the State where it is located. Holders of inherited and/or purchased lands that are not in dispute, even though commonly perceived as *de facto* secure, may be affected by unfair expropriation of such lands. Therefore, this study focused on *de jure* with a view to examining the importance of title registration, which was captured in the model as the proportion of household's farmland to which the household holds registered title.

3.5. Econometric framework for modelling household food security

As noted above, the main outcome variable for the study is the HFS Scores of the farm households. This is essentially a count variable, ranging from zero – 18 for households with children and zero – 10 for households without children. We note that Poisson regression is an appropriate framework to model count variables such as the HFS score; therefore, we deployed the framework in this study of HFS among households of rice farmers in Northern Nigeria.

The Poisson distribution assumes that each count is the result of the same Poisson process in which each counted event is independent and equally likely. Poisson regression estimates how predictors affect the number of times the event occurred, which in this study refers to the number of affirmative responses to the 18 food insecurity questions. However, one of the assumptions of the Poisson model requires that the expected value (mean) of the Poisson distribution is theoretically equal to its variance, therefore, accounting for the inherent heteroscedasticity and skewed distribution of nonnegative data. Sometimes the count data may include a larger number of zero values than a Poisson would predict. In such cases, the appropriate model is the Zero-Inflated Poisson (ZIP) regression (Cameron and Trivedi, 1998; Winkelmann 2000).

The ZIP models assume that some zeros occurred by a Poisson process, but others were not even eligible to have the event occur. Therefore, ZIP allows for two different processes: in the first process, the outcome is always a zero count while in the other process the counts follow a standard Poisson process. The first process is modelled as a logit model, and the second a Poisson model. The logit model is generated for the "always zero" cases while a Poisson model is generated to predict the counts for those households who are not always zeros. Operationalizing a ZIP model in Stata gives an allowance for the specification of two models - first the count model, then the model predicting the always zeros (inflate).

Suppose that for each respondent, there are two possible situations. Suppose that if situation 1 occurs, the count is zero. However, if situation 2 occurs, counts (including zeros) are generated according to a Poisson model. Suppose that situation 1 occurs with probability π and situation 2 occurs with probability 1 - π. Therefore, the probability distribution of the ZIP random variable y_i can be written as in Eq. (1):

$$\Pr(y_i = j) = \begin{cases} \pi_i + (1-\pi_i)\exp(-\mu_i) & if\ j = 0 \\ (1-\pi_i)\dfrac{\mu_i^{y_i}\exp(-\mu_i)}{y_i!} & if\ j > 0 \end{cases} \tag{1}$$

Where:

μ_i is from the Poisson component of the model, which can include an exposure time *t* and a set of *k* regressors (the *X's*), and is defined in Eq. (2) as follow:

$$\mu_i = \exp(\ln(t_i) + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_k X_{ki}) \tag{2}$$

Often, $X_1 \equiv 1$, in which case β_1 is the *intercept*. The regression coefficients $\beta_1, \beta_2, \ldots, \beta_k$ are unknown parameters that are estimated from a set of data.

λ_i is from the logistic component of the model, which may also include an exposure time *t* and a set of *m* regressors (*the* $Z's$), in which the $Z's$ and the $X's$ may or may not include terms in common. It is defined as Eq. (3):

$$\lambda_i = \exp(\ln(t_i) + \gamma_1 Z_{1i} + \gamma_2 Z_{2i} + \cdots \gamma_m Z_{mi}) \tag{3}$$

π_i is the logistic link function, defined as Eq. (4):

$$\pi_i = \frac{\lambda_i}{1+\lambda_i} \tag{4}$$

In this study, the ZIP regression framework was deployed to analyse HFS among households of rice farmers in northern Nigeria. The results were also compared with those of traditional Poisson and Instrumental Variable Poisson in search of appropriate specification and endogeneity test. The number of affirmative responses to food insecurity questions in Appendix Table A1 (HFS score) is the outcome variable of interest, while the other variables defined in Table 1 are the regressors. Note that the same set of regressors used in the Poisson section of ZIP were also used in Logit. Exposure time (t) is also not applicable to the study, given that all households responded to questions contextualised over the past 12 months of visit to each.

It is instructive to note that the complete dataset for the study data had 74 households without a child with $0 \leq HFS\ Score \leq 10$ and 475 households with at least one (1) child, with $0 \leq HFS\ Score \leq 18$. Bearing in mind that certain HFS scores for the two categories of households represents different levels of food insecurity (see Appendix Table A2), we opted to drop the relatively fewer cases of households without children, and based the final analysis on data of the 475 households with at least a child.

3.6. Hausman specification and endogeneity tests

Evidence in literature suggests that endogeneity may be a source of concerns in regression models seeking to assess influence of LTPRs on HFS (Brasselle et al., 2002), with some evidence in these regards already reported in some studies on Nigeria (Babatunde and Qaim, 2010; and Ogundari, 2017). It is instructive to note that some commonly used regressors in HFS models (e.g. education, extension contact and farm as well as off-farm income, etc.) may also be important predictors of household decision to get their farmland registered. Therefore, rather than directly capturing income (farm and/or off-farm) in the HFS model, we included only income determinants such as farm size, proportion of farmland that fall in lowland area and socio-economic variables such as education and extension contact. We also included a dummy variable to capture household participation in off-farm activities in the model. In addition, we expressly conducted Hausman (1978) specification tests to examine the possibility of the endogeneity of land titling as well as participation in off-farm activities in the HFS model. The Hausman test was also conducted to determine if the ZIP (including the logit model of

[1] Simpson index of land fragmentation $\left[\mathrm{SI} = 1 - \frac{\sum a^2}{(\sum a)^2}\right]$ has a value between 0 and 1. SI = 0 indicates complete land consolidation, i.e., the farm operates with only one parcel. Increase in SI value implies the farmland becomes more fragmented.

Table 1. Definitions of study variables and their descriptive statistics.

Variable	Descriptive statistics (n = 475)			
	Min	Max	Mean	Std.Dev.
FSS Count (number of affirmative responses)	0.00	18.00	7.44	5.83
Farm size (Ha)	0.10	28.00	2.09	2.71
Freehold share of farmland	0.00	1.00	0.77	0.40
Leasehold share of farmland	0.00	1.00	0.11	0.29
Registered x Freehold share	0.00	1.00	0.11	0.30
Lowland share of farmland	0.00	1.00	0.61	0.44
Simpson index of land fragmentation[1]	0.00	0.77	0.23	0.26
Extension contact (At least once = 1; None = 0)	0.00	1.00	0.74	0.44
Age of Head (Years)	18.00	80.00	43	12
Age squared	324.00	6400.00	2022	1140
Education of Head (Schooling years)	0.00	18.00	7.19	6.09
Gender of Head (Female = 1, Male = 0)	0.00	1.00	0.07	0.26
Head is single (1 if Yes, 0 otherwise)	0.00	1.00	0.04	0.21
Head is widowed/divorced (1 if Yes, 0 otherwise)	0.00	1.00	0.02	0.13
Head works off-farm (1 if Yes, 0 otherwise)	0.00	1.00	0.61	0.49
Household size (number of people)	1.00	43.00	11.33	6.84
Location is Northeast (1 if Yes, 0 otherwise)	0.00	1.00	0.13	0.34
Location is North-central (1 if Yes, 0 otherwise)	0.00	1.00	0.32	0.47

determinant of "certain zero" [no incidence of food insecurity] and Poisson model of severity of food insecurity) is preferable to the traditional Poisson model or otherwise, given the study data. All analyses and tests were undertaken using the relevant procedures in Stata 16.

As noted in Stata 16 documentations, the Hausman is a general implementation of Hausman's (1978) specification test, which compares an estimator $\widehat{\theta}_1$ that is known to be consistent with an estimator $\widehat{\theta}_2$ that is efficient under the assumption being tested. The null hypothesis is that the estimator $\widehat{\theta}_2$ is indeed an efficient (and consistent) estimator of the true parameters. If this is the case, there should be no systematic difference between the two estimators. If there is a systematic difference in the estimates, there exists a reason to doubt the assumptions on which the efficient estimator is based.

In this application, we compared the Instrumental Variable Poisson (ivpoisson) estimates with those of the traditional Poisson, and conducted the Hausman endogeneity test as reported in Appendix Table A3. The instruments included two dummy variables – native (that captured whether or not the household head is a native of the community) and PHCN (that captured whether or not the community is connected to the national electricity), in addition to the exogenous regressors in Table 1. We posit that natives may have a stronger sense of security of the inherited land than non-natives have of purchased land, and thus may be less likely to invest in land titling. Similarly, non-natives may have less access to farmland, and as such may have greater likelihood to combine farming with off-farm activities than natives do. We also postulate greater access to off-farm activities in communities linked to the national electricity grid than what obtains in communities without electricity supply. To make a choice between ZIP and traditional Poisson, we compared estimates from the ZIP and traditional Poisson regression models.

4. Results and discussion

4.1. Socio-economic profiles of households of the rice farmers

The socio-economic profiles of the sampled farm households are summarised in Table 2; while Table 3 summarises the characteristics of the farmlands cultivated by their members. As shown in Table 2, the majority (57.0%) of the rice farmers across the three geopolitical zones of Northern Nigeria were within the age bracket of 31–50 years. The mean age was 43 years. This suggests that rice farmers in Northern Nigeria are mostly within the mid-age, and are relatively younger than the typical farmer in the area, which Eze et al. (2011) reported was 59 years old. This however, is most likely because of the recent drive by the Federal Government of Nigeria to encourage the youths to embrace agriculture, targeting rice among selected crops.

Results on Table 2 also show that the typical rice farmer is 94% likely to belong to a male-headed household, 94% likely to be married, and 70% likely to belong to a household whose members jointly cultivated about 2 ha of land, which in 61% of the cases are fragmented into two or more parcels. Results on Table 3 also show that majority (62.4–69.7%) of the households across the three GPZ inherited their farmlands, while about 17% purchased the land. Over 70% of the households perceived they enjoy secure tenure on the land, as most believed they could invest in tree cropping (87%), sell (78.4%) and/or bequeath (76.0%) the land to their children. However, only a few (<10%) of the landholding were registered either with the Local Government Authorities (6.8%) or the State authorities (2.0%). The general LTPRs patterns are similar across the three GPZs, except that incidences of leasehold are relatively higher (15.2%) in the Northeast while incidences of communal holding are relatively higher in the North-central (20.7%).

4.2. Household food security status in Northern Nigeria

Figure 1 summarises the distribution of the rice farmers' households by HFS Scores while Table 3 summarises the distribution by food security status and geopolitical zone. The results showed that about 17.5% of the households recorded zero HFS score, while about half (55.8%) were of high or marginal food security status.

The results in Table 4 is a confirmation that food insecurity remains a major challenge in Northern Nigeria, with the prevalence of low and very low food security being much higher in the Northeast (60.9%) and the North-central (50.3%) than the average (44.2%). A chi-square test of association between HFS Status and geopolitical zone confirms that the HFS status distribution varies significantly ($p < 0.01$) across the geopolitical zones.

4.3. Econometric results with respect to household food security

Table 5 summarises the main econometric results of this study. The results include estimates of the traditional Poisson model (m_1), the Instrumental Variable [IV] Poisson model (m_2), and the Zero Inflated Poisson [ZIP] model (m_3), including the count (Poisson part) and the

Table 2. Socio-economic characteristics of the rice farming households.

Description	North central		North east		North west		All	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
Age Group								
≤30	36	22.0	16	22.0	40	13.0	92	17.0
31–40	48	29.0	22	30.0	82	26.0	152	28.0
41–50	43	26.0	24	32.0	93	30.0	160	29.0
51–60	24	15.0	7	9.0	76	25.0	107	19.0
>60	14	8.0	5	7.0	19	6.0	38	7.0
Mean Age (years) = 43								
Gender								
Male	148	90.0	69	93.0	300	97.0	517	94.0
Female	17	10.0	5	28.0	10	3.0	32	6.0
Education Attainment								
No formal education	42	25.0	18	24.0	118	38.0	178	32.0
Arabic education	9	5.0	0	0.0	51	17.0	60	11.0
Primary	26	16.0	8	11.0	42	14.0	76	14.0
Secondary	50	30.0	18	24.0	42	14.0	110	20.0
Tertiary	38	23.0	30	41.0	56	18.0	124	23.0
Mean Year of Schooling = 7								
Marital Status								
Married	152	92.0	64	86.0	299	96.0	515	94.0
Widowed/Divorced	10	6.0	9	12.0	8	3.0	27	5.0
Single	3	2.0	1	1.0	3	1.0	7	1.0
Household Size								
1–5	35	21.0	25	34.0	47	15.0	107	19.0
6–10	54	33.0	35	47.0	122	39.0	211	38.0
11–15	39	24.0	7	9.0	80	26.0	126	23.0
>15	37	22.0	7	9.0	61	20.0	105	19.0
Mean Household size = 10 persons								
Farm size (ha)								
Small farm (<2)	98	59.0	62	0.84	225	73.0	385	70.0
Medium farm (2–5)	49	30.0	12	0.16	72	23.0	133	24.0
Large farm (>5)	18	11.0	0	0.00	13	4.0	31	6.0
Mean Farm size = 2.09								
Simpson Index (Land Fragmentation)								
Fragmented	82	50.0	30	41.0	104	34.0	216	39.0
Consolidated	83	50.0	44	59.0	206	66.0	333	61.0
Mean Simpson Index = 0.23								

Source: Field Survey; 2017.

logit "certain zero" (Inflate) component. The parameters of both the traditional Poisson and ZIP models were computed using the maximum likelihood estimation (MLE) method, while the IV-Poisson model was estimated by the generalized methods of moments (GMM). The Likelihood ratio tests showed that the two MLE versions provide a good fit to the data, as the calculated chi-square values associated with the two versions of the model were both significant at $p < 0.01$.

4.4. Regression specification-error test

Ramsey's (1969) Regression Specification Error Test (RESET) is specifically meant for linear regression models. The test is necessary when the regression model contains irrelevant extra variables, functional form misspecification, and omission of important variables(s). In order to address the concern that the poisson model may suffer omitted variable bias which is plausible if some important but unmeasured variables that may explain food insecurity which is correlated with some of the regressors have been omitted in the analysis. A post estimation command in Stata "*estat ovtest*" for an ordinary least square (OLS) estimate of the food security score was conducted. The calculated F value was 0.6559, which is not significant at $p < 0.10$, thus rejecting the null hypothesis of no omitted variables in the model.

4.5. Hausman specification tests

Results in Table 5 also provide a summary of the Hausman specification tests; including the endogeneity test [m_2 vs m_1] and the Independence of Irrelevant Alternatives [IIA] test (m_3 vs m_1). The latter is synonymous with asserting that the logit (inflate) part of the ZIP model is irrelevant. First, we find that the calculated Chi-square value associated with the Hausman endogeneity test was not significant even at $p < 0.10$. This shows that the difference in coefficients of the IV Poisson and the traditional Poisson models is not systematic. Hence, there is no sufficient evidence to suggest that the variables on land titling and participation in off-farm activities are endogenous to our HFS models. The results in respect IIA [logit part of the ZIP] however, revealed that the difference in coefficients of the traditional Poisson and the Poisson part of the ZIP model is systematic at $p < 0.01$. Hence, we found ZIP as the most appropriate specification of the HFS problem, given our study data.

Beyond the choice of specification, evidence-based results in Table 5 are generally consistent, particularly in terms of signs of most

Table 3. Distribution of cultivated parcels by tenure types.

GPZ	North central	Northeast	Northwest	All
Acquisition mode %				
Inherited	62.4%	69.7%	62.8%	63.4%
Purchased	9.8%	12.1%	22.0%	17.5%
Leasehold	12.4%	15.2%	7.7%	9.9%
Communal	20.7%	3.8%	9.5%	11.9%
Rights Held on Farmland (%)				
Can grow tree crops	85.1%	84.9%	88.2%	87.0%
Can restrict access to others	78.4%	83.3%	86.2%	83.8%
Can develop structures on land	81.2%	84.1%	85.7%	84.3%
Can lease out to others	76.2%	84.1%	85.4%	82.7%
Can sell the land	66.9%	81.1%	83.2%	78.4%
Can bequeath to own children	66.7%	80.3%	79.4%	76.0%
Land titling Status %				
Has well defined boundaries	15.0%	25.8%	11.6%	14.2%
Registered with Traditional Council	12.8%	9.9%	8.5%	9.9%
Registered with Local Government	6.9%	15.2%	5.2%	6.8%
Registered with the State	1.2%	3.0%	2.2%	2.0%

Source: Field Survey; 2017.

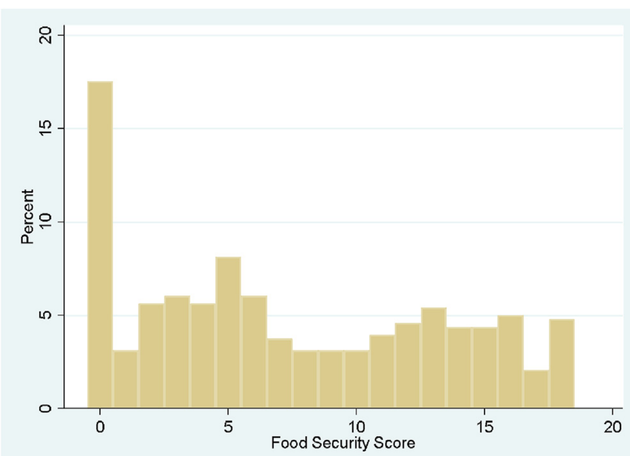

Figure 1. Distribution of rice farmers' households by HFS Scores.

parameters, across the three specifications: Poisson, IV Poisson, and Zero Inflated Poisson (ZIP) model. The ZIP specification has the largest number of significant coefficients (14 out of 18, with seven being significant at 1% level), while the IV Poisson had the lowest number of significant coefficients (five). If land titling was to be endogenous, however, the IV Poisson results would suggest that the influence of all the land and LTPR related variables were insignificant, even though they generally share similar signs with those of the traditional Poisson and ZIP specifications. There was, however, no evidence to support endogeneity of any of the LTPRs related variables, given the study data. Hence, we consider evidence-based on ZIP model to be efficient and consistent, and thus robust for policy analysis.

4.6. Determinants of "Certain Zero" (No Food Insecurity)

The ZIP inflate (logit part of ZIP) regression result provides evidence with respect to the influence of the hypothesised food security determinants on the likelihood of the FSS score being certainly zero. That is, that a household will not return any affirmative response to any of the 18-food insecurity related questions; thus implying that such households are certainly food secure in all regards. As shown in the last three columns of Table 5, only three of the hypothesised FSS determinants were associated with significant coefficients. These include the gender of the household head (Female = 1), a dummy variable for a household head that is single and total income.

The likelihood of recording a "certain zero" is significantly ($p < 0.01$) higher among female-headed households and households ($p < 0.10$) whose heads are single. These suggest, *ceteris paribus*, that female-headed

Table 4. Classification of households by food security status and geopolitical zone.

Food Security Status	Northwest	Northeast	North-central	Total
Very low food security	52	23	49	124
	(20.1)	(35.9)	(32.2)	(26.1)
Low food security	41	16	29	86
	(15.8)	(25.0)	(19.1)	(18.1)
Marginal food security	95	14	32	141
	(36.7)	(21.9)	(21.0)	(29.7)
High food security	71	11	42	124
	(27.4)	(17.2)	(27.6)	(26.1)
Total	259	64	152	475
	(100.0)	(100.0)	(100.0)	(100)

Note: Pearson Chi^2 (df = 6) = 22.32 Prob. = 0.001.
Source: Field Survey; 2017.

Table 5. Estimated ZIP model of household food security in Northern Nigeria.

Explanatory Variables	Poisson (m_1)		IV-Poisson (m_2)$^+$		ZIP Count ($m_{3,a}$)			ZIP Inflate ($m_{3,b}$)		
	Coef.	z	Coef.	z	Coef.	z	exp (coef.)	Coef.	z	exp (coef.)
Farm size (Ha)	-0.0051	-0.74	-0.0054	-0.33	-0.0064	-0.97	0.99	0.0006	0.01	1.00
Freehold share of farmland	-0.1496***	-2.7	-0.3375	-1.05	-0.1629***	-2.9	0.85	-0.2886	-0.69	0.75
Leasehold share of farmland	-0.0629	-0.84	-0.0518	-0.33	-0.1654**	-2.2	0.85	-1.0491	-1.61	0.35
Registered x Freehold share	0.0873	1.53	0.8544	0.88	0.1224**	2.14	1.13	0.2068	0.48	1.23
Lowland share	-0.1441***	-3.61	-0.0606	-0.4	-0.0596	-1.47	0.94	0.4550	1.43	1.58
Simpson index (land fragmentation)	0.0145	0.21	0.0307	0.19	0.0017	0.02	1.00	-0.0976	-0.19	0.91
Extension contact (Access = 1)	-0.0366	-0.93	-0.0732	-0.72	-0.0835**	-2.12	0.92	-0.2843	-0.94	0.75
Age of Head (Years)	0.0567***	6.27	0.0582***	2.66	0.0435***	4.9	1.04	-0.0565	-0.92	0.95
Age squared	-0.0005***	-5.19	-0.0005**	-2.29	-0.0004***	-3.87	1.00	0.0006	0.85	1.00
Education of Head (Schooling years)	-0.0056*	-1.9	-0.0116	-1.08	-0.0052*	-1.72	0.99	0.0170	0.76	1.02
Gender of Head (Female = 1)	-0.3822***	-4.11	-0.3753	-1.53	0.1558*	1.67	1.17	1.8889***	4.03	6.61
Head is single	0.1509	1.42	0.1846	0.68	0.3763***	3.59	1.46	1.0886*	1.81	2.97
Head is widowed/divorced	0.4888***	3.37	0.5322	1.62	-0.1577	-1.09	0.85	-22.1206	0.00	0.00
Household income	-4.29E-08**	-2.07	0.0000	-0.71	0.0000	0.4	1.00	0.0000*	1.87	1.00
Household size	0.0037	1.45	0.0026	0.45	0.0019	0.76	1.00	-0.0125	-0.62	0.99
Northeast dummy	0.3547***	6.83	0.2891*	1.96	0.2573***	4.84	1.29	-0.7722	-1.63	0.46
North-central dummy	0.2274***	5.84	0.2052**	2.27	0.2223***	5.54	1.25	-0.0930	-0.32	0.91
Constant	0.6274***	2.78	0.6718	1.23	1.1239***	5.04	3.08	-0.1799	-0.12	0.84
Diagnostics										
LR Chi sq. (17)	234.74***				144.40***					
Log likelihood	-1944.12				-1521.38					
Hausman Chi-sq.(17) – endogeneity test [m_2 vs m_1]	1.45									
Hausman Chi-sq.(17) – IIA test [m_3 vs m_1]	1805.03***									

Note: $^+$ *Instrumented:* Freehold_Reg.; *Instruments:* Farmsize_Ha Freehold Leasehold Lowland SI Extension contact Age AgeSq SchlgYrGender Never married Once married total_income HHSize Northeast Northcentral Native PHCN.
***, **, * represent statistical significance at 1%, 5% & 10%.

households and single-person households are those that are most likely not to experience any form of food insecurity.

The coefficient of household total income is positive and significant at the 10% level. This shows that a unit increase in household income will increase the likelihood of a household recording a "certain zero", and thus not experiencing any form of the food insecurity dimensions that underlie the USDA HFS assessment.

4.7. LTPRs and severity of household food insecurity

The ZIP – Count (Poisson part) of the estimated ZIP model provides evidence with respect to the influence of various hypothesised determinants on the severity of household food insecurity. Results in respect of the influence of land and LTPRs related variables – farm size and the share of personally inherited or purchased (freehold), leased, registered and lowland area in the farmland is found in the first six rows of Table 5. Four out of the six land and LTPRs related variables were associated with significant coefficients in the ZIP count (severity of food insecurity) model. The coefficient of the share of freehold and leasehold farmland were both negative and significant at 1% and 5% levels respectively while that of the share of freehold land that was registered was positive at the 5% level. These show that the severity of food insecurity among the farm households' declines with an increase in share farmlands acquired through direct inheritance or purchase (freehold) as well as lease, as against cultivation of communal land. These results are consistent with the evidence in Shittu et al. (2018), who found that only smallholder farmers that were confident that their title to farmland is well defined and *de facto* secure that embraced agricultural practices with Climate-Smart Agriculture potentials.

It also corroborates the evidence from the literature that secure land tenure provides incentives for farmers to invest and make improvements to their land to ensure full utilization of land (Roth and McCarthy, 2013). The evidence with respect to land titling, however, does not follow *a priori* expectation. Results in Table 5 showed that the larger the area of farmland that has been registered, the larger the food insecurity. This, however, may not be unconnected with the high cost of land titling in Nigeria. This factor tends to limit title registration to lands in an urban and peri-urban landscape that are planned for sale for housing purposes, and those that have been subject to conflicts.

On the other hand, the coefficient of the share of lowland cultivated was negative and significant at the 10% level. This shows that the severity of food insecurity among the farm households declines with an increase in the share of lowland that was cultivated. This can be because the households can cultivate rice throughout the year and consequently, produce more for household consumption and for sale, given the swampy nature of the farm. Thereafter, they have a better chance to reduce food insecurity than their upland farmers' counterparts. This study, therefore, suggests that cultivating lowland and/or adopting irrigation farming in the study area can reduce food insecurity.

4.8. Socio-demographic factors and severity of household food insecurity

The ZIP – Count (Poisson part) of the estimated ZIP model provides evidence with respect to the influence of various socio-demographic variables on the severity of household food insecurity. Results in respect of the influence of socio-demographic characteristics – access to extension services, age, education, gender, a dummy variable for a household head that is single, as well as dummies for the northeast and north central GPZs are found immediately after the LTPRs variables in Table 5. Eight out of the 10 socio-demographic variables were associated with significant coefficients in the ZIP count (severity of food insecurity) model.

The coefficient of access to extension contact was negative and significant at the 5% level. This shows that the severity of food insecurity among the farm household declines with having access to extension services. This suggests that access to extension services will enhance the chances of the farm households to have access to better crop production techniques, improved input as well as other production incentives, hence, raising their farm output.

Results in Table 5 shows that there is a significant and positive relationship between the age of the household head and the severity of food insecurity, even though the relationship is not linear as confirmed by the negative coefficient of the age squared. This further shows that a year's increase in age will increase the severity of food insecurity of the farm household in Northern Nigeria. However, as the household heads grow older in life, their food insecurity reduces, suggesting that rice farming' households tend to be food secure later in life as against when they are still much younger. This can be because the farming households had acquired more experience in farming operations, off/non-farm activities, accumulate wealth and use efficient planning strategies, therefore, having better chances to reduce food insecurity. This result agrees with that of Olagunju et al. (2012) who found that a year increase in the age of the household head reduces food insecurity.

The coefficient of household head education is significantly negative at 10%. This shows that a year's increase in the level of education of household heads will reduce the severity of food insecurity. This suggests that the level of formal education has a great impact on reducing household food insecurity. On the contrary, the coefficient of the gender of the household head is positive and significant at 10%. This shows that being a female-headed household will increase the severity of food insecurity among the rice farming household in the study area. This could be as a result of a lower dependency ratio observed in male-headed households where both the head and their spouse are engaged in income-generating activities. This, however, is not so in the female-headed households where the dependency is mainly on the head who are either widowed or unmarried. Hence, buttressing the significantly positive effect of the household head that is single, widowed or divorced on the severity of food insecurity.

The results in Table 5 further reveals that the coefficient of the dummy variables for northeast and north central GPZs are significant and positive at 1%. This shows that the severity of food insecurity is location-specific as farm households residing in these two GPZs are prone to food insecurity as against their counterparts in the northwest region.

5. Conclusions

We examined the influence of LTPRs on household food security among rice farmers in Northern Nigeria and conducted Hausman (1978) endogeneity and specification tests. The ZIP model provided evidence with respect to the influence of various hypothesised determinants on the severity of household food insecurity. Household food security was measured using household food security survey modules of the USDA approach. This study makes use of the 2017 Federal University of Agriculture, Abeokuta (FUNAAB) ECOWAS RAAF PASANAO[2] Survey, a Nation-wide Survey of Cereals Production Systems and Willingness to Accept Incentives to Adopt Climate-smart Practices among Smallholders in Nigeria using household socio-economic cross-sectional survey data from 549 households. With reference to the USDA classification of household food security status among farming households in the study area, the paper found that about 26.1% of the sampled households were highly food secure, 29.7% were marginal food secure, while 18.1% and 26.1% fall into low and very low food secure categories.

The main factors that influence the severity of households' food insecurity include the share of personally inherited or purchased (freehold), leased, registered, and lowland area in the farmland, access to extension services, age, education, gender, a dummy variable for a household head that is single, household income, as well as dummies for the northeast and north-central GPZs. Similarly, the factors that determine whether a household will be food secure at all costs are share of farmland on leasehold, the gender of household head (Female = 1), a dummy variable for a household head that is single, and household income.

Based on the empirical results, the paper concludes that investment should be made by all three tiers of government and relevant stakeholders into irrigation agriculture. Given that there is a natural scarcity of lowland, this strategy can be pursued among the Northern rice farmers through the adoption of irrigation systems. In the same vein, the extension agents should be adequately funded and trained for prospective professional attributes to allow for the effective extension services delivery. The focus should also be on the promotion of sustainable land management through the inventory and assessment of soil as well as land resources and their use. Finally, rural land governance systems in northern Nigeria should be strengthened to enhance the security of Land Tenure and Property Rights and the promotion of medium to long-term land leasing.

Declarations

Author contribution statement

Kehinde, M.O.: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Shittu, A.M.: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Adewuyi, S.A.; Osunsina, I.O.O.; Adeyonu, A.G.: Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

[2] Economic Community of West African States (ECOWAS) Regional Agency on Agriculture and Food (RAAF) Programme for Food and Nutrition Security in West Africa (PASANAO).

Appendix

Table A1. The 18-Households Food Security questions as adapted

S/N	Questions/Statements	N	S	O
1	We were worried our food would run out before we got money to buy more			
2	The food we bought just didn't last and we didn't have money to get more			
3	We couldn't afford to eat balanced diet			
4*	We relied on only a few kinds of low-cost food to feed the children			
5*	We couldn't feed the children a balanced meal			
6*	The children were not eating enough because we just couldn't afford enough food			
7	Did some adults ever have to eat less than you felt you should eat because there wasn't enough money to buy food?	Yes( ) No( )		
8	How often did this happen in the last 12 months?			
9	Did some adults ever had to eat less than you felt you should eat because there wasn't enough money for food	Yes ( ) No( )		
10	Were some members ever hungry but didn't eat because you couldn't afford enough food?	Yes ( ) No( )		
11	Did some members ever lose weight within the last 12 months because there wasn't enough food?	Yes ( ) No( )		
12	Were there ever a time within the last 12 months that some adults could not eat for a whole day because there wasn't enough money to buy food	Yes ( ) No( )		
13	How often did this happen in the last 12 months?			
14*	Did you ever have to cut the size of some of the children's meals within the last 12 months because there wasn't enough money to buy food?	Yes ( ) No( )		
15*	Did any of the children ever skip meals because there wasn't enough money for food within the last 12 months because there wasn't enough money to buy food?	Yes ( ) No( )		
16*	How often did this happen in the last 12 months?			
17*	In the last 12 months, were the children ever hungry but you just couldn't afford more food?	Yes ( ) No( )		
18*	In the last 12 months, did any of the children ever not eat for a whole day because there wasn't enough money for food?	Yes ( ) No( )		

Note: N=Never, S = Sometimes, O = Often.
*Not applicable to households without children. Source: USDA Guide, 2000.

Table A2. USDA Food Security Classification

Status	Number of Affirmative Responses	
	Households with children	Households without children
High Food Security	0–2	0–2
Marginal Food Security	3–7	3–5
Low Food Security	8–12	6–8
Very Low Food Security	13–18	9–10

USDA, 2016.

Table A3. Hausman Endogeneity Test Results

	(b)	(B)	(b-B)	sqrt (diag (V_b-V_B))
	m3	m1	Difference	S.E.
Freehold_Reg	0.85439	0.087299	0.767091	0.970496
Farmsize_Ha	-0.00541	-0.00515	-0.00026	0.014784
Freehold	-0.33747	-0.14961	-0.18787	0.317167
Leasehold	-0.0518	-0.06291	0.01111	0.136159
LowLand	-0.06063	-0.14409	0.083457	0.14484
SI	0.030714	0.014473	0.016241	0.141986
Extensionc ~ t	-0.07317	-0.03656	-0.03661	0.093636
Age	0.058208	0.056725	0.001482	0.019956
AgeSq	-0.0005	-0.00048	-2.3E-05	0.000199
SchlgYr	-0.0116	-0.00557	-0.00603	0.010381
Gender	-0.37526	-0.38221	0.006946	0.227178
Never_marr ~ d	0.18459	0.150876	0.033713	0.250035
Ever_married	0.532214	0.488785	0.04343	0.295808
total_income	-3.64E-08	-4.29E-08	6.54E-09	4.67E-08
HHSize	0.002582	0.0037	-0.00112	0.005139
gpz_2	0.289091	0.354706	-0.06562	0.137871
gpz_3	0.205224	0.227369	-0.02214	0.081672
_cons	0.671804	0.627391	0.044414	0.495582

b = consistent under Ho and Ha; obtained from ivpoisson
B = inconsistent under Ha, efficient under Ho; obtained from poisson.
Test: Ho: difference in coefficients not systematic.

$chi^2(17) = (b-B)'[(V_b-V_B)(-1)](b-B) = 1.45$ Prob > $chi^2 = 1.0000$.
Further note for ivpoisson
Instrumented: Freehold_Reg
Instruments: Farmsize_Ha Freehold Leasehold LowLand SI Extension contact Age AgeSq SchlgYr Gender Never_married Ever_married total_income HHSize Northeast Northcentral Native PHCN.

Table A4. Hausman Specification Test Results

	(b)	(B)	(b-B)	sqrt (diag (V_b-V_B))
	m3	m1	Difference	S.E.
Freehold_Reg	0.1224	0.0872	0.035102	0.006029
Farmsize_Ha	-0.006	-0.0051	-0.00128	
Freehold	-0.1629	-0.1496	-0.01331	0.009703
Leasehold	-0.1654	-0.0629	-0.10253	
LowLand	-0.0596	-0.1440	0.084453	0.008109
SI	0.0017	0.0144	-0.01277	
Extensionc ~ t	-0.0835	-0.0365	-0.04695	0.002482
Age	0.0434	0.0567	-0.01326	
AgeSq	-0.0003	-0.0004	0.000129	
SchlgYr	-0.0051	-0.0055	0.000412	0.000621
Gender	0.1558	-0.3822	0.538049	0.009068
Never_marr ~ d	0.3762	0.1508	0.2254	
Ever_married	-0.1577	0.4887	-0.64652	0.006232
total_income	9.23E-09	-4.29E-08	5.21E-08	1.07E-08
HHSize	0.0019	0.0037	-0.00178	
gpz_2	0.2573	0.3547	-0.09739	0.011337
gpz_3	0.2222	0.2273	-0.00511	0.00962
_cons	1.1239	0.6273	0.496571	

b = consistent under Ho and Ha; obtained from zip.
B = inconsistent under Ha, efficient under Ho; obtained from poisson.
Test: Ho: difference in coefficients not systematic$chi^2(17) = (b-B)'[(V_b-V_B)(-1)](b-B) = 1805.03$Prob > $chi^2 = 0.0000$(V_b-V_B is not positive definite).

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