Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.4, No.14, 2013

Do Land Disputes Affect Smallholder Agricultural Productivity? Evidence from Kenya

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The research is financed by Centre for Environmental and Economic Policy in Africa (CEEPA), University of Pretoria, South Africa. The data used in this study came from Research on Poverty, Environment, and Agricultural Technologies (REPEAT) project, a collaborative initiative involving Tegemeo Institute (Egerton University, Kenya), World Agro-forestry Centre (ICRAF, Kenya) and the Foundation for Advanced Studies on International Development (FASID, Japan).

Abstract
Rural households experience land disputes with relatives or neighbors. These conflicts, even if small-scale in nature, may have considerable impact on incentive to invest on land productivity enhancing inputs. This study investigates the impacts of land disputes on households' incentive to invest in farmyard manure and inorganic fertilizers, and on crop productivity in Kenya. A truncated normal hurdle model is applied on farm plot level data. The results show that land conflicts affect smallholder farmers' optimization behaviour. Farmers are indisposed to apply farmyard manure or to plant perennial crops on disputed plots. When other production inputs are controlled for, active land disputes reduce agricultural productivity through other avenues such as constrained crop choice and reduced crop care by about 13 percent. In view of these results and in the context of the ever shrinking farm sizes, the efficiency of land disputes resolution systems emerge very important policy issue.
Keywords: Land disputes, chemical fertilizers, organic fertilizers, agriculture, Kenya

1. Introduction

Formal land tenure systems have been touted to increase land-related investments (Deininger *et al*., 2006). Economic theory posits that property rights in land are a prerequisite for land development and conservation (Demsetz, 1967). As a result, most of the earlier studies focused on the impact of secure land rights on investment on land. In this case, land rights were narrowly construed to mean land ownership with title deeds. Results from these studies have been mixed. While some studies have found little or no impact of land rights on investment on land (Pinckney and Kimuyu, 1994; Place and Migot-Adholla, 1998), others have found land registration encourages long-term investments on land (Lee, 1980; Place and Hazell, 1993; Deininger *et al*., 2006). Individuals owning land with title deeds were found to have greater incentive to develop ways of preserving and regenerating it. Reduction in the probability of losing land parcels provide land owners with greater assurance that they will be able to 'enjoy the fruits of their labor' especially if they engage in long-term land conservation investments. Insecure land rights are thought to encourage survival strategies with short-term horizons that are detrimental to land resource.

Conversely, some other studies have shown that land registration can exacerbate rather than reduce land conflicts. For example, an attempt to impose formal land tenure system on an existing well-established customary system in Mbeere district of Kenya was found to be counterproductive (Wilson, 1972). This is a pointer to many innumerable cases where under customary land system, rights to land are recognized and respected even without the formal institution of title deeds. In such cases, investment on land has taken place irrespective of whether the ownership is formalized or not. There are also equally countless cases where land ownership has been contested even when the land is registered. For example, there are incidences where women in Africa have lost access to matrimonial land after the death of their spouse regardless of the institution of title deeds (Richardson, 2004).

Literature is emerging revealing that land conflicts do occur among relatives or neighbors irrespective of whether land is 'owned' under the formal or the customary system. In Kenya, besides the large scale ethnic related land conflicts, households do experience small scale conflicts. Results from focus group discussions conducted by the authors in June 2012 to examine the scale of emerging land constraints in rural Kenya established that with the diminishing landholding sizes, land conflicts among relatives and neighbors are on the increase (Muyanga, 2013). Such conflicts have the potential of keeping a piece of land either unused or sub-optimally utilized for some time especially in context of inefficient land dispute resolution systems. Land conflicts, even if small-scale in nature, have impact on incentive to invest on land and consequently on agricultural productivity. For example, Yamano and Deininger (2006) found that pending conflicts reduce organic fertilizer use by 31 in Kenya. Deininger and Castagnini (2006) found that agricultural outputs from plots affected by conflicts are lower compared to outputs from dispute free plots in Uganda. The decline in agricultural productivity was estimated somewhere between 5.5 and 11 percent. The study also found that land conflicts increase chances of selling the disputed parcel to unsuspecting buyers.

Land disputes in Kenya are handled either by the customary or the formal legal dispute resolution systems. The customary dispute resolution approach is taken outside the courts under the authority of local provincial administration officials or councils of elders. Customary dispute resolution system is more accessible, has local knowledge and is less costly when contrasted with the formal court system (Nyambu-Musembi, 2003; Kane *et al*., 2005). However, evidence is emerging that this system is becoming monetized with all the related rent-seeking tendencies (Henrysson and Joireman, 2006). Alternatively, dispute resolution is taken up with the formal decentralized dispute resolution units; the district Land Dispute Tribunal. If one party is not satisfied with a ruling at this level, the case is referred to the Provincial Land Dispute Tribunal, and consequently to the Central Land Dispute Tribunal if an amicable solution is not found at the provincial level. It is important to mention that these land dispute resolution mechanisms have not succeeded in effectively stemming land conflicts in Kenya. Unresolved land disputes still persist, a situation associated with the systems' inefficiencies and many appeals (Mugo, 2006). Land cases can take between five to ten years before a lasting resolution is found.

This study is set out to evaluate the impact of contested land ownership on investment on land productivity enhancing inputs and agricultural productivity in Kenya. It is hypothesized that unresolved land disputes affect agricultural productivity through two fronts. First, land disputes are hypothesized to restrict smallholder farmers' production decisions. In this case we focus on whether land disputes affect chemical and organic fertilizers 'use' and 'amount' decisions. Manure and chemical fertilizers are considered long-term investment and short-term investments, respectively. This is so because nutrients in manure are released to the soil over a long period of time while nutrients in manufactured chemical fertilizers are directly absorbed by the plants. Second, land disputes are hypothesized to influence land productivity through other avenues such constrained crop choices, interference with planting and inputs application timing, and reduced crop care.

Land is a very important factor in agricultural production in Kenya. This is because about 75 percent of the people derive their livelihood from land (Republic of Kenya, 2007) and landholding sizes and fertility are declining with increasing population densities. Besides, the national absolute rural poverty stands at 49.1 percent (Republic of Kenya, 2007). Substantial reduction in poverty will only be possible within a framework of improved agricultural productivity while conserving the land resource. The rest of the paper is organized as follows. The next section presents the methods and the data sources. The third section presents the results while fourth section concludes.

2. Methods and data sources

2.1 Econometric models

The overall objective of this study is to establish the impact of land disputes on agricultural productivity. As mentioned in the foregoing section, land disputes are hypothesized to influence agricultural productivity through two avenues; first, through influencing inputs use and quantity used decisions and second, directly via other avenues such as reduced crop care especially in the case of active conflicts. Consequently, we first model the impact of land conflicts on inorganic and farmyard fertilizer use. We conclude by modelling the impact land conflicts on crop productivity directly and indirectly through their effects on farm input use.

The conceptualization of impact of land disputes on land productivity enhancing inputs starts with the observation that farmer's decision to use a farm input is a sequential two step process. Initially, the farmer decides whether or not to use a farm input and if so, chooses the quantity of the respective input to use. Modelling decisions sequentially affords the flexibility of letting different factors affect the 'use' and the 'amount to use' decisions in different ways. While modelling agricultural inputs use in sub-Saharan Africa is common to encounter a non trivial percentage of the households that do not use certain inputs such as fertilizers. Survey data on input use exhibit a continuous distribution over strictly positive values and a 'piles up' of zeroes at some given extreme value. Since farmyard manure and inorganic fertilizers have been available in sub-Saharan Africa for a long while, it is usually assumed farmers are aware of the usefulness of these inputs (Ricker-Gilbert, 2011). However, owing to other conditions, for example financial or agronomic constraints, some farmers choose not to use them. Therefore, a 'zero' in input quantity use represents the farmer's optimal choice rather than a missing data value. Dependent variable distributed this way is referred to as *corner solution response*, where the corner in this case is at zero (Wooldridge, 2010). The standard ordinary least square (OLS) regression techniques are not suitable when the data are distributed in this manner. A corner solution model is more appropriate.

The traditional approach to deal with corner solution outcomes has been the standard Tobit model (Tobin, 1958).

In the population, let y be the corner solution response and x be the vector of covariates. Assume

$$y = \max(0, x\beta + u), \quad u \mid x \sim Normal(0, \sigma^2) \tag{1}$$

where u is unobservable, x is a vector of variables that explain decision to purchase and level of input use and β is a corresponding vector of parameters to be estimated. Expression (1) defines the standard Tobit model, $Tobit(x\beta, \sigma^2)$. Yamano and Deininger (2006) use this model on their earlier study which is related to the current one in some aspects. However, as shown by Wooldridge (2010), Tobit is fairly restrictive. The model implies that the partial effects of an explanatory variable on decision to apply an input, $P(y > 0 \mid x)$, and the amount used, $E(y \mid x, y > 0)$, must have the same sign. Tobit model also implies that the relative effects of two continuous variables on $P(y > 0 \mid x)$ and $E(y \mid x, y > 0)$ are identical. Consequently, more flexible models that allow separate mechanisms to determine 'participation decision' and the 'amount decision' are more appealing.

In this study, we use truncated normal hurdle model suggested by Cragg (1971). Using Wooldridge (2010) exposition and notation, let s be a binary variable that determine whether y is zero or strictly positive and w^*, a continuously distributed , nonnegative latent variable. Assume y is generated as $y = s \cdot w^*$. Note that w^* is observable when $s = 1$. If we assume that, conditional on a set of observed covariates, the mechanisms determining s and w^* are independent, then a two-part model is obtained,

$$E(y \mid x) = E(s \mid x) \cdot E(w^* \mid x) = P(s = 1 \mid x) \cdot E(w^* \mid x). \tag{2}$$

According to Cragg (1971), the binary variable s part is assumed to follow a probit model,

$$P(s = 1 \mid x) = \Phi(x\gamma) \tag{3}$$

while the latent variable w^* part is assumed to have a truncated normal distribution. Because $y = w^*$ when $y > 0$ we can obtain the conditional density, $f(y \mid x, y > 0)$, and the unconditional density, $f(y \mid x)$, and consequently the log-likelihood function for a random draw i,

$$\begin{aligned} \ell_i(\theta) = 1[y_i = 0] \log[1 - \Phi(x_i\gamma)] + 1[y_i > 0]\{\log[\Phi(x_i\gamma)] - \log[\Phi(x_i\beta / \sigma)] \\ + \log[\phi[(y_i - x_i\beta) / \sigma] - \log(\sigma)\} \end{aligned} \tag{4}$$

where $\theta = (\gamma, \beta, \sigma)'$. Since the parameters in the two parts are allowed to freely vary, the maximum likelihood estimation (MLE) of γ is the probit estimator of the probit regression of $s_i = 1[y_i > 0]$ on x_i and the MLE of β and σ^2 are obtainable from a truncated normal regression of y_i on $x_i \ \forall \ y_i > 0$.

Next we discuss some of the specification tests to be carried out to gauge how well the models fit the data. For the probit part, McFadden (1974) proposes the pseudo-R-squared defined as $1 - \ell_{ur} / \ell_o$ where ℓ_{ur} is the log-likelihood function for the estimated model and ℓ_o is the log-likelihood function in the model with only an intercept. However, a more plausible measure of goodness of fit carried out in this study is the percent of outcomes correctly predicted proposed by Wooldridge (2010). Similarly, we examine how well the truncated normal model fits the data by making comparisons with the standard Tobit and the lognormal hurdle models. The truncated normal hurdle model nests the Tobit model; when $\gamma = \beta / \sigma$ in (4), the truncated normal model collapses to the Tobit model. Thus, the usual log-likelihood ratio (LR) test is sufficient to compare the unrestricted truncated model with the restricted Tobit model under the null hypothesis, $H_o : \gamma = \beta / \sigma$. The test has a chi square distribution with degrees of freedom equal to the number of the explanatory variables. The truncated normal hurdle model is also compared with its closest two-part alternative, the lognormal hurdle model (Cragg, 1971). Unlike in the truncated normal model vs. Tobit model, neither truncated normal model nor lognormal hurdle model nests the other. Thus, the LR test is no longer available in this case. Since the probit part remains the same, we again use the percent of outcomes correctly predicted measure. However, to compare the lognormal part to the truncated normal part, we use the Vuong's (1989) model selection statistic. The test evaluates whether the difference between the truncated normal and the lognormal log-likelihoods evaluated at the estimated parameters is significantly different from zero.

Lastly, we model how chemical and farmyard manure use affect crop productivity. The analysis is carried out at the farm plot level. In this case, we assume that the farmers are utility optimizing agents. Farmers are assumed to evaluate the available production possibilities and allocate their resources to maximize their utility. After the first order differentiation of the farmers' objective function we emerge with a linear population production model of the form

$$q = z\pi + \mu \tag{5}$$

where q is the net value of crop output per acre of plot i; z is a vector of explanatory variables that are hypothesized to influence land productivity including quantity of farmyard and inorganic fertilizer use intensities, the element 1 is assumed to be the first member in vector z; π is the vector of coefficients to be estimated while μ is the stochastic error term. The standard approach to estimating model (5) is the ordinary least square (OLS) method. While we hypothesize that land disputes influence agricultural productivity through influencing inputs use, we need to account for other possible avenues through which land disputes can influence agricultural productivity by including land conflicts dummies directly in vector z. Such avenues would include effects of land disputes on crop care.

It is important to mention that there were concerns that higher quality land is likely to engender disputes and this could result in endogeneity problem in the estimation of models (1) and (5). In that case the suitable approach to estimating these models is either the instrumental variable method or the two step control function approach suggested by Wooldridge (2010). In this study we use the control function approach since it offers a direct exogeneity test for potential endogenous variables. First, we estimate a reduced form linear probability model of land disputes incidences at the land plot level whereby we include at least one variable, instrument variable (IV), that is thought to be highly correlated with land disputes occurrence and uncorrelated input use and crop output variables. In the second stage residuals from the first stage reduced form regression are incorporated in the estimation of models (1) and (5) to control for land disputes endogeneity. The instrumental variables used included the number of years the plot has been owned, the number of trees planted on the plot, and plot owner's religious affiliation and ethnicity.

The formal exogeneity test of the land dispute variable in these models using the control function approach failed to reject the null of exogeneity. This could be due to a number of reasons. First, as pointed out by Bound *et al.* (1995) obtaining plausible instrumental variables is an elusive task. There is empirical and theoretical evidence that IV estimation with weak instruments may perform bad and even poorer than OLS (Stock et al., 2002). Second, two reasonable considerations appear to water down the endogeneity fears in this study. These include: 1/ with high population growth, land has become a very scarce resource that is subject to conflict irrespective of quality, and 2/ the inclusion of the plot level land quality controls such as the slope of the plot and the geographical location of the plot.

2.2 Data source and variables

Data used in this study comes from a survey of 899 households conducted in 2007 in rural Kenya. The unit of analysis is the farm plot and there were 1263 plots in total. The data collection exercise was a part of Research on Poverty, Environment, and Agricultural Technologies (RePEAT) project, a collaborative initiative involving Tegemeo Institute (Egerton University, Kenya), World Agroforestry Centre (ICRAF) and the Foundation for Advanced Studies on International Development (FASID, Japan). The survey covered 15 districts across the country. The survey instrument captured plot level information including presence of active land disputes or future dispute concerns, chemical fertilizer and farmyard manure application, and other plot attributes. The instrument also collected household level information such as age, gender and level of education of the households' heads, the households' incomes, and the region where the households are located. Data on the number of number of cattle owned and adult members in the household was also collected. While cattle ownership proxied manure availability at close proximity, the number of adult members proxied human labour availability; manure is bulky and thus its application is labour intensive. Since animal manure and chemical fertilizers are taken as long-term and short-term investments respectively, they are not necessarily considered close substitutes. Thus, it is assumed decisions concerning chemical fertilizer and manure use are independent. A Spearman's rank correlation test between quantity of fertilizer and manure use returned a fairly weak positive relationship.

3. Results and discussion

3.1 Descriptive analysis

This initial sub-section discusses descriptive and bivariate relationships as a prelude to the econometric findings. Out of the 1263 plots, about four and nine percent of the plots had active ownership disputes and future disputes concerns, respectively. The major causes of disputes include boundaries, inheritance, and land sales related. Boundary conflicts are as a result of encroachment by neighbours' especially in situation where there are no clear land demarcations. Inheritance disputes relate relatives unable to reach an agreement over inheritance. Most of the plots (67%) were owned with title deeds. Table 1 summarizes the farm plot dispute (actual disputes/dispute concerns) and no dispute status against plot attributes and household characteristics.

Table 1. Characteristics of disputed and non-disputed land plots

	Plots with disputes (actual/concerns)	Plots without disputes
Owned with title deeds (% in each group)	42	68
Cultivation of annual crops (% in each group)	81	73
Cultivation of perennial crops (% in each group)	7	18
Applied fertilizer (% in each group)	43	44
Applied manure (% in each group)	51	51
Fertilizer application (KSh/acre)	302.28	383.01
Manure application (Kgs/acre)	308.89	520.64
Distance from the plot to household (minutes)	4.99	9.47
Gentle plots (slope) (% in each group)	71	72
Plot size (acres)	3.31	2.97
Productivity (value of output/acre) in KSh '000	32.86	34.42
Number trees (mean)	110.90	116.85
Number of cows (mean)	4.27	5.85

Source: Source: Tegemeo Institute/ICRAF/ FASID RePEAT project Surveys.

Out of the plots whose ownership was disputed, about 42 percent of them had title deeds. This underscore the point we alluded to earlier on that disputes arise even in cases where plots are formally registered. Perennial crops are likely to be planted on dispute-free plots. This is an indication that household will hesitate putting long-term crops on disputed plots. Presence of disputes influences chemical fertilizer and manure application. Higher intensities of manure are applied on plots whose ownership is undisputed (309kg/acre) compared to plots that have disputes (521kg/acre). Similarly, more fertilizer (KSh383/acre) is applied on plots without disputes compared to KSh302 per acre applied on the disputed ones. There is no significant difference between the disputed and non-disputed plots with regards to the slope and land productivity. These findings confirms our earlier assertion that with the diminishing land holding, all land types, irrespective of quality, have become important and thus are likely to endear conflicts. The results also show that plots owned by female household heads are more likely to attract disputes. Among the disputed plots, a large percentage is owned by females (29%) compared to 19 percent in the dispute-free plots.

3.2 Impact of land disputes on inputs "use" and "amount of use" decisions

Table 2 presents the results of the factors influencing the fertilizer "use" and "amount of use" decisions. In panel [a] we include dummies of actual disputes types while panel [b] include dummies of the future dispute concern types among the other covariates. The first two columns in each panel presents the first hurdle (probit) model results while the third and the fourth columns presents the second hurdle model of the truncated normal regression. First we discuss on how well the fertilizer models fit the data. The results from the two probit models, tell a consistent story. The signs of the coefficients are the same and the same covariates are statistically significant in each model. The models correctly predict fertilizer "use" decision about 70 percent and "no use" decision about 64 percent of the time. The overall weighted proportion of correct prediction is about 68 percent.

Next we evaluate how well the truncated normal model fits the data compared to the Tobit and the lognormal models. Generally, the results indicate that log-likelihood values of the truncated normal models are generally larger than those from the Tobit models counterparts in the two specifications (Table 2). The LR test strongly rejects the null hypotheses, $H_o : \gamma = \beta / \sigma$, in the two truncated normal models (second and fourth columns of Table 2), accordingly supporting the more flexible truncated normal hurdle model.

Next, we compare the squared correlation between y_i and the estimated unconditional mean $\hat{E}(y_i \mid x_i)$ across all i in both truncated normal and Tobit models. Again, the truncated normal hurdle model fits the unconditional mean substantially better than the standard Tobit model. To test how well the truncated normal hurdle model performs compared to the lognormal model, we use the Vuong's (1989) model selection statistic test. We fit the data first using the truncated normal model and next using the lognormal models. The difference in the log likelihoods of truncated normal and lognormal models is about 4.56 in the two models and is significant at one percent level. Similarly, conditional on fertilizer use, [$E(y \mid x, y > 0)$], the truncated model fits the conditional mean a lot better than the lognormal model too. Thus, unambiguously the Cragg's truncated normal hurdle model fits substantially better than both the Tobit and the lognormal models.

We are now ready to discuss the factors influencing the fertilizer "use" and "amount of use" decisions as presented in Table 2. The coefficients in the probit part are the average partial effects (APEs). The results indicate that the presence of actual plot disputes or concern about future plot disputes does not appear to influence fertilizer use and amount decisions. A joint LR test of the unrestricted specification against a restricted version (dispute types restricted to zero) with the null that all the dispute types parameters are jointly equal to zero supported the null. The only factors that influence fertilizer use decision are the plot slope, distance from the plot, and the plot size. Household are more inclined to applying fertilizer to less gentle plots with a probability of about 13 percent. Perhaps plots that are inclined are more likely to be less fertile therefore predisposing households' decisions to apply fertilizer on them. If the distance to a plot increases by a minute walking time, the probability to apply fertilizer on that plot reduces by about one percent. Similarly, an increase in plot size by one acre reduces the probability of fertilizer application by two percent. At the household level, household income, gender and the age of the household influence decision to apply fertilizer on plots.

Table 2. Factors influencing decision to apply fertilizer and quantity of fertilizer applied

	[a]				[b]			
	Hurdle I [Probit model]		Hurdle II [TN model]		Hurdle I [Probit model]		Hurdle II [TN model]	
Variables	APEs	SE	Coef.	SE	APEs	SE	Coef.	SE
Disputes (absence of disputes is the base)								
Inheritance	-0.01	0.05	-89.25	102.57	-0.02	0.06	-78.34	93.78
Boundary	-0.01	0.05	15.72	73.17	-0.03	0.05	107.64	78.18
Land sale	0.04	0.12	-125.13	147.86	0.05	0.13	-92.41	125.67
Other	-0.08	0.06	-47.14	105.93	-0.08	0.06	13.16	79.30
Plot slope (1=flat; 0=slopping)	-0.13***	0.03	-26.91	39.38	-0.13***	0.03	-25.01	36.28
Distance to the plot (minutes)	-0.01**	0.01	-60.21*	34.42	-0.01**	0.01	-57.86*	31.53
Plot size (acres)	-0.02***	0.01	-48.50**	23.55	-0.02***	0.01	-46.44**	21.36
Tenure (1=with title; 0=without title)	0.02	0.03	133.47	94.98	0.02	0.03	121.51	83.75
Head's education level (no education is base)								
Primary education	0.07*	0.04	23.60	70.26	0.07*	0.04	27.88	65.73
Secondary and post-secondary	0.05	0.05	83.74	88.98	0.04	0.05	83.78	83.13
Household income ('000 KSh)	0.05**	0.02	100.98**	47.01	0.06**	0.023	95.77**	41.34
Household head gender (male=1; female=0)	0.07**	0.03	-140.42	104.07	0.07**	0.034	-135.84	95.88
Age of household head (years)	0.02**	0.01	-2.54	2.10	0.02**	0.01	-2.37	1.90
/sigma			56.40***	17.47			54.23***	16.00
Number of observations	1263		552		1263		552	
Log-likelihood	-716.50		-1644.26		-716.49		-1642.73	
Pseudo R^2	0.17				0.17			
Proportion correctly predicted (use)	0.64				0.64			
Proportion correctly predicted (don't use)	0.70				0.70			
Proportion correctly predicted (overall)	0.68				0.68			

*Note: *** p<0.01, ** p<0.05, * p<0.1*

Table 2 shows that generally presence of actual land parcel disputes or concern about disputes in the future does not influence the quantity of fertilizer applied on plots. A joint LR test upholds the null hypothesis that actual disputes/dispute concerns do not jointly influence the intensity of fertilizer use. The factors that influence the quantity of fertilizer applied are the distance to the plot, the plot size and the household income. The APEs for these three variables and their standard errors are computed using the bootstrap approach. The average partial effects for distance, plot size and income variables are (respectively) -40, -33 and 69 in the model [a] and -39, -31 and 65 in the model [b]. Farmers apply more chemical fertilizers to plots at close proximity to the household compared to the far-flung ones. Large plot sizes receive low quantities of fertilizer while increase in household income increases the quantity of fertilizer applied.

We switch to the econometric results of the factors influencing the manure "use" and "amount of use" decisions (Table 3). The results are presented in the same way as in Table 2. In terms of how well the models fit the data, the first hurdle probit models do equally well as far as overall percentage correctly predicted. The overall weighted proportion of correct prediction is about 69 percent for the two models. The LR tests support the Cragg's truncated normal compared to the standard Tobit in the model. Similarly, the Vuong's (1989) model selection tests to compare the truncated normal hurdle and the lognormal hurdle models support the former. Apparently, we cannot do better with the Tobit or the lognormal models and thus we go by the more flexible truncated normal model.

Consequently, we present the results of the truncated normal hurdle model of factors influencing the manure "use" and "amount" decisions (Table 3). While concerns about future land disputes do not appear to influence manure use decision, actual land disputes related to inheritance seem affect the decision to apply manure on farm plots. The coefficient is however significant at ten percent level. We implement the LR tests on the unrestricted specification against restricted version (all dispute types coefficients restricted to zero) with the null that all parameters on the disputes types are jointly equal to zero. The results uphold the null hypotheses. The factors that influence the decision to use manure include the plot's slope and the distance from the plot to the homestead. Just as the fertilizer case, household are more disposed to applying manure to less gentle plots and to plots that are at close to the homestead. At the household level, the decision to use manure hinges on the households' incomes, gender of the household head and the households' cattle herd size.

The fourth column in Table 3 presents the truncated normal hurdle regression results of the factors that influence the intensity of manure applied. We compute the APEs and the bootstrap standard errors of the statistically significant covariates only. While not all dispute types affect the quantity of manure applied on farm plots, disputes related to inheritance and other disputes such as user rights do. Active land inheritance disputes reduce the quantity of manure applied by about 1,546.88 kilograms per acre. This represents a decline of about 64 percent from the average manure application rates in dispute fee plots. Other types of active disputes reduce the quantity of manure application by about 1,425.80 kilograms per acre; however this variable is only significant at ten percent significance level. Concerns about future inheritance land disputes reduce manure application by about 840.16 kilograms which represents about 35 percent drop from the mean application rate. A joint LR tests of the unrestricted specifications against restricted versions rejects the null that all actual disputes/dispute concerns types jointly do not influence the quantity of manure applied. This implies that, land disputes, either active or future concerns, reduce the amount of manure applied on farm plots.

Other important correlates of the amount of manure applied on plots are the distance to the plot from the households' homestead, the level of education of the household head, the households' level of income and the households' geographical location. While increased distances to farm plots reduce manure application, increase in the level of education of the household head and households' income increase it. Manure is bulky and its transportation is expensive and thus application rates are bound to be negatively influenced by distances to the plots and positively by the households' incomes.

Table 3. Factors influencing decision to apply manure and quantity of manure applied

	[a]				[b]			
	Hurdle I [Probit model]		Hurdle II [TN model]		Hurdle I [Probit model]		Hurdle II [TN model]	
Variables	APEs	SE	Coef.	SE	APEs	SE	Coef.	SE
Nature of disputes (absence of disputes is the base)								
Inheritance	-0.20*	0.11	-615.89**	309.87	-0.03	0.06	-415.12***	120.36
Boundary	0.12	0.09	-54.83	243.56	-0.05	0.06	-224.92	209.07
Land sale	-0.04	0.18	-174.89	241.60	0.04	0.12	-165.87	265.79
Other	-0.20	0.15	-551.03*	324.80	-0.05	0.07	-109.96	330.85
Plot slope (1=flat; 0=gentle slope)	-0.07**	0.03	-258.30	232.78	-0.06**	0.03	-257.19	231.36
Distance to the plot (minutes)	-0.09***	0.02	-88.10**	37.30	-0.09***	0.02	-88.40**	37.90
Plot size (acres)	-0.01	0.00	180.88	161.00	-0.01	0.00	179.62	161.86
Tenure (1=with title; 0=without title)	-0.02	0.03	4.46	155.93	-0.02	0.03	-22.71	158.79
Head's education level (no education is base)								
Primary education	0.03	0.04	435.14*	260.88	0.03	0.04	449.59*	259.69
Secondary and post-secondary	0.01	0.05	474.00*	254.54	0.00	0.05	491.43**	249.84
Household income ('000 KSh)	0.07***	0.03	727.75*	417.23	0.07***	0.03	724.41*	420.49
Household head gender (male=1; female=0)	0.06*	0.03	-63.00	136.75	0.07**	0.03	-25.35	138.26
Age of household head (years)	-0.01	0.01	3.80	6.72	-0.01	0.01	3.79	6.59
Number of adult members in the household	0.01	0.01	8.34	24.71	0.01	0.01	10.51	24.28
Livestock (number of cows)	0.06***	0.02	102.27	183.75	0.06***	0.02	105.36	185.07
/sigma			2368.14***	780.79			2366.57***	781.33
Number of observations	1263		640		1263		640	
Log-likelihood	-733.37		-4189.55		-736.01		-4855.26	
Pseudo R^2	0.16				0.16			
Proportion correctly predicted (overall)	0.69				0.69			

*Note: *** p<0.01, ** p<0.05, * p<0.1*

3.3 Impact of land disputes on agricultural productivity

Table 4 presents results from factors influencing agricultural productivity (log of net output value per acre). The first panel present the results when a dummy for active plot disputes are included while second panel presents the results when a dummy for plot dispute concerns in the future is included. The results show that, beside their influence on farmyard manure, somehow active land disputes and land disputes concerns affect land productivity through other avenues. Active disputes incidences reduce land productivity by about 13 percent while future disputes concerns reduce land productivity by about nine percent. However, the land disputes concerns dummy is only significant at ten percent.

Table 4. Results from Control Function estimation of factors influencing land productivity

Log of value (KSh)/acre is the dependent variable	[I]		[II]	
	Coef.	Robust S.E.	Coef.	Robust S.E.
Plot level variables				
Disputes (actual/concerns) (yes=1; 0=no)	-0.13**	0.06	-0.09*	0.05
Plot slope (1=flat; 0=gentle slope)	0.05	0.04	0.05	0.04
Distance to the plot (minutes)	-0.03*	0.02	-0.03*	0.02
Plot tenure (1=title deed; 0=no title deed)	0.18**	0.07	0.13**	0.06
Manure applied per acre('000Kgs)	0.02	0.01	0.02	0.01
Fertilizer applied per acre ('000KSh)	0.06**	0.02	0.07***	0.02
Household level variables				
Number of adult members in the household	-0.09	0.09	-0.01	0.01
Gender of household head (male=1; female=0)	-0.10	0.08	-0.04	0.07
Age of household head (years)	0.03	0.02	0.02	0.02
Household income '000KSh	0.15***	0.04	0.13***	0.04
Head's education level (base: no education)				
Primary education	0.06	0.06	0.07	0.07
Secondary and post-secondary	-0.02	0.79	0.01	0.08
Province (central province is the base)				
Nyanza	-0.08*	0.04	-0.09**	0.05
Western	-0.20*	0.11	-0.12	0.09
Rift valley	-0.23***	0.06	-0.21***	0.06
Eastern	-0.01	0.08	-0.04	0.08
_cons	0.31**	0.15	0.48**	0.21
Observations	1263		1263	
R-squared	0.44		0.50	

*Note: *** p<0.01, ** p<0.05, * p<0.1*

Other variables that influence land productivity include the distance to the plot; plot ownership tenure; intensity of fertilizer use; household's income level; and the geographical location where the plot is situated. For example, an increase by one minute walking distance to the plot reduces productivity by about three percent while getting a plot formally registered increases its productivity by 18 percent in the first model and by 13 percent in second model. Similarly, an increase of about KSh1000 worthy of fertilizer applied to a plot increases the plot's agricultural productivity by between six to seven percent in the two models. The quantity of manure applied seemingly does not influence land productivity. This result is not surprising since farmyard manure is considered a long term investment. An increase in household income by KSh1000 increases agricultural productivity by between 13 and 15 percent. Lastly, the geographical region where the plot is located indeed influences its agricultural productivity.

4. Conclusions and policy implications

This study set out to evaluate the impact of land disputes on agricultural productivity using truncated normal hurdle regressions. The three key empirical findings from this study are as follows: First, the descriptive results show that disputes influence the type of crops planted on disputed parcels. Perennial crops are likely to be planted on plots whose ownership is not contested. Since perennial crops are basically the cash and the industrial crops, land disputes bear some reduced agricultural productivity and to a large extent rural households' welfare implications. Second, the econometric analysis results show that while both active and future dispute concerns do not affect fertilizer "use" and "amount to use" decisions, they do affect manure application intensities. Land conflicts generally reduce the amount of organic manure applied on farm plots. Active or future disputes concerns related to inheritance significantly reduce the amount of manure applied on farm plots. Disputes related to inheritance occur in cases where relatives are unable to reach an agreement over inheritance. Unlike plot boundary disputes, inheritance related disputes are more likely to cause dispossessions of land compared to boundary and sales related disputes. Even though the quantity of manure applied does not appear influence land productivity directly, it definitely interferes with land productivity in the long run. To satisfactorily quantify the effects of reduced manure use on agricultural productivity, one has to appeal to time series dynamic econometric models. Third, active land disputes reduce land productivity through other avenues such constrained crop choices and reduced crop care. When other major agricultural inputs are controlled for, active disputes reduces agricultural productivity by about 13 percent while future disputes concerns reduce land productivity by nine percent. This estimate compares with the 6-11 percent found by Deininger and Castagnini (2006) in their study on land conflict in Uganda.

Since land disputes constrain smallholder farmers' optimization behaviour through crop choices and manure use intensities and by extension agricultural productivity, results from thus study bear important policy implications. Smallholder farmers are indisposed to committing long-term investments on plots that they may eventually end up losing if the dispute is not resolved in their favour. In an environment of high household poverty, shrinking land sizes and eroding soil fertility due to high population growth rates, the efficiency of land disputes resolution systems emerge very important policy issue.

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