Norwegian University of Life Sciences (NMBU)

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Centre for Land Tenure Studies

Centre for Land Tenure Studies Working Paper 9/19

Conference paper: 6th African Conference for Agricultural Economist, Abuja, Nigeria
September 2019

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Abstract

We assess the extent of access and degree of participation by smallholder tenants in the land rental market in Malawi. Our study is based on three rounds of nationally representative Living Standards Measurement Surveys collected in 2010, 2013 and 2016, from which we construct a balanced panel. We apply the transaction cost theory, which suggests transaction costs to be non-linear and depend on resource as well as socioeconomic characteristics within the customary tenure system that determines who hold, use and transfer land. Controlling for unobserved heterogeneity, the dynamic random effects probit and Tobit models show that transaction costs in the rental market (on the tenant side) are non-linear, high and lead to state dependency in the market. This implies that past land rental experience, social capital and networks, trust and reputation significantly reduce transaction costs and facilitate entry and extent of participation in the rental market. The results point towards the need for land tenure reforms that can reduce these high transaction costs. Access to information through social network could be one way that can improve land access for land-poor and potential tenants, thereby enhancing both equity and efficiency effects of land rental markets.

Keywords: Land rental markets, Transaction costs, Dynamic random effects models, Malawi
JEL Codes: Q12, Q15

1. Introduction

Sub-Saharan Africa (SSA) is a region that is vulnerable to land scarcity problems due to its heavy dependence on agriculture for livelihood for most of its population. The cultural norms that determine land rights and the political history that resulted in un-egalitarian land distribution, coupled with population growth exaggerate this land scarcity problem (Holden et al., 2010, pp. 19 - 43). Between 2010 and 2015, SSA experienced an annual population growth rate of 1.4 percent, compared to 0.3 percent in developed countries and 0.9 percent as world average, during the same period (United Nations, 2014). Such population growth coupled with unequal initial land distribution has created a heterogeneity in ownership of production resources among individual households and across countries. This has resulted in research and policy interest in SSA, to reallocate productive resources in the agricultural sector for improved allocative efficiency and thereby improving production efficiency among farming households (Gollin & Udry, 2019; Holden et al., 2010; Restuccia & Santaeulalia-Llopis, 2017).

Theory indicates that one way to enhance production efficiency is through the promotion of land rental markets (Holden et al., 2010). Theory and evidence further indicates that the potential benefits of developing the land rental markets –as a potential efficiency and equity enhancing mechanism– stems from market imperfections in non-land factor markets, such as for labour, credit, traction power and purchased inputs (Holden et al., 2010; Pender & Fafchamps, 2006). That is, the development and intensity of land rental market reallocations depend on the extent of factor imbalances, substitutability and complementarities of factors of production, and the associated transaction costs in factor markets. Although imbalances in factors of production have influenced the development of land rental markets in SSA, literature reviewed in this paper (section 2 below) emphasizes the significance of transaction costs in constraining the improvement in the efficiency of land rental markets. Fafchamps (2004) and Holden and Ghebru (2005) indicated that in SSA, the associated transaction costs in rural factor markets, partly depend on policies and institutions that facilitate local access to information, which is costly to collect, verify and disseminate. Such information is mainly used for building trust and reputation among potential partners when searching, screening, negotiating or monitoring and enforcing contracts. This implies that local community market transactions are also a function of social capital factors in SSA (Fafchamps, 2004).

Holden and Ghebru (2005) indicated that the influence of social capital factors in land rental markets may result in non-linear transaction costs that are a function of amount of land transacted. Such factors may cause transaction costs to be either convex or non-convex. The initial convex costs associated with entry barriers for traded land may restrict participation and may glue potential participants into autarky corner positions. The initial entry barrier is also associated with the spatial dispersion of land implying search, monitoring and transport costs that only partly are reducible. The nonconvex costs imply marginal decrease after high initial costs with respect to traded land that promote participation in land rental markets (Holden & Ghebru, 2005). Following Alston et al. (1984), all forms of land rental contracts (wage based, sharecropping and fixed rent) are subject to transaction costs. The sharecropping contracts are considered to have higher transaction costs (second to wage contracts) because of higher selection, monitoring and enforcement costs. Thus, it is presumed that such contracts attract more of social network-based exchange to hedge against market imperfections and reduce costs, mainly the moral hazard challenge (Binswanger & Rosenzweig, 1986; Holden et al., 2010). On the contrary, fixed rental contracts are associated with lower levels of transaction costs and such contracts are hence less subject to social network-based exchange (ibid., 2010). Nevertheless, with market imperfections in both land and non-land factor markets, search or negotiating costs in fixed rental contracts can also be high and may attract social network-based exchange in SSA (Fafchamps, 2004), despite limited literature in land rental markets.

The dominance of sharecropping contracts in many Asian and African countries, like Ethiopia, that have implemented land tenure reform programs, has allowed for more research on understanding the nonconvexity of transaction costs and policy implications compared to fixed rental contracts in land markets (Deininger et al., 2009, 2011; Gebru et al., 2019; Holden & Ghebru, 2005; Jin & Deininger, 2009; Kimura et al., 2011). With the development of land rental markets across SSA countries dominated by fixed rental contracts, there is a growing need to understand the non-linear and dynamic nature of transaction costs for policy interventions that influence the potential and actual impact of land rental markets (Muraoka et al., 2018; Ricker-Gilbert & Chamberlin, 2018). Because of the diversity in policy and institutional factors that facilitate access to market information, cultural norms, social capital and networks that build tenure security, trust, and reputation across space and time; context specific research is important for fine-tuning of relevant policy interventions while comparing the salient features across countries and regions (Jin & Deininger, 2009).

Therefore, in this paper we assess how transaction costs affect entry and extent of participation in land rental markets among smallholder farming households in Malawi – a densely populated agriculture-dependent country in SSA. We raise three questions that remain context dependent in the land rental markets literature. First, to what extent are the transaction costs a barrier for entry into land rental markets in Malawi? Secondly, to what extent are the transaction costs impeding the redistribution of land ownership holdings into more optimal operational holdings[1] among smallholder farming households? Thirdly, are transaction costs impeding entry and the extent of land rental market participation state dependent in Malawi? We include the third question to try and understand the significance of social capital factors like trust and reputation in areas with dominant fixed rental contracts. To our knowledge this is the first study to implement a nationwide research to understand the state dependency and non-linearity of transaction cost in land rental markets in an African country. Thus, we aim to contribute to both the thinking around the development of the land rental market policy strategies in Malawi and draw some conclusions of relevance to other SSA countries.

Our study uses three rounds of nationally representative Living Standard Measurement Survey–Integrated Surveys on Agriculture (LSMS-ISA) data collected in 2010, 2013 and 2016 in Malawi. Our focus is on the tenant side of the land rental market mainly because the data contains a significantly larger number of households renting-in land than those renting out[2]. In addition to participation decisions, we assess the state dependency of land rental markets by applying the theory of farm household and non-linear transaction costs model (Holden et al., 2007; Holden et al., 2010). We use dynamic random effects probit and Tobit models with lagged dependent variables to control for unobservable factors that may influence entry and extent of participation (Wooldridge, 2010). Specifically, we use the lagged dependent variables to assess the extent of state dependency in the market that may cause non-linear transaction costs associated with households building social capital or trust and reputation networks in the land rental markets.

Controlling for unobserved heterogeneity, the results indicate significant and high transaction costs in the land rental markets in Malawi. These costs are considered to limit potential tenants' access to land and possibly push them into an autarky situation, thereby reducing allocative efficiency of productive resources among farming households. We find that lagged participation in the land rental market is associated with significantly higher probability and intensity of participation, implying state dependency despite the dominance of short term fixed rental contracts. This indicates that there are significant entry barriers into the rental market, while earlier participation helps to reduce transaction costs. This reduction could be through

[1] Ownership entails land to which a household has user and transfer rights, whether *de facto* or *de jure* while operational or farming area entails land that a household uses for production, from both owned land and land for which the household has temporary user rights only, like borrowed or rented land (Holden et al., 2013).

[2] Out of a balanced panel data of 1511 households, in 2010, the classification was 7.3% tenants and 0.1% landlords; in 2013 9.9% tenants and 0.5% landlords; and in 2016 8.9% tenants and 1.7% landlords. The reason for this strong imbalance is still unclear but it limits the suitability of the data for analysis on the supply side. A similar problem is also found in large survey data from other countries (Deininger et al., 2017).

reduced information asymmetries and costs, more trust and enhanced reputation that facilitates contract formation and contract renewals. Overall, our results show the significance of social network-based exchange in short term fixed rental contracts, which can be important for land policy reforms for most countries in SSA. Policies that enhance dissemination of land market information through either land campaigns, farmer to farmer exchange or community meetings, will be relevant in this region.

The rest of the paper is organised as follows. Part two presents a literature review on land rental markets and the land policy context in Malawi. Part three gives the theoretical framework and hypotheses. Part four describes the estimation methods and data. The descriptive statistics, results with discussion and conclusions follow in parts five, six and seven, respectively.

2. Literature review

2.1 Transaction costs and land rental markets in context

The economic theory on land rental markets indicates that imperfections in non-land factor and land markets generally cause varying spatial and intertemporal transaction costs in land rental markets (Fafchamps, 2004; Holden et al., 2010). A potential landlord and a potential tenant will have to search for a potential partner for the preferred period. Imperfect information contributes to the initial search costs for the matching of potential landlords and tenants. Social networks may help to reduce these search costs and facilitate matchmaking in the market. At an early stage, when the market is thin, such costs may still be high. After finding a potential partner, a contract must be negotiated and agreed upon. The duration of the contract and payment for the period are minimum conditions for a fixed rent contract. Advantages of a longer-term contract may be that it reduces the need to search for new partners and it facilitates more long-term planning. On the other hand, this reduces the flexibility that a short-term contract gives. Literature shows that such transaction costs provide a better explanation of land rental market participation decisions in improving allocative efficiency of production factors especially when property rights are secure and agriculture remains less capital intensive (Baland et al., 2007; Bell & Sussangkarn, 1988; Deininger, 2003; Skoufias, 1995). Apart from land markets being a function of climatic and bio-physical characteristics as described (Binswanger & Rosenzweig, 1986), the literature on land rental contracts from Asia, Latin America and partly Africa indicates that the extent of transaction costs are mostly a function political history and social variables (social class or kinship contracts) that influence search and negotiation costs in contract formulation as well as monitoring and enforcement costs (Deininger, 2003; Ravallion & Van de Walle, 2008).

Specifically, literature from countries in Eastern Europe and Latin America, China and Vietnam shows that transaction costs in land rental markets are higher with insecure property rights due to risk of expropriation and imperfections in land and non-land markets (Deininger, 2003). On the contrary, reforms that improve tenure security and performance of local institutions that facilitate land transactions are likely to enhance efficiency and equity gains of land rental markets, especially under sharecropping contracts (Deininger & Jin, 2005; Deininger et al., 2003; Deininger, 2003; Ito et al., 2016; Kimura et al., 2011; Macours et al., 2010; Min et al., 2017). Apart from improving institutions at government policy level, studies from Ethiopia indicate that local institutions that facilitate social based exchange (considered important for building trust and reputation when market information costs are high) may also positively or negatively influence land rental market transaction costs (Deininger, 2003; Gebru et al., 2019; Holden & Ghebru, 2005; Holden et al., 2013; Pender & Fafchamps, 2006; Teklu & Lemi, 2004). This shows that policies and institutions can either promote or constrain participation in land rental markets depending on how they affect the level of transaction costs in the market.

In SSA countries with dominant fixed rental contracts, traditional norms or inheritance practices that discriminate the women and youth (male and female heirs), tenure insecurity and thin local community land markets are considered to significantly contribute to high and non-linear transaction costs (Baland et al., 2007 in Uganda ; Chamberlin & Ricker-Gilbert, 2016 in Malawi and Zambia; Holden et al., 2010 in Uganda, Kenya, Malawi; Jin & Jayne, 2013 in Kenya; Lunduka et al., 2009 in Malawi; Ricker-Gilbert & Chamberlin, 2018 in Tanzania). Therefore, understanding the non-convexity of transaction cost in land rental markets across Africa, including Malawi, has the potential to improve land policies that can enhance allocative efficiency of productive resources. Building on these studies, we contribute to this literature with a deeper assessment of the nonconvexity of transaction costs by looking at the state dependency of land rental markets dominated by short term fixed rental contacts.

2.2 The case of Malawi

The context of land rental markets in Malawi is important for this study because land governance is dominated by customary tenure systems, which are considered a potential source of social network-based exchange in factor markets (Fafchamps, 2004). Apart from dominant fixed rental contracts (Holden et al., 2006), the country further differs from other SSA countries in different aspects. Firstly, in Malawi the instituted legal framework allows for households to trade their private or customary land following proper guidelines with respect to land use changes compared to other countries that completely prohibit land market activities (Government of Malawi, 2002, 2016b). For instance, legal framework in Ethiopia prohibit land sales and only allows renting up to 50 percent of owned land per household (Teklu & Lemi, 2004).

The dominant use of a hand hoe for farm activities in Malawi also presents us with a possibility of understanding the extent to which land markets equilibrate the land to non-land factor ratio in this context. This is important because human labour is the main non-land factor among farming households in Malawi compared to other countries with production systems that heavily use animal power or mechanization (Holden et al., 2010). Furthermore, the Land Governance Assessment Framework for Malawi showed the need for improved land governance mainly related to transparency in land administration processes for improved tenure security (Deininger et al., 2014). Following a long debate on land tenure reform, Malawi enacted the new land and land related laws in 2016 aimed to enhance land governance, transfer and use (Government of Malawi, 2016a, 2016b).

3. Theoretical model and hypotheses

Fundamentally, under a fixed rental contract, once a potential landlord and tenant negotiate a contract, we assume the tenant objective is to maximize income utility, where income is equal to production revenue less costs from renting in land and net return from labour use on the farm (because of limited space, we refer to Appendix A for full model specification and assumptions). Thus, the theoretical model applied in this paper integrates the farm household income maximising model with non-linear transaction costs in line with Holden et al. (2010, pp. 27-36), and the dynamic transaction cost model for tenants specified in Holden et al. (2007). Earlier models focusing on allocative efficiency in land rental markets include Bliss and Stern (1982), Bell and Sussangkarn (1988), Skoufias (1995), Holden and Ghebru (2005), and Gebru et al. (2019). In line with the theory of farm household (discussed in Appendix A), a household will maximize income from using owned land and labour resources plus or minus amounts of productive resources traded in the market. We assume non-linear transaction costs that account for social capital factors that may bring nonconvex costs in the maximization problem. Solving the maximisation problem in Appendix A, we derive the associated land demand functions that account for non-linear transaction costs and show the optimal conditions for households' participation decisions in land rental markets. In summary, a household will trade land when the marginal benefit to land use is (i) larger or equal to the marginal cost (land rent plus transaction cost) of renting in land; and (ii) larger or equal to net return (land rent less transaction costs) if renting out land. Since the transaction costs in the rental market are non-linear in amount of land transacted, this implies local and not global optimal conditions (Carter & Yao, 2002). To further understand the concavity of transaction costs, we include the comparative statics in Appendix A.

From the comparative statics, we note that transaction costs can be non-convex (fixed but marginally decreasing). With non-convex transaction costs, potential households may be encouraged to participate in land rental markets by overcoming the hurdle of entering the land rental markets because of marginally decreasing costs. As discussed above, these non-linear transaction costs can be affected by institutions and policy interventions through changes in tenure insecurity or access to information, among other factors. Overall, both market and non-market/social factors that are observable and unobservable can affect the level of transaction costs and influence entry and extent of participation in land rental markets. Considering that our focus is on the tenant household decision to participate in the land rental market mainly under short term fixed rental contracts, we therefore hypothesize that;

H1. *Entry and extent of participation by (potential) tenants in the land rental market dominated by fixed rent contracts, is rationed and state dependent*.

This is due to the initial search and negotiation costs that create a barrier to entry (Holden et al., 2007). These costs may be higher where rental markets are thinner. This means that lagged entry and extent of participation variables positively explain later participation in rental markets as such households have invested to overcome the first hurdle related to market entry. Their market experience, social networks that help build trust and reputation may help in later participation decisions (Holden et al., 2007).

H2. *The likelihood of entry and extent of participation as a tenant in the land rental market declines with own land holding size*
Households with more owned land are less likely to be potential tenants and the extent of land demanded in the rental market is likely to be lower the more they have the land (Bliss & Stern, 1982; Skoufias, 1995).

H3. *The coefficient on own land in the model for extent of participation is close to 0 due to high non-linear transaction costs*.
Following the theory of farm household that maximise income, in a well-functioning rental market with only linear transaction costs the coefficient on own land should be -1 as indicated in Bliss and Stern (1982) and Holden et al. (2010). With non-linear transaction costs and entry barriers, we expect adjustment in the rental market to be constrained and drive this coefficient towards zero.

4. Estimation method and data

To assess entry and extent of tenant household participation in the market and further understand the state dependency of such participation, we follow Holden et al. (2007) and specify the tenant's access to rental market as;

$$A_{jt}^{i} = \sum_{L} A_{jt}^{L} \left[c_0 + c_{jt}^{L} \left(A_{jt}^{i}, \bar{A}_{jt}, \bar{L}_{jt}, \int_{-\gamma}^{t} A_{jt-n}^{L}\, dt, \int_{-\Gamma}^{t} \varphi_t^{p}\, dt; z^{h} z^{\varsigma} \right) \right] \quad (1)$$

From equation 1, following the decision to trade in land A_{jt}^{i} is the amount of land rented in by household j at time t, which is an aggregate of accessed land from a number of landlord households, given as $\sum_{L} A_{jt}^{L}\,[.]$. This access is a function of transaction costs c which include an initial fixed cost, c_0 , and a variable cost (c_{jt}^{L}). The variable costs are a function of both observable and unobservable factors. This includes the rented area itself, and the tenant's endowments of land and labour, $\bar{A}_{jt}$ and $\bar{L}_{jt}$. The non-linearity in the transaction costs is dynamic ($\int_{-\gamma}^{t} A_{jt-n}^{L}\, dt$) and assumed to be lower for tenants that have participated in the market in earlier years. We capture this effect with lagged participation, by splitting this into initial year participation and lagged participation in the previous survey rounds (n) variables. The variable $\int_{-\Gamma}^{t} \varphi_t^{p}\, dt$ is for past and present land policies that influence transaction costs in rental market. Lagged participation is also considered to capture trade experience and we consider this to be an important factor for building social capital or networks that build trust and reputation in rental markets. Both the initial and lagged participation variables account for relevant unobserved household characteristics. Therefore, equation 2 below presents the reduced form of household participation decision (R_{jt}), where the parameters of interest are ρ for lagged participation variables; γ and π for land and labour endowment variables and τ for yearly dummies that partially control for policy mix.

$$R_{jt} = \alpha + \boldsymbol{R_{jt-1}\rho} + \boldsymbol{\bar{A}_{jt}\gamma} + \boldsymbol{\bar{L}_{jt}\pi} + \boldsymbol{z\beta} + \tau + \mu_j + \varepsilon_{jt} \quad (2)$$

The variable $\bar{A}_{jt}$ is for owned farmland area in hectare (ha) for household j and at time t. This includes inherited land through customary systems or government distribution and purchases. The variable excludes borrowed land, farmland for those on wage contract in estate farms, encroached and rented in land. Thus, we use only owned farmland area to assess participation decisions with respect to land endowment. We consider households only accessing land from the excluded sources to be landless in the ownership sense, because they only hold a user right that is endogenous but not transfer rights or other more land tenure secure rights (Holden et al., 2013). To capture such landless households, our model specification therefore includes a dummy for being a landless household.

Although it is the change in owned farmland area that is key for hypotheses two and three, Yamano et al. (2009) indicated that purchased land may partly substitute for the rental market and that households who purchase land have less need for rent-in land. Otsuka et al. (2003) also indicated that land acquired through government and customary systems is more likely to be subject to competing claims with more transaction costs than purchased land. Therefore, our model specification in equation 2 includes both total owned land and the share of purchased land at household level. In addition, the theoretical model discussed in Appendix A assumes own farm labour relative to operational land. Thus, we used the ratio of owned farmland to labour units[3] (total adult equivalent labour units), as an indicator of household net farm labour use. Furthermore, in Malawi the use of a hand hoe is dominant in the farming activities that require physical strength, for instance ploughing and weeding (Takane, 2008). Thus, we assume more adult labour, and particularly male labour, may be associated with a higher demand for agricultural land. Hence, we controlled for share of male labour at household level.

The model includes a set of household and community characteristics (**Z**). Specifically we used sex, age and education of household head; household size to labour unit ratio (consumer to worker ratio); current and one-year lag of total livestock units per labour unit ratio, for wealth that can be liquidated easily to support production and labour use decisions at household level; and distance to urban centres with population of more than 20,000 people for proximity to urban areas.

To estimate equation 2, we use the dynamic panel data models with binary and censored response variables that include lagged variables of entry and extent of participation to control for unobserved heterogeneity (Wooldridge, 2010). Assuming that data observation is from *t=0* so that R_{jt} is the first observation of outcome *R*, for *t*=1, ….T, the dynamic random effects probit model can be specified as;

$$P\left(R_{jt} = 1 \middle| R_{j,t-1}, \dots, R_0, \boldsymbol{z_j}, c_i\right) = \Phi(\boldsymbol{z_{jt}\delta} + \rho R_{j,t-1} + \mu_j) \tag{3}$$

Where R_{it} is the dependent variable and z_{jt} is a vector of explanatory variables for each household in all time periods. Φ is for a standard normal distribution function with probability of success at time *t* also depending on outcome in *t-1* period and the unobserved heterogeneity (μ_j). One can test $H_0: \rho = 0$ to assess state dependency in the model, once μ_i is controlled for. The model assumes μ_j to be additive and given as $\mu_j = \psi + \alpha_0 R_{j0} + \boldsymbol{z_j \alpha_1} + \epsilon_j$. Where $\epsilon_j \sim Normal(0, {\sigma_\epsilon}^2)$ and independent of $(R_{j0} + \boldsymbol{z_j})$**.** The ψ is a constant variable. This structure allows the use of a likelihood function similar to random effect probit model if we add R_{j0} and

[3] We calculated the labour units for household members present in the house for at least a month and not away the whole year.

$\boldsymbol{z_j}$ to the list of explanatory variables so as to have $x_{jt} = \{1, \boldsymbol{z_{jt}}, y_{j,t-1}, y_{j0}, \boldsymbol{z_j}\}$. By doing so, we control for the unobserved effects of μ_j and household initial conditions (Wooldridge, 2010).

On the extent of participation, Wooldridge (2010) specifies the dynamic random effects Tobit model as;

$$R_{jt} = max[0, \boldsymbol{z_j\delta} + \rho_1 R_{j,t-1} + \mu_j + \varepsilon_{jt}] \tag{4}$$

$$\varepsilon_{jt}|(z_j, R_{j,t-1,} \ldots R_{j0}, \mu_j) \sim Normal(0, \sigma_\varepsilon{}^2) \tag{5}$$

For all t =1, ...,T and j=1,2, …, N households in the cross-section. Unlike the probit, the lagged outcome variable in Tobit depends on whether $R_{i,t-1}$ is equal or greater than zero. Hence $\rho_1 R_{j,t-1}$ can be replaced with $\pi_1 r_{j,t-1} + \rho_1(1 - r_{j,t-1})R_{j,t-1}$. Where r_{jt} is binary and equal to one if $R_{jt} = 0$ and zero otherwise. Like the probit, this reduces the list of explanatory variables to $x_{jt} = \{\boldsymbol{z_{jt}}, R_{j,t-1}, R_{j0}, \boldsymbol{z_j}\}$. With these models, one can compute the conditional or unconditional means similar to probit and Tobit models but only with balanced panel data. Holden et al. (2007) indicated that "with unbalanced data, one needs to estimate different conditional distribution of μ_i for each configuration of missing data that may be feasible with sub panels without selection bias". Thus, after data cleaning, we constructed a balanced panel of 1511 households from the 1,523 households observed in 2010 LSMS-ISA data from Malawi. This implies 0.8 percent attrition rate from constructing the balanced panel, which we control for in the model using estimates from a probit model presented in Appendix Table A1.

The balanced data accounted for changes in household head over time and also provided parcel level information including sources of land and global positioning system (GPS) measured parcels in hectares (ha). As per the dynamic random effects model specifications, we used entry and extent of participation in 2010 as the initial year to control for unobserved heterogeneity. At the same time, we used 2010 participation as lagged participation (previous survey round) variable in 2013, and the participation decision in 2013 as lagged participation variable in 2016.

5. Descriptive statistics

Table 2 below presents the summary statistics. From the table, the percent of households that participated in the land rental markets were 7.3, 9.9 and 8.9 percent for 2010, 2013 and 2016 respectively. From our calculations presented in Appendix Table A2, an average of 51 and 35 percent of the households that participated in the initial year (2010) also participated in 2013 and 2016, respectively. The average owned land and operational farm area per household in our sample was between 0.5 - 0.6 ha. Among tenant households, the average rented in land across the years was 0.5 ha with household land endowment of 0.4 ha, which is significantly lower than 0.5 ha owned land among non-tenant households. The percent of landless households among tenant households was also significantly higher than non-tenant households, by an average of 14 percent. This shows that the rental market possibly transfers land towards landless and land-poor households although we do not know how land-rich those renting out this land are.

From Table 2, tenant households are operating an average of 0.9 ha, which is significantly larger than the average operational and owned farmland (0.5 ha) for non-tenant households. This could imply that tenant households are non-land rich households that can manage to increase their operational land size with respect to non-land resource endowment (labour and capital).

Table 2: Summary statistics

	Total sample		Tenant households		Non-tenant households		
Variable	**2013**	**2016**	**2013**	**2016**	**2013**	**2016**	**ttest**
Participation in land rental market							
Initial year (2010) – (*percent*)	7.3	7.3					
Subsequent years – (*percent*)	9.9	8.9					
Initial year (2010) rented in land							
(*mean –ha*)	0.03	0.03	0.47	0.47			
(*median –ha*)	(0.00)	(0.00)	(0.36)	(0.36)			
Subsequent years rented in land							
(*mean –ha*)	0.05	0.05	0.50	0.51			
(*median –ha*)	(0.00)	(0.00)	(0.36)	(0.33)			
Land area							
Owned farmland (*mean –ha*)	0.50	0.55	0.37	0.38	0.50	0.57	****
(*median –ha*)	(0.35)	(0.36)	(0.20)	(0.18)	(0.37)	(0.38)	
Operational farmland (mean – ha)	0.55	0.61	0.88	0.90	0.51	0.58	****
(*median –ha*)	(0.40)	(0.42)	(0.61)	(0.72)	(0.37)	(0.40)	
Landless/zero own farmland (*percent*)	30.71	30.44	42.67	44.03	29.39	29.12	****
Share of purchased farmland (*mean*)	0.03	0.05	0.03	0.03	0.03	0.04	
Labour							
Own farmland to labour ratio (*ha/adult equiv. labour unit*)	0.14	0.15	0.10	0.09	0.15	0.16	****
Share of male labour (*mean*)	35.48	34.56	34.54	34.84	35.58	34.53	
Control Variables							
Sex of HH head (*1=Female*)	22.50	26.08	13.33	14.93	23.51	27.16	****
Age of HH head (*mean –years*)	44	47	42	44	45	47	****
Education of HH head (*mean – years*)	6.29	6.12	6.68	7.04	6.25	6.02	**
Household size to labour ratio (*mean No. of persons/adult equiv. labour unit*)	1.39	1.32	1.41	1.36	1.39	1.31	*
Total Livestock Units (TLU) to labour ratio (*mean TLU No./ adult equiv. labour unit*)	0.09	0.11	0.09	0.14	0.09	0.11	
One-year lag TLU (*mean lag TLU No./ adult equiv. labour unit*)	0.04	0.09	0.05	0.11	0.04	0.09	
Distance to urban center (*mean km*)	28.41	28.50	30.78	34.87	28.13	27.86	****
N	**1511**	**1511**	**150**	**134**	**1361**	**1377**	

Note: The t-tests compare variables for tenant and non-tenant households.
**** p<0.001, *** p<0.01, ** p<0.05,* p<0.1

However, there are no significant differences in share of male labour between tenant and non-tenant households although labour relative to land endowment is higher for non-tenant. We assume the lower average labour to land ratio among tenant households to be an effect of high percent of landless households among those renting in land because they reflect zero ratio values[4]. At the same time, this might also reflect the differences in consumer worker ratio that is slightly for tenant households, imply more consuming units that may require more

[4] Since the percent of landless households was not constant over the years, we could not directly drop the landless household and test the differences in labour units. This required creating a new balance panel that exclude landless households.

operational farmland for food self-sufficiency. Since there are no significant differences in purchased land between tenant and non-tenant households, we consider rental markets to be key in reallocating land and non-land resources in Malawi.

A review of the other control variables in Table 2, shows high significant differences in sex and age of household head and distance to urban areas, with slight differences in education of households' head at 5 percent significance level. Tenant households are less likely to be female-headed, are headed by a slightly younger person with slightly more education than non-tenant households and land markets are common in rural areas. On average, the data shows that almost all contracts were for one growing season or one calendar year and only 4 percent of the households combined upfront money payment with sharecropping contracts.

6. Results and discussion

We present the estimated average partial effects $[E(y|\boldsymbol{X})]$ from the dynamic random effects probit and Tobit models in Table 3 below. The table shows the marginal change in rental market participation decisions with respect to all other explanatory variables. Following the sequence of introducing control variables, we present four estimated models for both probit and Tobit. The first three models include lagged participation and resource endowment variables while the fourth model include all the other household and community control variables. Further details on coefficients from the dynamic random effects probit and Tobit models are attached in Appendix B, Table B1. The focus on the unconditional mean partial effects is chosen to assess participation decisions that include potential tenant households in the land rental market.

From the dynamic random effects probit model results presented in Table 3, we note that both the initial year participation dummy and the lagged rent-in dummy variables are significant at 5 percent level and are positively associated with the probability of participation in the land rental market. Using the unconditional mean partial effects, we note that the initial participation year (2010) and lagged rent-in dummies increased probability of participation in later years by about 9 percent points (model P4). A review of the extent of participation from the Tobit models T1-T4 show a very similar pattern of responses as from the probit models. The initial year dummy and lagged total land area rented-in significantly increase the average amount of land rented-in by a mean area of 0.02 – 0.04 ha, significant at least at 5 percent level in all model specifications. However, one should note that these are averages for the full sample and that the share of households participating in the rental market is small in our sample, meaning that many potential tenant households are possibly remaining in the autarky situation due to access constraints.

Linking the dynamic random effects probit and Tobit models, we note that the initial participation dummy not only increases entry into land rental markets but also increases the amount of land a household is willing and able to rent-in in subsequent years. This confirms the challenge of getting over the first hurdle of entry into the market. Thus, controlling for unobserved heterogeneity, there is state dependency in the land rental market (on tenant side) in Malawi. That is, those that have entered the market benefit by continuing to have better access. This is likely due to factors such as better knowledge of the market and potential landlords, or reputation as potential tenants. Therefore, we cannot reject hypothesis one (H1) and conclude that participation in the land rental market is state dependent in Malawi despite the dominance of short term fixed rental contracts.

For the second hypothesis (H2), the probit model results in model P1 of Table 3 indicate that a one ha increase in own farmland area reduces probability of participation by 3 percentage points, which we consider to be very small given that the average farm size is below one ha. This result gives weak support to hypothesis H2. When we add the dummy for landless households in models P2-P4, the own land variable is no longer significant. Landless households have a 2-4 percentage points higher likelihood of accessing land in the rental market than households who own land. This implies that the rental market to some extent transfers land to landless households or that landless households are more willing to participate than those with some land. This concurs with the study by Baland et al. (2007) in Uganda where landless households were observed to purchase more land than those with initial land inheritance and that community members were more willing to trade land to those with low probability of inheriting land, a sign of social-network based exchange that reduces transaction costs. Thus, we can indicate that the probit model results only have weak support for hypothesis H2 and we should inspect the dynamic Tobit models as well before we conclude.

From the Tobit models, we note that owned land size is significant and negatively associated with the amount of land rented-in in model T1 but not in models T2-T4. From model T1, a one ha increase in own land increases rented in area by 0.01 ha on average, demonstrating the severe allocative inefficiency in the land rental market. Like in the probit models, landless households also rent-in more land than landed households. Despite significance of landless variable in models T2-T4, these households were able to rent in an extra of 0.01 ha land only compared to landed households. This does not change the overall picture of a highly inefficient market, although we cannot still conclude before assessing hypothesis three (H3).

The hypothesis three (H3) stated that the coefficient on own land in the model for extent of participation is close to 0 due to high non-linear transaction costs. To assess this hypothesis, we use the Tobit model results from both Table 3 and Appendix B- Table B1 and B2. From Table 3, the average partial effect of both owned farmland and the landless dummy are close to zero (0.01) while significantly different from zero. Contrasting these results with those presented in the Appendix Table B1 and B2, linear prediction estimates $[E(y|\boldsymbol{X}, y > 0)]$ shows that households who own land are likely to rent in an extra of 0.1 ha only while landless households will likely rent in 0.3 ha more land than landed households. The marginal effect obtained in Table B2 implies a change of only 0.02 ha (model T1-margins) for those who own land and 0.04 ha (model T4-margins) for landless households. This still indicates the high level of transaction costs even for households already participating in the market. Therefore, we cannot reject hypothesis H3 and conclude that with thin land rental markets in Malawi, the non-linear transaction costs are high. However, these costs are also subject to social network-based exchange observed from the tenant side.

Table 3: Dynamic random probit and Tobit models for renting-in land (Average Partial Effects – $[E(y|\boldsymbol{X})]$ for probit and Tobit)

VARIABLES	P1	P2	P3	P4	T1	T2	T3	T4
Initial year (2010) rent-in dummy	0.1199***	0.1191***	0.1223***	0.0929***	0.0390***	0.0386***	0.0395***	0.0233**
	(0.038)	(0.038)	(0.039)	(0.034)	(0.015)	(0.015)	(0.015)	(0.011)
Lag rent-in dummy	0.0901**	0.0888**	0.0848*	0.0890**	0.0229*	0.0220*	0.0206	0.0185*
(previous survey round)	(0.043)	(0.043)	(0.045)	(0.040)	(0.013)	(0.013)	(0.013)	(0.010)
Initial year (2010) rent-in land (ha)					0.0307	0.0321	0.0334	0.0160
					(0.022)	(0.022)	(0.022)	(0.016)
Lag total rent-in land (ha)					0.0321*	0.0297*	0.0277	0.0275**
(previous survey round)					(0.018)	(0.017)	(0.017)	(0.013)
Own farmland (ha)	-0.0301***	-0.0175	0.0022	-0.0174	-0.0108***	-0.0047	0.0042	-0.0049
	(0.010)	(0.011)	(0.016)	(0.019)	(0.004)	(0.005)	(0.007)	(0.006)
Landless/zero own farmland (1= yes)		0.0265**	0.0223*	0.0390***		0.0133**	0.0115*	0.0143***
		(0.013)	(0.014)	(0.015)		(0.006)	(0.006)	(0.005)
Own farmland to labour ratio			-0.0878	-0.0764			-0.0389*	-0.0218
(ha/adult equiv. labour unit)			(0.065)	(0.076)			(0.024)	(0.021)
Share of male labour			0.0038	-0.0297			0.0019	-0.0111
			(0.024)	(0.027)			(0.011)	(0.010)
Share of purchased own farmland			-0.0195	-0.0072			-0.0088	-0.0023
			(0.033)	(0.032)			(0.013)	(0.010)
Sex of HH head (1=Female)				-0.0486***				-0.0186***
				(0.015)				(0.006)
Age of HH head (years)				-0.0007				-0.0004
				(0.001)				(0.000)
Education of HH head (years)				-0.0007				0.0000
				(0.001)				(0.000)
Household size to labour ratio				0.0147				0.0057
(No. of persons/adult equiv. labour unit)				(0.015)				(0.005)
Total Livestock Units (TLU) to labour				0.0052				0.0020
ratio *(TLU No./ adult equiv. labour unit)*				(0.005)				(0.003)
One-year lag TLU to labour ratio				0.0051				0.0022
(lag TLU No./ adult equiv. labour unit)				(0.004)				(0.003)
Distance to urban center (km)				0.0018****				0.0007****
				(0.000)				(0.000)
Regional dummy (1= Central)								
2. Northern region				-0.1009****				-0.0363****
				(0.013)				(0.005)
3. Southern region				-0.0485****				-0.0205****

				(0.014)				(0.005)
Inverse mills ratio, attrition				0.0234				0.0305
				(0.106)				(0.037)
2016.year	-0.0149	-0.0155*	-0.0154*	-0.0097	-0.0069*	-0.0071*	-0.0070*	-0.0019
	(0.009)	(0.009)	(0.009)	(0.013)	(0.004)	(0.004)	(0.004)	(0.004)
Constant	-1.713****	-1.845****	-1.841****	-1.773***	-1.247****	-1.337****	-1.323****	-1.474****
	(0.20)	(0.23)	(0.26)	(0.56)	(0.08)	(0.10)	(0.11)	(0.39)
lnsig2u	-0.684	-0.657	-0.588	-0.961				
	(0.76)	(0.75)	(0.77)	(0.87)				
sigma_u					0.507****	0.520****	0.533****	0.418****
					(0.12)	(0.12)	(0.12)	(0.12)
sigma_e					0.726****	0.714****	0.705****	0.713****
					(0.07)	(0.07)	(0.07)	(0.07)
Observations	3,022	3,022	3,022	3,022	3,022	3,022	3,022	3,022
Left Censored (_n)					2,738	2,738	2,738	2,738
Uncensored (_n)					284	284	284	284
Number of Panel households	1,511	1,511	1,511	1,511	1,511	1,511	1,511	1,511

Note: The table presents Average Partial Effects. Standard errors in parentheses. **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1

In their study from Malawi, Restuccia and Santaeulalia-Llopis (2017) indicated that the "introduction of rental markets in Malawi, where operational scale can deviate from land-use rights, substantially improves aggregate productivity reducing poverty and alleviating income inequality". This was based on their macro level assessment of Total Factor Productivity (TFP) in the agricultural sector compared to non-agricultural sectors in other countries using the 2010/11 LSMA-ISA data. Their study estimated the TFP from the residual of the production function while assuming the input (capital and land per labour unit) elasticities in the agricultural sector of Malawi to be similar to the U.S. agricultural sector. We agree with studies that have questioned this comparison considering the large differences between the two countries (Gollin & Udry, 2019). Assuming fixed set of heterogeneous farmers (with only reallocations across but not within farms and less heterogeneity in agricultural products at the farm) they also found that operated land size and capital are essentially unrelated to farm productivity.

Despite the Restuccia and Santaeulalia-Llopis (2017) study estimating the positive effect of land markets in reallocating agricultural production resources on reducing income inequality in Malawi, our results show that transaction costs are high and significantly impede even distribution of resources among farming households. The success of rental markets in efficiently reallocating resources and improving productivity in Malawi may significantly depend on integrating the social economic factors that determine tenure security and social networks. This is augmented by the results that female headed households are less likely to rent in land and that rental markets are more common in rural areas where there are limited opportunities for off farm work. This is in line with the arguments of Gollin and Udry (2019), who indicated the importance of considering farm size heterogeneity, misallocation and classical measurement error for both capital and land in African agriculture when assessing reallocation of production resources through markets.

7. Conclusion

Land markets, and more so the land rental markets, are developing in many countries across Sub-Saharan Africa in a way that is facilitating the reallocation of productive resources among farming households. The rationale and potential benefits from these land rental markets rests on imperfections in both land and non-land factor markets characterized by transaction costs that emanate fundamental production relations and from land and agricultural policies and local institutions that affect information flows and exchange, and particularly rural factor markets. Based on the farm household land rental model with non-linear transaction cost theory, both policies and institutions can influence non-convex (marginally decreasing) transaction costs and promote entry and extent of participation in the land rental market among potential households, respectively. We used three rounds of nationally representative household data from Malawi (LSMS-ISA) collected in 2010, 2013 and 2016 to assess allocative efficiency of land rental markets and whether these markets are state dependent on the tenant side. We used a balanced household panel of 1511 households and controlled for unobserved heterogeneity using dynamic random effects probit and Tobit models.

Results show that land rental markets, on the tenant side are characterised by high transaction cost but access and participation in the market is state dependent and not a level-playing field with equal access for everybody. The high non-linear transaction costs are likely to contribute to severe allocative production inefficiencies among farming households. Past trade experience reduces transaction costs and improve access. This is likely to be due to improved information access, building of trust and reputation, reducing entry costs and extent of participation.

We found that land rental markets are more active in rural areas and also correlated with other socioeconomic factors at household level. Landless households were more likely to access rented land but the marginal change in land rented in remains significantly low. Therefore, amidst global challenges of population pressure, growing landlessness and food insecurity, our study shows the importance of improving access to and participation in the land rental market by reducing the non-linear transaction costs in the rental market. Since we observed significant state dependency, policy interventions are relevant that promote access to information on land available for rent and that utilise social networks like community land campaigns and enhance farmer to farmer information exchange. This can help to enhance the functioning of the rental market thereby improve access to land especially for land constrained households and the youth.

Acknowledgements

This work is part of the Capacity Building for Climate Smart Natural Resource Management and Policy (CLISNARP) project under NORHED facilitated by the Norwegian University of Life Sciences (School of Economics and Business), Mekelle University in Ethiopia and the Lilongwe University of Agriculture and Natural Resources (LUANAR) in Malawi. We recognise the World Bank: LSMS – Integrated Surveys on Agriculture (ISA) for the data.

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Appendix A

A farm household and land rental market transaction costs model

Assuming a farm household endowed with land $(\bar{A})$ and labour $(\bar{L})$ has the potential to trade these resources to achieve desired levels of resource use on the farm. Such a household would have the ability to either rent in or out land or else hire in or out labour resources in short to medium term. Thus, the household intermediate resource use functions would be $A = \bar{A} + A^i - A^o$ and $L = \bar{L} + L^i - L^o$. Where A and L is the level of land and labour use on the farm, A^i and L^i is the amount of land and labour rented or hired in, while A^o and L^o is amount of land and labour rented or hired out, respectively. The $\bar{A}$ is for all pieces of land area owned by the household and $\bar{L}$ is the sum of time labour used for work (L_u) and for leisure (L_e) given as $[\bar{L} = L_u + L_e]$. Where the decision to trade resources in the market implicitly indicates the time use for work and leisure at household level. We assume total labour endowment to be the total number of household individuals in adult equivalent, that assign total time to work and leisure (Singh, Squire, & Strauss, 1986). Thus, the land and labour resource use function will hold if;

(i) $A^i > 0 \; and \; A^o = 0$	(ii) $L^i > 0 \; and \; L^o = 0$	for renting or hiring in
(iii) $A^o > 0 \; and \; A^i = 0$	(iv) $L^o > 0 \; and \; L^i = 0$	for renting or hiring out
(v) $A^o = 0 = A^i$	(vi) $L^o = 0 = L^i$	for not participating

With these conditions, a farm household will derive utility from production income that is generated from using land and labour resources through either trade in the resource market or own farm production in monetary equivalent terms. Following Singh et al. (1986) the household problem is therefore to maximise income (Y) utility generated from using these resources. The utility function is given as $Max\, U = U(Y)$ while the income function is;

$$Y = P_q q(A, L) - \rho A^i + \rho A^o - \omega L^i + \omega L^o \quad (1)$$

$$\text{and } A^i \geq 0 \text{ , } A^o \geq 0, L^i \geq 0 \text{ , } L^o \geq 0$$

Where the decision variables are A^i, A^o, L^i, L^o for renting or hiring in and out land and labour, as above. The income function (Y) is a twice differentiable and quasi-convex function.

From the income function in 1, ρ is the land rent in land markets and ω is the wage rate in labour markets. The revenue function has P_q for output prices and $q(A, L)$ is a production function that is also a function of land and labour use. This income is assumed to be equivalent to the consumption goods acquired by the household either through own farm production or markets (Singh et al., 1986). The basic assumption in equation 1 is that households can freely trade in the land, labour and all other markets (like credit and other inputs), and that markets work perfectly without constraining the household decision to trade.

However, Binswanger and Rosenzweig (1986) indicated that the immobility of land, the incentive and moral hazard problems in labour market results in high labour transaction costs from negotiating and monitoring while the long gestation period and poor collateral suitability of agriculture sector limit access to credit and capital. This result in imperfect land, labour and credit markets, characterised by market fragmentation; information asymmetry and enforcement problems (Fafchamps, 2004; Holden, Otsuka, & Place, 2010). Such transaction costs may therefore restrict potential households from participating in the land or labour markets. For simplicity, we assume away liquidity constraints related to credit and output markets because of delayed output in agriculture and the associated production and price risks in outputs markets (Carter & Yao, 2002). At the same time, agricultural output may depend on individual household risk preferences and crop choices. This allows us to normalise the output price to one in the income function. Thus, with transaction costs (assuming linear transaction costs), the income function would be;

$$Y = q(A, L) - \{(\rho + \eta)A^i\} + \{(\rho - \eta)A^o\} - \{(\omega + \tau)L^i\} + \{(\omega - \tau)L^o\} \quad (2)$$
$$\text{and } L^i \geq 0 , L^o \geq 0, A^i \geq 0 , A^o \geq 0$$

In equation 2, the P_q or output price is normalised to one for all goods hence we dropped it. The new variables compared to equation 1 are η for transaction costs in land markets and τ for transaction costs in labour markets. All other variables remain as above. Equation 2 indicates that a household renting in land will incur a cost, that is a sum of land rent and transaction costs multiplied by area rented in. For households renting out land, they will gain a land rent less transaction costs multiplied by land area transacted. This also apply in the labour market.

In equation 2 we assumed linear land rent and labour wage rate because households are less likely to trade in small pieces of land or spatially isolated land plots because of immobility of land (Holden, Otsuka, & Deininger, 2013). For the labour market, the physical strength required to do certain agricultural related work implies that not every individual would supply their labour to any agricultural activity. For instance, the labour of individuals under the age of 15 is easily used for planting or harvesting but not extensive ploughing or weeding. This implies linear wage rates for specific agricultural activities. However, the biophysical characteristics of land and labour described by Binswanger and Rosenzweig (1986) implies that this might not hold for transaction costs when formulating and enforcing contracts in the markets. Therefore, despite linear land rent and wage rate, we consider the transaction costs to be non-linear in land and labour markets. This changes the income function to;

$$Y = q(A, L) - \{\rho A^i + \eta(A^i)\} + \{\rho A^o - \eta(A^o)\} - \{\omega L^i + \tau(L^i)\} + \{\omega L - \tau(L^o)\} \quad (3)$$
$$\text{and } L^i \geq 0 , L^o \geq 0, A^i \geq 0 , A^o \geq 0$$

Where the land transaction costs(η) are a now function of land rented in or out and labour transaction costs(τ) are a now function of labour hired in or out. The land rent (ρ) and wage rate (ω) remain linear as above.

So far in the model we have looked at joint land and labour market decisions for a farm household. However, the availability or seasonality of agricultural labour markets throughout the production season implies that households sequence their decisions, starting with land trade decision at the start of the production season and later make labour market decisions within the season. Based on this assumption, we hold the household decision to trade labour constant and focus on land rental decisions relative to labour endowment. We abstract from the fact that agricultural land rental market is spatially fragmented into many poorly integrated markets. On one hand, the spatial isolation and varying transportation distances determines linear land rent while information asymmetry and market fragmentation imply varying non-linear transaction costs. following the assumption of non-linear varying transaction costs, we revise the income function as;

$$Y = q(\bar{A} + A^i - A^o, L) - \{\rho A^i + \eta(A^i)\} + \{\rho A^o - \eta(A^o)\} - \omega L \quad (4)$$

and $A^i \geq 0$, $A^o \geq 0$, $L > 0$

The $q(\bar{A} + A^i - A^o, L)$ is a production function where $(\bar{A} + A^i - A^o) = A$ for land resource use and L is the net labour use ($L = \bar{L} + L^i - L^o$) on the farm. Recall the ($\bar{L}$) includes time spent working and for leisure. The ωL is cost function in the labour market and ω is market wage rate or shadow wage rate for non-traded labour. All other variables are as above.

With the income function specified in equation 4, the household utility maximisation problem becomes;

$$\underset{A^i, A^o, L}{\text{Max}}\, U = U\left[q(\bar{A} + A^i - A^o, L) - \{\rho A^i + \eta(A^i)\} + \{\rho A^o - \eta(A^o)\} - \omega L\right] \tag{5}$$

and $A^i \geq 0$, $A^o \geq 0$, $L > 0$

Where U is the twice differential quasi concave utility function and the households' decision variable is to either to rent in or out land plus labour use on the farm. Since the objective of the household is maximise utility from income, we simplify the mathematics and focus on maximising income with respect to resource use. This reduces our objective function to;

$$\underset{A^i, A^o, L}{\text{Max}}\, Y = q(\bar{A} + A^i - A^o, L) - \{\rho A^i + \eta(A^i)\} + \{\rho A^o - \eta(A^o)\} - \omega L \tag{6}$$

and $A^i \geq 0$, $A^o \geq 0$, $L > 0$

Solving equation 6, the first order conditions (FOC) with respect to land and labour variables are;

Rent in land

$$\frac{\partial Y}{\partial A^i} = \frac{\partial q}{\partial A^i} - \rho - \frac{\partial \eta}{\partial A^i} \leq 0 \qquad \perp \qquad A^i \geq 0 \tag{7}$$

That is, the net return in income with respect to rented in land $\left(\frac{\partial Y}{\partial A^i}\right)$ is equal to the marginal change in revenue on rented in land $\left(\frac{\partial q}{\partial A^i}\right)$ less land rent (ρ) and marginal change in transaction costs with respect to rented in land $\left(\frac{\partial \eta}{\partial A^i}\right)$, which is non-linear. Using the complementary slack conditions, we derive the optimal conditions in equation 8 below

$$\text{i.e. } \frac{\partial q}{\partial A^i} = \rho + \frac{\partial \eta}{\partial A^i} \quad \text{if } A^i > 0 \qquad \text{or} \qquad \frac{\partial q}{\partial A^i} < \rho + \frac{\partial \eta}{\partial A^i} \ \text{ if } A^i = 0 \tag{8}$$

Equation 8 shows that a household renting in land will maximise income if the marginal revenue from rented in land $\left(\frac{\partial q}{\partial A^i}\right)$ is greater or equal to marginal cost of renting in land $\left(\rho + \frac{\partial \eta}{\partial A^i}\right)$. Secondly, rented in land will be zero if the marginal revenue is less than marginal cost of renting in land.

Rent out land

$$\frac{\partial Y}{\partial A^o} = -\frac{\partial q}{\partial A^o} + \rho - \frac{\partial \eta}{\partial A^o} \leq 0 \qquad \perp \qquad A^o \geq 0 \tag{9}$$

Similar to equation 7, the non-linear transaction costs are not constant, and the marginal change is per land area rented out. Solving equation 9 and using the complementary slack conditions, equation 10 shows that households will only rent out land if the marginal benefit on land to be rented out $\left(\frac{\partial q}{\partial A^o}\right)$ is les or equal to net return $\left(\rho - \frac{\partial \eta}{\partial A^o}\right)$ and that they will not rent out land if marginal benefit on land to be rented out is greater than the net return.

$$\text{i.e. } \rho - \frac{\partial \eta}{\partial A^o} \leq \frac{\partial q}{\partial A^o} \implies \frac{\partial q}{\partial A^o} \geq \rho - \frac{\partial \eta}{\partial A^o} \tag{10}$$
$$\frac{\partial q}{\partial A^o} = \rho - \frac{\partial \eta}{\partial A^o} \quad \text{if } A^o > 0 \qquad \text{or} \qquad \frac{\partial q}{\partial A^o} > \rho - \frac{\partial \eta}{\partial A^o} \quad \text{if } A^o = 0$$

Net farm labour use

$$\frac{\partial Y}{\partial L} = \frac{\partial q}{\partial L} - \omega < 0 \qquad \perp \qquad L > 0 \tag{11}$$
$$\text{i.e. } \frac{\partial q}{\partial L} = \omega \quad \text{if } L > 0$$

For labour use, the marginal revenue with respect to labour should be greater or equal to the market or shadow wage rate.

Based on the FOCs (equation 8 to 10), the optimal conditions for non-participating household or the shadow value with respect to land endowment is given in equation 12 below.

$$\rho - \frac{\partial \eta}{\partial A^o} < \left(\frac{\partial q}{\partial A}\right) < \rho + \frac{\partial \eta}{\partial A^i} \tag{12}$$

This indicates that non-participating households consider their shadow value to land to be greater than the net return from renting out land and at the same time less than the marginal cost of renting in land and lie within a threshold. Table 1 gives a summary of the FOCs.

Table 1: Summary of first order conditions

	Land rental market		
	Net buyer $(\boldsymbol{A^i > 0})$	***Non-participant*** $(\boldsymbol{A^0 = 0 = A^i})$	***Net seller*** $(\boldsymbol{A^o > 0})$
Net farm labour use $(\boldsymbol{L > 0})$	Land poor $MR_{A^i} = MC_{A^i}$	Land sufficient $MR_{A^o} < MR_A < MC_{A^i}$	Land rich $MR_{A^o} = MC_{A^o}$

To further assess if these conditions hold, we review the second order conditions (SOC) and the associated Hessian matrix as sufficient conditions below.

From equations (7) and (9), the SOCs are;

Net buyer of land

$$\frac{\partial Y}{\partial A^i} = q_{A^i A^i} - \eta_{A^i A^i} \leq 0 \tag{13}$$

Net seller of land

$$\frac{\partial Y}{\partial A^i} = q_{A^0 A^0} - \eta_{A^0 A^0} \leq 0 \tag{14}$$

Cross derivatives

$$\frac{\partial^2 Y}{\partial A^i \partial A^o} = -q_{A^i A^o} = \frac{\partial^2 Y}{\partial A^i \partial A^o} \tag{15}$$

Assessing the SOCs indicates that, if transaction costs are linear, the second order conditions would be $q_{A^i A^i} \leq 0$ or $q_{A^0 A^0} \leq 0$ (as expected). However, with non-linear transaction cost, the second order conditions are $\frac{\partial^2 q}{\partial {A^i}^2} \leq \frac{\partial^2 \tau}{\partial {A^i}^2}$ and $\frac{\partial^2 q}{\partial {A^o}^2} \leq \frac{\partial^2 \eta}{\partial {A^o}^2}$. This implies that the extent of resource trade adjustment depends on the level of varying non-linear transactions costs. Equations 16 and 17 below presents a 2 by 2 Hessian matrix for assessing the convexity of these transaction costs.

$$[H] = \begin{bmatrix} f_{11} & f_{12} \\ f_{21} & f_{22} \end{bmatrix} \implies \begin{bmatrix} q_{A^i A^i} - \eta_{A^i A^i} & -q_{A^i A^o} \\ -q_{A^o A^i} & q_{A^0 A^0} - \eta_{A^0 A^0} \end{bmatrix} \begin{bmatrix} dA^i \\ dA^o \end{bmatrix} \geq 0 \tag{16}$$

$$|H| = \left(q_{A^iA^i} - \eta_{A^iA^i}\right)\left(q_{A^0A^0} - \eta_{A^0A^0}\right) \geq (q_{A^iA^o})^2 \tag{17}$$

The $|H|$ implies that, depending on the extent of transaction costs, the hessian may not satisfy the sufficient conditions for a global maximum solution. Thus, to understand this convexity in transaction costs, we further did the comparative statics. We assess that the marginal varying transaction costs are non linear [$\frac{\partial A^i}{\partial \bar{A}} \neq -1$ and $\frac{\partial A^o}{\partial \bar{A}} \neq 1$].

Comparative statics

The FOCs gives demand functions which we denote as $A^*(\omega, \rho, \bar{L}, \bar{A})$ for land and $L^*(\omega, \rho, \bar{L}, \bar{A})$ for labour, considering that we normalised the output prices to one. Using the Jacobian Matrix, we solve for $\frac{\partial A^i}{\partial \bar{A}} = -1$ and $\frac{\partial A^o}{\partial \bar{A}} = 1$. Assuming an interior solution for households renting in or out land ($A^i > 0;\ A^o > 0$) the associated marginal change in resource use, using equations (7) and (9) are

$$-[H_j] = -\begin{bmatrix} \frac{\partial^2 Y}{\partial A^i \partial \omega} & \frac{\partial^2 Y}{\partial A^i \partial \rho} & \frac{\partial^2 Y}{\partial A^i \partial \bar{L}} & \frac{\partial^2 Y}{\partial A^i \partial \bar{A}} \\ \frac{\partial^2 Y}{\partial A^o \partial \omega} & \frac{\partial^2 Y}{\partial A^o \partial \rho} & \frac{\partial^2 Y}{\partial A^o \partial \bar{L}} & \frac{\partial^2 Y}{\partial A^o \partial \bar{A}} \end{bmatrix} \begin{bmatrix} d\omega \\ d\rho \\ d\bar{L} \\ d\bar{A} \end{bmatrix} \Rightarrow -[H_j] = \begin{bmatrix} 0 & -1 & -q_{A^i\bar{L}} & -q_{A^i\bar{A}} \\ 0 & 1 & q_{A^o\bar{L}} & q_{A^o\bar{A}} \end{bmatrix} \begin{bmatrix} d\omega \\ d\rho \\ d\bar{L} \\ d\bar{A} \end{bmatrix}$$

Thus, the changes in land rental markets with respect to endowment will be;

1. *The change in renting in land with respect to land endowment is*

$$\frac{\partial A^i}{\partial \bar{A}} = \frac{\left|H_{jA^i}\right|}{|H|} = \frac{\begin{bmatrix} -q_{A^i\bar{A}} & -q_{A^iA^o} \\ q_{A^o\bar{A}} & q_{A^0A^0} - \eta_{A^0A^0} \end{bmatrix}}{\begin{bmatrix} q_{A^iA^i} - \eta_{A^iA^i} & -q_{A^iA^o} \\ -q_{A^oA^i} & q_{A^0A^0} - \eta_{A^0A^0} \end{bmatrix}} = \frac{-q_{A^i\bar{A}}\left(q_{A^0A^0} - \eta_{A^0A^0}\right) + \left(q_{A^iA^o} * q_{A^o\bar{A}}\right)}{\left(q_{A^iA^i} - \eta_{A^iA^i}\right)\left(q_{A^0A^0} - \eta_{A^0A^0}\right) - \left(q_{A^iA^o}\right)^2} \tag{18}$$

Assuming the shadow return to own land is equal to rented in land values, then

(i) $q_{A^i\bar{A}} = q_{A^iA^i} - \eta_{A^iA^i}$ (ii) $q_{A^o\bar{A}} = q_{A^oA^i}$ (19)

This results in a solution that is equal to -1 iff $\eta_{A^iA^i} = 0$. Thus, the rate of market adjustment depends on $q_{A^i\bar{A}} = q_{A^iA^i} - \eta_{A^iA^i}$ and the change will be $\frac{\partial A^i}{\partial A} > -1$ if increasing marginal variable transaction costs and $\frac{\partial A^i}{\partial \bar{A}} < -1$ if decreasing marginal variable transaction costs.

2. *The change in renting out land with respect to land endowment is*

$$\frac{\partial A^o}{\partial \bar{A}} = \frac{\left|H_{jA^o}\right|}{|H|} = \frac{\begin{bmatrix} q_{A^iA^i} - \eta_{A^iA^i} & -q_{A^i\bar{A}} \\ -q_{A^oA^i} & q_{A^o\bar{A}} \end{bmatrix}}{\begin{bmatrix} q_{A^iA^i} - \eta_{A^iA^i} & -q_{A^iA^o} \\ -q_{A^oA^i} & q_{A^0A^0} - \eta_{A^0A^0} \end{bmatrix}} = \frac{q_{A^o\bar{A}}\left(q_{A^iA^i} - \eta_{A^iA^i}\right) - \left(q_{A^iA^o} * q_{A^o\bar{A}}\right)}{\left(q_{A^iA^i} - \eta_{A^iA^i}\right)\left(q_{A^0A^0} - \eta_{A^0A^0}\right) - \left(q_{A^iA^o}\right)^2} \tag{20}$$

Assuming the shadow return to own land is equal to net return to renting out land, then

(i) $q_{A^i\bar{A}} = q_{A^iA^o}$ (ii) $q_{A^o\bar{A}} = q_{A^0A^0} - \eta_{A^0A^0}$

Where the solution is equal to 1 iff $\eta_{A^0A^0} = 0$. Thus, the rate of market adjustment depends on $q_{A^o\bar{A}} = q_{A^0A^0} - \eta_{A^0A^0}$ and the change will be $\frac{\partial A^o}{\partial \bar{A}} > 1$ if increasing marginal variable transaction costs and $\frac{\partial A^o}{\partial \bar{A}} < 1$ if decreasing marginal variable transaction costs. This imply that land market transaction costs can increase to ration out potential participant or decrease to promote participation, subject to factors that influence transaction costs like access to information.

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Table A1: Probit model for attrition bias from 2010 baseline year

	Attrition Probit Model	
VARIABLES	Coefficient	Robust standard error
Sex of HH head (1=female)	0.072	(0.05)
Age of HH head (years)	-0.026****	(0.00)
Education of HH head (years)	0.023****	(0.00)
Household size	-0.144****	(0.01)
Total Livestock Units (TLU)	-0.063**	(0.03)
One-year lag TLU	0.005*	(0.00)
Distance to urban center (km)	-0.007****	(0.00)
Population density	-0.062****	(0.01)
Compared to Central Region		
Northern region	-0.299****	(0.07)
Southern region	-0.172****	(0.04)
Year 2010	-1.572****	(0.06)
Year 2013	-0.492****	(0.04)
Constant	1.919****	(0.12)
LR Chi (12)	1075.56	
Prob > chi2	0.000	
Observations (n)	6,099	

Note: The attrition is 1= dropout from 2010 and 0 otherwise. **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1

Table A2: Initial year and subsequent land rental market participation

Participation		**2013 (%)**		**2016 (%)**		**Total (N)**
Initial year = 2010		*No*	*Yes*	*No*	*Yes*	
	No	93.29	6.71	93.21	6.79	1,400
	Yes	49.55	50.45	64.86	35.14	111
Total (N)		1,361	150	1,377	134	1,511
%		90.07	9.93	91.13	8.87	100

Appendix B

Table B1: Dynamic random probit and Tobit models for renting-in land (partial derivative coefficients)

VARIABLES	P1	P2	P3	P4	T1	T2	T3	T4
Initial year (2010) rent-in dummy	1.031**	1.030**	1.070**	0.823**	0.516***	0.511***	0.526***	0.388**
	(0.43)	(0.43)	(0.46)	(0.38)	(0.19)	(0.19)	(0.19)	(0.18)
Lag rent-in dummy	0.775***	0.769***	0.742**	0.788***	0.303*	0.292*	0.275	0.308*
(previous survey round)	(0.29)	(0.30)	(0.31)	(0.28)	(0.18)	(0.18)	(0.18)	(0.17)
Initial year (2010) rent-in land (ha)					0.406	0.426	0.445	0.267
					(0.29)	(0.29)	(0.29)	(0.27)
Lag total rent-in land (ha)					0.425*	0.394*	0.369	0.458**
(previous survey round)					(0.24)	(0.23)	(0.23)	(0.22)
Own farmland (ha)	-0.259***	-0.151	0.019	-0.154	-0.142***	-0.062	0.056	-0.082
	(0.10)	(0.10)	(0.14)	(0.17)	(0.05)	(0.06)	(0.09)	(0.10)
Landless/zero own farmland (1= yes)		0.229**	0.195	0.346***		0.176**	0.153*	0.238***
		(0.11)	(0.12)	(0.13)		(0.08)	(0.08)	(0.08)
Own farmland to labour ratio			-0.768	-0.676			-0.518*	-0.362
(ha/adult equiv. labour unit)			(0.59)	(0.69)			(0.31)	(0.36)
Share of male labour			0.034	-0.263			0.025	-0.184
			(0.21)	(0.24)			(0.15)	(0.17)
Share of purchased own farmland			-0.171	-0.064			-0.118	-0.038
			(0.30)	(0.28)			(0.18)	(0.17)
Sex of HH head (1=female)				-0.430***				-0.309***
				(0.14)				(0.09)
Age of HH head (years)				-0.007				-0.006
				(0.01)				(0.00)
Education of HH head (years)				-0.006				0.001
				(0.01)				(0.01)
Household size to labour ratio				0.130				0.094
(No. of persons/adult equiv. labour unit)				(0.14)				(0.09)
Total Livestock Units (TLU) to labour				0.046				0.033
ratio *(TLU No./ adult equiv. labour unit)*				(0.04)				(0.04)
One-year lag TLU to labour ratio				0.045				0.037
(lag TLU No./ adult equiv. labour unit)				(0.04)				(0.05)
Distance to urban center (km)				0.016****				0.011****
				(0.00)				(0.00)
Regional dummy (Compared to Central)								
Northern region				-1.164****				-0.837****

				(0.26)				(0.15)
Southern region				-0.387***				-0.273****
				(0.12)				(0.07)
Inverse mills ratio, attrition				0.207				0.507
				(0.93)				(0.61)
2016.year	-0.128	-0.134*	-0.135*	-0.086	-0.092*	-0.094*	-0.093*	-0.032
	(0.08)	(0.08)	(0.08)	(0.11)	(0.06)	(0.06)	(0.05)	(0.07)
Constant	-1.713****	-1.845****	-1.841****	-1.773***	-1.247****	-1.337****	-1.323****	-1.474****
	(0.20)	(0.23)	(0.26)	(0.56)	(0.08)	(0.10)	(0.11)	(0.39)
lnsig2u	-0.684	-0.657	-0.588	-0.961				
	(0.76)	(0.75)	(0.77)	(0.87)				
sigma_u					0.507****	0.520****	0.533****	0.418****
					(0.12)	(0.12)	(0.12)	(0.12)
sigma_e					0.726****	0.714****	0.705****	0.713****
					(0.07)	(0.07)	(0.07)	(0.07)
Observations	3,022	3,022	3,022	3,022	3,022	3,022	3,022	3,022
Left Censored (_n)					2,738	2,738	2,738	2,738
Uncensored (_n)					284	284	284	284
Number of Panel households	1,511	1,511	1,511	1,511	1,511	1,511	1,511	1,511

Note: Standard errors in parentheses. **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1.
The Tobit model results gives the linear prediction $[E(y|\boldsymbol{X}, y > 0)]$

Table B2: Dynamic random Tobit models for renting-in land (Marginal effects conditional on amount of land rented in)

VARIABLES	T1-Margins	T2-Margins	T3-Margins	T4-Margins
Initial year (2010) rent-in dummy	0.0800***	0.0792***	0.0814***	0.0564**
	(0.030)	(0.030)	(0.030)	(0.026)
Lag rent-in dummy	0.0470*	0.0452*	0.0425	0.0446*
(previous survey round)	(0.028)	(0.027)	(0.027)	(0.024)
Initial year (2010) rent-in land (ha)	0.0629	0.0660	0.0688	0.0387
	(0.046)	(0.045)	(0.045)	(0.039)
Lag total rent-in land (ha)	0.0659*	0.0611*	0.0572	0.0665**
(previous survey round)	(0.036)	(0.035)	(0.035)	(0.031)
Own farmland (ha)	-0.0221***	-0.0096	0.0087	-0.0119
	(0.008)	(0.009)	(0.014)	(0.015)
Landless/zero own farmland (1= yes)		0.0273**	0.0237*	0.0345***
		(0.012)	(0.012)	(0.012)
Own farmland to labour ratio			-0.0802*	-0.0526
(ha/adult equiv. labour unit)			(0.049)	(0.052)

Share of male labour			0.0038	-0.0267
			(0.023)	(0.024)
Share of purchased own farmland			-0.0182	-0.0056
			(0.027)	(0.025)
Sex of HH head (1=female)				-0.0449****
				(0.014)
Age of HH head (years)				-0.0008
				(0.001)
Education of HH head (years)				0.0001
				(0.001)
Household size to labour ratio				0.0137
(No. of persons/adult equiv. labour unit)				(0.013)
Total Livestock Units (TLU) to labour				0.0047
ratio *(TLU No./ adult equiv. labour unit)*				(0.006)
One-year lag TLU to labour ratio				0.0054
(lag TLU No./ adult equiv. labour unit)				(0.007)
Distance to urban center (km)				0.0016****
				(0.000)
Regional dummy (Compared to Central)				
Northern region				-0.1088****
				(0.017)
Southern region				-0.0421****
				(0.011)
Inverse mills ratio, attrition				0.0736
				(0.089)
Year 2016	-0.0142*	-0.0146*	-0.0144*	-0.0047
	(0.009)	(0.009)	(0.008)	(0.011)
Observations	3,022	3,022	3,022	3,022
Number of Panel households	1,511	1,511	1,511	1,511

Note: Standard errors in parentheses. **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1. The table omitted the constant, sigma_u, sigma_e and number of censored variables because the information if similar to Table B1 above