Norwegian University of Life Sciences
School of Economic and Business

Philosophiae Doctor (PhD)
Thesis 2020:71

# Land markets and agricultural household decisions nexus in Malawi

## Landmarkeder og småbønders tilpasning i Malawi

Sarah Ephrida Tione

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**Dedication**

To my lovely daughter – **Nthanda Myra Chowa** who turned 5 years on 25$^{th}$ September 2020.

*Leaving you at 10 months was the scariest and the most courageous decision I have ever made. Thank you for giving me the first five years of your life without informed consent.*

*Lots of love, Mom.*

**Acknowledgements**

As the firstborn to Mr and Mrs Tione, I was inspired to study and become an economist at a very young age. Following my Dad –a financial economist, I became an agricultural economist. With inspiration from my Mom –a math and science primary school teacher, I had set my goal to pursue education to PhD level early in my career. Dad and Mom, thank you for your inspiration, prayers, support and encouragement. You are an example of what every girl child needs to realise her dream and become a woman of substance in the world.

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Sarah Ephrida Tione,
Ås 2020.

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**Paper I**: Sarah E. Tione and Stein T. Holden (2020). Urban proximity, demand for land and land shadow prices in Malawi. *Land Use Policy*, 94,104509, 1-14. doi: https://doi.org/10.1016/j.landusepol.2020.104509

**Paper II:** Sarah E. Tione and Stein T. Holden (2019). *Transaction costs and land rental market participation in Malawi*. Working Paper. Aas, Norway.

**Paper III:** Sarah E. Tione and Stein T. Holden (2020). *Can rainfall shocks enhance access to rented land? Evidence from Malawi*. Working Paper. Aas, Norway.

**Paper IV:** Sarah E. Tione (2020). *The falling land to labour ratios and agricultural trade response strategies in Malawi*. Working Paper. Aas, Norway.

**Summary**

The general trend of agricultural land in Sub-Saharan Africa (SSA) continues to tilt towards land scarcity emanating from farm household-level population pressure and increase in urbanisation rates. Understanding the agricultural household decisions nexus or linkages in ownership and access to agricultural land and non-land factor of production is of interest in policy research for development and transformation of rural economies in SSA. This thesis contributes to this scholarly literature. The objective is to assess the changing trends in land transactions, opportunities and constraints in institutions that facilitate transfers and distribution of agricultural land among smallholder farm households in Malawi, a country in SSA. Four independent but related empirical research papers in chapters two to five of this thesis address this objective, with a summary of the overall policy implications in the introduction chapter.

The first research paper assesses the important spatial and intertemporal changes in the land shadow values or prices that shape patterns of agricultural land valuation and transactions. Paper two analyses the dynamic nature of transaction costs in the land rental markets that can facilitate land transactions in a market. Paper three addresses the question of whether downside and upside lagged rainfall shock effects, can kick-start access to rented land among potential tenants. Lastly, the fourth paper jointly assesses the farm household decisions to either rent-in land or hire out labour for casual work in seasonal agricultural labour markets.

Almost a decade after global policy discussions on large-scale land transfers in SSA, this thesis recommends the need to refocus land policy discussions to improving farm household-level access to agricultural land. The agricultural development policies and land use strategies should promote land campaigns that can improve low-cost access to land market information at the local or community level. These policies and strategies should also aim at easing the capital burden or liquidity constraints amongst potential tenant households in the agricultural sector.

The land information dissemination initiatives can take advantage of the existing agricultural extension and information systems. On the other hand, initiatives like establishing a land bank or implementing subsidies, can ease the capital burden and support agricultural operations or other household needs among farming households. With recurring rainfall shocks in Malawi, these initiatives should also target rural areas most affected by downside rainfall shocks. Overall, reducing the friction in the land markets can sustain livelihoods and contribute to the transformation of both rural and urban areas, as land scarcity challenges continue in Malawi.

**Sammendrag**

Landbruksland er i ferd med å bli en stadig knappere faktor i Afrika sør for Sahara (SSA) på grunn av økende befolkningspress og urbanisering. Forståelse av bønders tilpasning, eierskap og tilgang til land og andre produksjonsfaktorer er viktig for politikkutforming for bedre utvikling og transformasjon av rurale områder i SSA. Denne avhandlingen er et bidrag til litteraturen på dette området. Målsettingen er å analysere endringene i eiendomsforhold, institusjonelle muligheter og skranker som påvirker transaksjoner og eierstruktur blant småbrukere i Malawi, et land i SSA. Målsettingen oppfylles gjennom fire uavhengige, men relaterte artikler i kapittel to til fem i avhandlingen, samt en introduksjon i kapittel en som ser på overordnede politikkimplikasjoner.

Den første artikkelen studerer geografisk variasjon og endringer over tid i skyggepriser på land som mål på verdsetting av landbruksland og landtransaksjoner. Den andre artikkelen analyserer hvordan transaksjonskostnader endrer seg dynamisk i leiemarkeder for land som bidrar til omfordeling av land. Artikkel fire studerer hvordan klimasjokk i form av tørke og flom påvirker omsetningen av land gjennom leiemarkeder. Den siste artikkelen analyserer hvordan småbønders beslutninger om å leie ut arbeidskraft og leie inn land henger sammen.

Nesten et tiår etter de globale diskusjonene om store landtransaksjoner i SSA knyttet til høye energi- og matpriser, anbefaler denne avhandlingen et nytt fokus på landpolitikk for å bedre tilgangen til land for bønder. Landbrukspolitikken og strategien bør fokusere på kampanjer som kan redusere kostnadene med å få tilgang til land gjennom bedre markedsinformasjon på lokalt nivå. Denne politikken og virkemidlene bør vektlegge å redusere kapitalbehovet og likviditetsskranker blant potensielle landfattige leietakere i landbrukssektoren.

Spredningen av landinformasjon kan gjøres gjennom eksisterende veilednings- og informasjonssystemer. I tillegg kan en landbank eller subsidier brukes til å lette på kapitalskrankene for å bønder som trenger det. Tiltak bør særlig rettes mot områder utsatt for klimasjokk som tørke. Ved å redusere friksjonen i landmarkedene kan bønder lettere tilpasse seg endrede rammebetingelser i rurale og urbane områder i Malawi.

## 1. Introduction

In Sub-Saharan Africa (SSA), rural farm households and to an extent peri-urban dwellers are smallholder farmers whose livelihood heavily relies on agricultural land and human labour factors of production (Fan & Rue, 2020; Lowder et al., 2014; Masters et al., 2013). It is the ownership and access to these factors of production (land and labour), plus access to capital that helps to sustain their livelihoods, by either using these resources for own production or trading them in factor markets (Ellis, 2000; Scoones, 2009). Owned agricultural land and labour endowment further serve as a safety net amidst frequent agricultural production and climatic shocks; land scarcity and degradation; imperfect markets and food consumption shocks (Carter & Olinto, 2003; Holden, 2020). Therefore, agricultural land and labour are important resources for the livelihoods of rural farm households in SSA.

Agricultural land is a central factor, but also has some fundamental characteristics that shape production and factor markets. This is because land is immobile, spatially dispersed and inherently heterogeneous. Hence, all other non-land factors (labour and capital) have to be taken to the land while output products are moved out of the land (Binswanger & Rosenzweig, 1986). This implies that the changes in ownership and access to agricultural land relative to labour or capital factors of production should be key in influencing the household decision to use or trade land and non-land resources. Despite this central role, agricultural land is increasingly becoming scarce across countries in SSA, especially in areas with high population density like in Rwanda and Malawi (Chamberlin et al., 2014; Masters et al., 2013).

With increasing land scarcity challenges across countries, there is a growing need for policy research in factor markets, that can promote ownership and access to agricultural land in a way that sustains livelihoods of farm households in SSA (Holden, 2020; Jayne et al., 2014). Such research is also important for achieving and tracking the Sustainable Development Goals (SDGs), and the 2030 Agenda for Sustainable Development that includes the SDGs and the implementation modalities (United Nations, 2015; United Nations Development Program, 2017). The policy research is also important for implementing the African Union Agenda 2063 that includes the declaration on land issues and challenges in Africa (African Union, 2020). Therefore, the objective of this thesis is to understand the changing trends in land transactions, opportunities and constraints in institutions that facilitate transfers and distribution of agricultural land among smallholder farmers in Malawi.

Historically, ownership and access to agricultural land in SSA have been mainly through government distribution and inheritance (Ainembabazi & Angelsen, 2016). However, the increase in population density and land fragmentation has reduced the redistribution of land over time (Blarel et al., 1992; Ntihinyurwa et al., 2019). With the limited redistribution of land, there is a growing heterogeneity in land ownership that has enabled the development of land markets, as an institution that can facilitate exchange between a willing buyer and a willing seller (Holden et al., 2010). Scholarly papers show that both land sales and rental markets are emerging across countries in SSA (Chamberlin & Ricker-Gilbert, 2016; Holden et al., 2010). However, the extent to which land markets are reallocating agricultural land across space and over time remains an empirical question in Sub-Saharan African countries.

On land sales markets, the need to permanently transfer land and the required capital when purchasing land make sales markets less prevalent, particularly among smallholder farm households in rural areas (de Janvry et al., 2002; Holden et al., 2010). On the contrary, rental markets temporary transfer use of agricultural land for a short or longer-term period and reduce the need for intensive capital to access land. Such flexibility in rental markets creates a wide range of opportunities for those willing to supply and those demanding agricultural land, hence making land rental markets more prevalent in SSA (Holden et al., 2010). With data from smallholder farmers in Malawi, this thesis assesses land rental markets, as an institution that facilitates access to agricultural land and use of non-land factors of production.

The transactions in the land rental markets can be either through wage, sharecropping or fixed rent contracts, and can last for a short (one year) or a longer-term period (Alston et al., 1984; Holden et al., 2010). The wage rental contract is mainly an agreement on work or service offered on the farm with payment as wage. The sharecropping rental contracts entail shared output agreements while the fixed-rental contracts involve the use of land with a fixed payment agreement, mostly in monetary terms. In all the forms of contracts, participants in the land rental markets can incur transaction costs associated with access to market information, searching for a willing buyer or a willing seller (partners) and transport cost, before engaging in contract negotiations, supervision, monitoring and enforcement of rental contract costs (Alston et al., 1984; Fafchamps, 2004; Holden et al., 2010).

Such transaction costs can vary across space and over time, hence resulting in spatial and intertemporal differences in costs incurred by market participants. These variations plus the related amount of land transactions in the market are key in defining the allocative efficiency of land rental markets. Therefore, this thesis analyses land transactions mainly under short-term and fixed-rent contracts that are dominant among smallholder farmers in Malawi. Through research work in four analytical papers, this thesis contributes to the agricultural land and labour factor markets literature and provides empirical evidence that could be relevant for land-use policies in Malawi and other countries across SSA.

The first empirical contribution from paper one is on the changing trends in land shadow prices or land valuation at the farm household-level. The assessment comes in almost a decade after the 2007–08 sharp increase in the world energy and food prices, that triggered the recent discussions on "land grabs" in most African countries (Cotula, 2013; White et al., 2012). The second paper contributes to the literature on the dynamic nature of transaction costs and how such costs can affect entry and extent of participation (amount of land rented-in) in the land rental markets. Paper three's contribution is on whether rainfall shocks can kick-start access to agricultural land through land rental markets whilst paper four contributes to the livelihood diversification and factor market allocations literature. This paper assesses the farm household decisions in the land rental and seasonal agricultural labour markets, as the livelihood trade response strategies to the growing land scarcity challenges in Malawi.

This thesis is organised in five chapters and their respective sections. Going forward in this chapter, I give a background on agricultural land in Malawi in section two, followed by a conceptual and theoretical framework in section three. In section four I present the survey methods and data with a detailed summary of the scientific contributions in section five. This chapter ends with policy implications and future research gaps in sections six and seven. The next four chapters in this thesis are a compilation of the research papers.

## 2. Agricultural land in Malawi: Tenure systems and land markets

In Malawi, the total land available is estimated at 9.8 million hectares with an average population density estimated at 186 persons per square Km (Government of Malawi, 2019). Suitable land for agriculture is 7.7 million hectares where large-scale estate farms occupy at most 1.5 million hectares (Deininger & Xia, 2018; Government of Malawi, 2002). Almost 93 percent of the estate owners hold between 10 to 30 hectares while only 6 percent hold above 50 or 500 hectares (Deininger & Xia, 2018). The smallholder farm households occupy at least 4.5 million hectares with an average landholding size of less than one hectare, after adjusting for wetlands, steep slopes, and traditional protected areas (Government of Malawi, 2002).

Of the total agricultural land, almost 90 percent is cultivated under rainfed farming, with some potential for irrigation that is yet to be fully developed (Chafuwa, 2017; Government of Malawi, 2016c). In 2019, the agricultural sector contributed 27 percent to the national Gross Domestic Product (GDP) while contributing almost 80 percent of the export earnings (Government of Malawi, 2020). On average, the smallholder sub-sector contributes 70 percent while the estate sub-sector contributes 30 percent to the agricultural GDP (Government of Malawi, 2016c). Evidence shows that most of the estate land is currently being underutilised and underperforming in yield, hence failing to generate the anticipated positive and spill-over effects in the agricultural sector. Issues of expired lease titles, lack of proper documentation, lack of payments of land rent and overlapping boundaries are some of the bottlenecks contributing to the poor performance of the estate sub-sector in Malawi (Deininger & Xia, 2018; Holden et al., 2006).

The Malawi National Land Policy–2002 stipulates that land in Malawi is mainly governed using customary, public and private tenure systems, where private system include freehold or leasehold land titles (Government of Malawi, 2002). Of the total land available in Malawi, 67 percent is under customary tenure system followed by 19 and 14 percent that is under public and private tenure systems, respectively. Agricultural land under smallholder farmers is mainly governed by the customary tenure system while estate land is mainly under private tenure systems. The customary tenure system grants communal land rights that are closely connected to ethnic identity, with Traditional Authorities (TA) or local leaders as custodians of the land.

Prior to the enactment of Land and related land Acts in 2016, the Malawi National Land Policy 2002 indicated that under the customary tenure system, "families and individuals are allocated exclusive fee simple usufruct[1] in perpetuity subject to effective utilisation" (Government of Malawi, 2002). This construe that farm households only hold user rights that can be passed on through inheritance while radical ownership remains with the TA or local leaders on behalf of the State. Based on the Land and Customary Land Acts–1967, the user right under customary tenure system was not legally recognised because customary land ownership in Malawi was also considered a community or family resource to be passed on through either matrilineal or patrilineal inheritance systems (Government of Malawi, 1967a; Government of Malawi, 1967b; Lunduka et al., 2009).

[1] Usufruct is defined as "the legal right of using and enjoying the fruits or profits of something belonging to another" Merriam-Webster dictionary (https://www.merriam-webster.com/dictionary/usufruct).

After revising the 1967 Acts, the Land and Customary Land Acts–2016 specifies the intention of the government to register all land as public or private (Government of Malawi, 2016a; Government of Malawi, 2016b). The private titles entail having well-defined land rights for either individual households under leasehold or to register customary land as a customary estate, that is demarcated at the level of the TA or local leaders. Public land includes government land and unallocated customary land. The Customary Land Act–2016 further stipulates that the aim of registering and legally recognising customary estate is to improve tenure security of landholders.

On disposal of the customary estate, the Customary Land Acts–2016 indicates that "*all transactions involving customary estates during the first five years of registering and titling the estates shall be approved by a land committee and the Traditional Authority in whose jurisdiction the land is situated. Any disposition of customary estate granted to a person or family unit shall not be permitted outside the immediate family during the first five years of titling the estat*e". The Act indicates some exceptions that are subject to a full evaluation of the land committee in the area if a family request to dispose of a customary estate. What is not clear on this disposal of customary estate statements is whether short-term land rental transactions fall under this category, since such contracts are not permanent disposal of customary land. Nevertheless, the short-term exchange of agricultural land is not a new phenomenon in Malawi.

Land rentals date back to the colonial period before independence in 1964. Upon colonising Malawi (then called Nyasaland), the British protectorate consolidated and transferred land to colonial settlers who established estate farms for producing export crops like tea and tobacco. To ensure sufficient access to labour, the colonial estate owners mobilised community labour through chiefs under a contract commonly called "*thangata*" system (Peters & Kambewa, 2007). Although this system was later observed to be oppressive and was abolished after independence, under this agreement local people could be offered small pieces of agricultural land within the estate for own food production as they offered labour on the estate, similar to sharecropping arrangements (Holden et al., 2006; Peters & Kambewa, 2007). Despite abolishing the labour system, recent trends on estate land show that individuals continue to engage in negotiated wage or sharecropping contracts in Malawi (Holden et al., 2006).

After independence, renting agricultural land under customary tenure system was still restricted, as farmland was considered a community property that could only be transferred through borrowing and not renting at a cost. It is only recently that evidence of renting agricultural land has been observed on customary land and among smallholder farmers in Malawi. Ellis et al. (2003) reported that farm households who could not trade their land from missing or absent land markets, resorted to hiring out labour for seasonal agricultural casual work in Malawi. Furthermore, Chirwa (2004) argued that previous agricultural strategies in Malawi were not successful because they ignored the question of land use and exchange among smallholder farmers. Thus, evidence of a developing land rental market on customary land started in the new millennium, which is largely informal and mostly between households of the same or neighbouring communities (Holden et al., 2006).

Recently, literature has been confirming the development of these markets, with evidence showing that participation is associated with improved perceived tenure security (Lunduka et al., 2009). Also land rental markets have been observed to have positive welfare impacts among smallholder farm households in Malawi (Chamberlin & Ricker-Gilbert, 2016; Ricker-Gilbert et al., 2019). Although evidence of land rental markets on agricultural land has surfaced in the new millennium in Malawi, recent policy discussions on the land use, exchange and the need to improve tenure security started around 1994. This was the time when the first newly elected democratic leader of Malawi established the Presidential Commission of Inquiry on Land Policy Reform (PCILPR) in 1996 (Holden et al., 2006).

I refer to these land policy discussions as recent considering that it was also partly the land issues that lead to a revolution and independence in 1964. After independence, the ruling government also tried to correct the colonial land issues between 1968 and early 1970s. However, these efforts had less focus on customary agricultural land across the country (Holden et al., 2006; Peters & Kambewa, 2007). Fast forward to 1996, the work of the PCILPR resulted in the institutionalisation of the Malawi National Land Policy in 2002 and the enacted Land and Customary Land Acts in 2016. Building on this evidence and the associated policy changes, this thesis contributes to the land question on the use and exchange of agricultural land among smallholder farmers in Malawi.

According to de Janvry et al. (2002), Deininger (2003), Ravallion and Van de Walle (2008) and Holden et al. (2010), improved tenure security and land markets were central in enhancing efficient allocation of land in Eastern Europe, Latin America, Asia and parts of Africa like in Ethiopia. Evidence in these regions shows that improved access to land can allow rural farm households to generate more income and activate household assets, like family labour, with zero or low opportunity cost outside the agricultural sector. Access to land can also help farm households achieve food self-sufficiency considering the price variations and shocks in agricultural output markets. With a willing buyer and a willing seller, transactions in the land rental markets can further complement other income strategies and facilitate migration or supply of labour in the wage market. Overall, land markets that efficiently allocate land for productive use and facilitate the use of non-land factors of production can help to reduce rural poverty and promote food security, even among landless households (de Janvry et al., 2002; Fan & Rue, 2020; Holden et al., 2010; Holden, 2020). Thus, contributing to the land question in Malawi while comparing the salient factors across the globe, should contribute to the development of land use policy strategies and lessons of relevance in SSA.

## 3. Conceptual and theoretical frameworks

In rural economies, land and non-land resources are complementary factors of production while non-land capital and labour are weak substitutes because of imperfections in credit or labour markets. Binswanger and Rosenzweig (1986) indicated that the incentive and moral hazard problems in the labour market result in high transaction costs for different market participants. Also, the long gestation period and poor collateral suitability of the agricultural sector further limit access to credit in the sector. These imperfections in the factor markets can lead to inefficient allocation of factors of production across space and over time. When non-land markets operate to improve such market imperfections, land markets are not necessary for reallocating resources to the most productive users (Deininger et al., 2008). Thus, land markets develop after output, capital and labour markets, as an efficiency-enhancing mechanism in allocating factors of production (Holden et al., 2010).

While land markets can develop to enhance the efficiency of resource allocation, the immobility, spatially dispersed and inherent heterogeneity of the land also result in varying transaction costs. The costs include fixed or variable transaction costs, where fixed costs are more associated with pervasive market entry barriers that determine unit land rent. Such costs are mainly related to the land being immobile and spatially dispersed or fragmented with long distance between parcels that limits the amount of land that is traded in the market (Holden et al., 2010). On the contrary, varying transaction costs are more associated with access to information on available land in the market, searching for potential or suitable partners and contract negotiations that are idiosyncratic to market participants (Holden et al., 2010).

With fixed costs, effective change can come with long-term investments like improving the transport infrastructure or facilitating land consolidation programs (Asiama et al., 2019; Holden et al., 2010). For varying transaction costs, reducing the gap in idiosyncratic costs can come with market integration by improving the land-related market information systems (Holden et al., 2010). Thus, both fixed and variable costs can lead to varying spatial and intertemporal transaction costs that can ration the participation of farm households in factor markets. This is mainly a character of rural areas with poor access to information and transport infrastructure (Binswanger & Rosenzweig, 1986; Holden et al., 2010). Thus, the economic theory on agricultural markets in rural economies (including most countries in SSA), generally indicates imperfect markets in both land and non-land factors of production (Binswanger & Rosenzweig, 1986; Fafchamps, 2004; Holden et al., 2010).

According to Greenwald and Stiglitz (1986), such market imperfections or externalities imply that rural economies are constrained pareto in-efficient. Hence, there exist policy interventions that can minimise or reduce such constraints and enhance the efficiency of markets to achieve the associated welfare effects. Building on this discussion, Figure 1 presents the schematic conceptual framework on access to land, land markets and welfare implications. In the figure, the thin arrows are used to present and discuss these concepts while the thick and bold arrows are used to show the areas of focus in the four research papers compiled in this thesis.

The conceptual framework in Figure 1 indicates that, although it is the geographical position of an area that defines available resources, distribution of these resources is partly shaped by institutions, policies and cultural norms that govern the ownership, access and use of resources. The governing policy includes the statutory laws and regulations instituted to facilitate resource allocation including development agendas like the commercialisation of the agricultural sector. Cultural norms represent the *de facto* rules instituted by communities in allocation and regulation of community resources while the geographical variables include the push or pull factors like population density, agro-ecological zones and urbanisation.

Since geographical and institutional characteristics define distribution and redistribution of factors of production, they can lead to heterogeneity in the endowment of the land and “desired land” at the household level. From Figure 1, the “desired land” implies ownership of non-land factors (labour and capital) that households can use or trade to achieve the desired level of land use. The geographical and institutional characteristics also shape household social, time and risk preferences that can influence perceptions of tenure security, household endowment and the decision to participate in the agricultural factor markets.

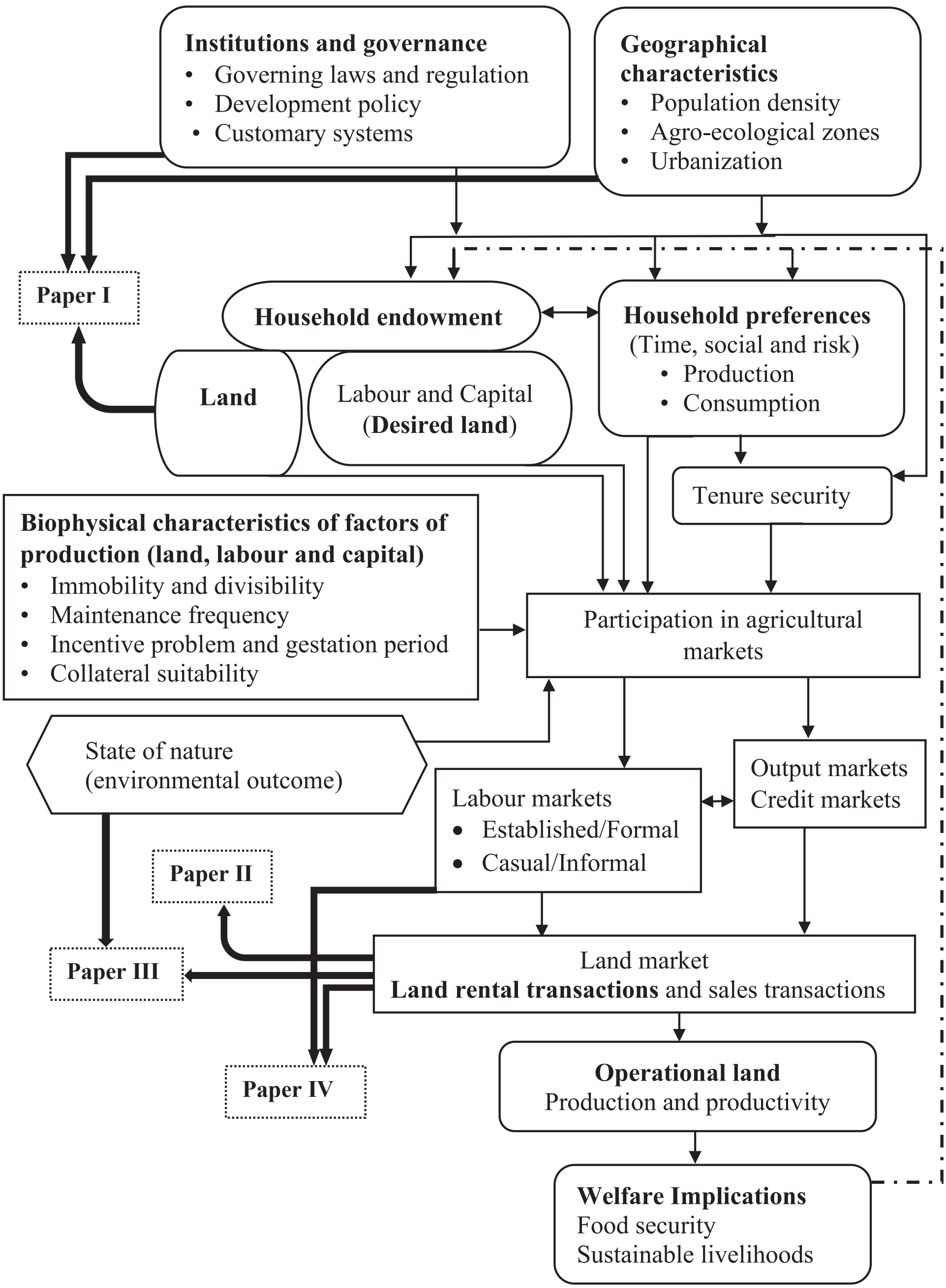

Figure 1: Land access, participation in land rental markets and welfare implications.

The decision to participate in these markets also depends on the biophysical characteristics of factors of production that influence transaction costs and development of markets (Binswanger & Rosenzweig, 1986). Participation in factor markets is further influenced by the state of nature or environmental outcomes associated with production and food consumption shocks (Quiggin & Chambers, 2006). Figure 1 further shows that the household decisions to trade agricultural land and labour can influence the change in operational farmland at the household level. For short to medium-term, the decision to rent-in land can increase household operational farmland, thereby increasing production or improving productivity that leads to welfare gains. In line with de Janvry et al. (2002) and Holden and Ghebru (2016), farm households can achieve food security and manage to sustain their livelihoods through land rental markets. Therefore, the theoretical framework in this thesis draws heavily on the farm household model, the theory of transaction costs and imperfect markets school of thought (de Janvry et al., 1991; Greenwald & Stiglitz, 1986; Singh et al., 1986).

Following the thick and bold arrows in the conceptual framework, Paper one analyses the changing trends in households' valuation of owned agricultural land, as a function of policy changes, population pressure and urbanisation. Paper two assesses the dynamic nature of transaction costs associated with market experience and information asymmetry when transacting agricultural land in the rental markets. Paper three analyses how the revealed state of nature, defined as the spatial variations in lagged rainfall shock variables, are influencing the decision to rent-in agricultural land. Paper four analyses how the growing land scarcity relative to family labour is influencing the household decision to trade in either land rental or seasonal agricultural labour markets by doing casual work. In the next sub-section, I discuss the overall theoretical framework that forms the basis for the analytical work in the four research papers.

### 3.1. A farm household and land rental market transaction costs model

The farm household model indicates that a household endowed with land and labour can use and/or trade these assets to achieve the desired level of resource use. Following Singh et al. (1986), the problem for such a farm household is to maximise income $[Y]$ utility generated from household decisions. The decisions include to either use these resources on own farm or trade them in the factor markets. The utility function for such a household can be given as $Max\ U = U[Y]$, where the utility is a twice differential quasi-concave function. Equation (i) specifies the farm household income utility function following the imperfect market theory. The theory indicates that varying spatial and intertemporal non-linear transactions costs characterise land and non-land factor markets in most rural economies.

$$\underset{A^i,A^o,L^i,L^o}{\text{Max}}\ U[Y] = U[P_q q(A,L,K;z^h) - \{\rho A^i + \eta(A^i)\} + \{\rho A^o - \theta(A^o)\} - \{\omega L^i + \tau(L^i)\} + \{\omega L^o - \varphi(L^o)\} - P_m M] \quad \text{(i)}$$

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

From the equation, ($A^i, A^o, L^i$ and $L^o$) are the choice or decision variables for renting-in $(A^i)$ or out $(A^o)$ agricultural land or hiring in $(L^i)$ or out $(L^o)$ labour. The income function [*Y*] is equivalent to the consumption goods acquired by the household either through own-farm production or through the markets while subtracting the production costs (Singh et al., 1986). Thus, the revenue function has $(P_q)$ for output prices and $q(A, L; z^h)$ for a production function that uses land ($A$), labour ($L$) and capital ($K$) factors, subject to household or community characteristics $(z^h)$.

From equation (i), the cost function reflects the trade of land ($A$) and labour ($L$) plus the cost of buying other marketed inputs ($M$). In the equation, $(\rho)$ is for constant land rent and $(\omega)$ is for unit wage rate, which I assume to be linear in the amount of land and labour traded in the market across space and in line with Holden et al. (2010). However, due to spatial and intertemporal variations in market costs, market participants can face varying non-linear transaction costs. Thus, the parameters $(\eta)$, $(\theta)$, $(\tau)$ and $(\varphi)$ reflect the varying non-linear transaction costs that are a function of the amount of land and labour traded in the markets (Holden et al., 2010). Further, I assume that transaction costs on the demand side are higher than the transaction costs on the supply side. This is because households demanding land and labour are more likely to incur higher searching costs than those supplying the resources (Binswanger & Rosenzweig, 1986). Thus, $(\eta)$ is greater than $(\theta)$ and $(\tau)$ is greater than $(\varphi)$ for land and labour markets, respectively. Lastly, $(P_m)$ is the price for other inputs purchased by the farm households.

For simplicity, I assume away the liquidity constraints, household risk preferences and crop choices because of the long gestation period of agricultural outputs and high output price fluctuations in most rural economies, including in Malawi. (Carter & Yao, 2002; Cornia et al., 2016; Quiggin & Chambers, 2006). Therefore, I normalise the output $(P_q)$ and input $(P_m)$ prices for all goods to one. After dropping the normalised prices and using the duality theory, I focus on the twice differentiable quasi-convex income function as specified in equation (ii). All variables in this equation remain as above.

$$\underset{A^i,A^o,L^i,L^o}{\text{Max}}\ Y = q(A, L, K; z^h) - \{\rho A^i + \eta(A^i)\} + \{\rho A^o - \theta(A^o)\} - \{\omega L^i + \tau(L^i)\} + \{\omega L^o - \varphi(L^o)\} \qquad \text{(ii)}$$

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

So far, the theory has generalised the farm household decisions on both the demand and supply sides of the market. However, the research work in this thesis focuses on farm household demand for agricultural land considering the land scarcity challenges in Malawi. Thus, to simplify the model, I further assume that the households renting-in the agricultural land are constrained in ownership of land, hence less likely to rent out their agricultural land. Thus, I drop the variables reflecting renting out of the land in equation (ii). On the labour decisions, the literature indicates that land markets transfer land-use from "land-rich and labour-poor" to "land-poor and labour-rich" households (Holden et al., 2010; Sadoulet et al., 2002). This means that a tenant household is less likely to also hire in labour. However, such households can hire out labour, especially among smallholder farmers with capital constraints to combine both renting-in land and hiring in labour. Therefore, I also drop the hire in labour variables from the specified income objective function to focus on households renting-in agricultural land or hiring out labour for agricultural work.

In addition, the variability or seasonality of agricultural labour markets throughout the production season (Feuerbacher et al., 2020) implies that farm households might sequence their agricultural land and labour trade decisions. That is, starting with the trade of agricultural land decision at the start of the production season and later making labour market decisions recursively or sequentially throughout the season. This means that farm households can face different cost functions for renting-in the land and hiring-out the labour. Thus, equation (iii) presents the reduced form of the farm household income function.

$$\underset{A^i,A^o,L}{\text{Max}}\ Y = q(\bar{A} + A^i, \bar{L} - L^o, K\colon Z^h) - \{\rho A^i + \eta(A^i)\} + \{\omega L^o - \varphi(L^o)\} \quad \text{and } A^i \geq 0, A^o \geq 0, L > 0 \qquad \text{(iii)}$$

From the production function given as $q(.)$, the variables $\left(\bar{A} + A^i = A\right)$ and $(\bar{L} + L^o = L)$ correspond to land and labour used on own farm, respectively. The $(\bar{A})$ and $(\bar{L})$ reflects owned land and labour while $\left(A^i\right)$ is for land rented-in and $(L^o)$ is for hired out labour. Recall that the $(\bar{L})$ includes time spent working and for leisure, while $(\omega)$ is for the market wage rate or shadow wage rate for non-traded labour. Based on this income function, the first-order conditions (FOCs) with respect to land and labour decisions are specified in equations (iv) and (v).

*Rent-in land*

$$\frac{\partial Y}{\partial A^i} = \frac{\partial q}{\partial A^i} - \rho - \frac{\partial \eta}{\partial A^i} \leq 0 \qquad \perp \qquad A^i \geq 0 \qquad \text{(iv)}$$

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

From equation (iv), 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 from land rented-in $\left(\frac{\partial q}{\partial A^i}\right)$ less land rent $(\rho)$ and marginal change in non-linear transaction costs $\left(\frac{\partial \eta}{\partial A^i}\right)$, which is a function of the amount of land rented-in. Solving equation (iv) and using the complementary slack conditions, a household renting-in the land will optimise income if the marginal revenue from the land rented-in $\left(\frac{\partial q}{\partial A^i}\right)$ is greater or equal to the marginal cost of renting-in land $\left(\rho + \frac{\partial \eta}{\partial A^i}\right)$. Secondly, land rented-in will be zero if the marginal revenue is less than the marginal cost of renting-in the land.

*Hire out labour*

$$\frac{\partial Y}{\partial L^o} = -\frac{\partial q}{\partial L^o} + \omega - \frac{\partial \varphi}{\partial L^o} \leq 0 \qquad \perp \qquad L^o > 0 \qquad \text{(v)}$$

i.e. $\omega - \frac{\partial \varphi}{\partial L^o} \leq \frac{\partial q}{\partial L^o} \Rightarrow \frac{\partial q}{\partial L^o} \geq \omega - \frac{\partial \varphi}{\partial L^o}$

$\frac{\partial q}{\partial L^o} = \omega - \frac{\partial \varphi}{\partial L^o}$ if $L^o > 0$ or $\frac{\partial q}{\partial L^o} > \omega - \frac{\partial \varphi}{\partial L^o}$ if $L^o = 0$

In equation (v), the marginal change in income subject to hiring out labour depends on the marginal change in wage rate less the marginal change in non-linear transaction costs $\left(\omega - \frac{\partial \varphi}{\partial L^o}\right)$ being higher than the opportunity cost of using the labour for own production $\left(\frac{\partial q}{\partial L^o}\right)$. That is, farm households will hire out labour only if the opportunity cost of using that labour on own farm is less than the wage earned in the market after subtracting the transaction costs.

*Non-participating households*

Based on the FOCs in equations (iv) and (v), the optimal conditions for non-participating household or the shadow value with respect to the land and labour endowment is given in equation (vi).

$\frac{\partial q}{\partial \bar{A}} < \rho + \frac{\partial \eta}{\partial A^i}$ for the land market or $\frac{\partial q}{\partial \bar{L}} < \omega - \frac{\partial \varphi}{\partial L^o}$ for the labour market (vi)

Equation (vi) indicates that non-participating households consider their shadow value to agricultural land and labour to be greater than the net return from either renting-in the land or hiring out labour. Overall, the theoretical framework shows that households will decide to trade these factors of production if it is profitable to engage in these factor markets after accounting for non-linear transaction costs.

The theory discussed so far is a static model with non-linear transaction costs that vary across space and in one production season. However, farm households are continuously engaging in these decisions over time, hence they accumulate knowledge that is used in subsequent years. Such knowledge or experience does not only depend on the within household decisions but also on community or geographical factors, governing policy and state of nature or environmental variables as presented in Figure 1. Thus, following Holden et al. (2007), I apply the reduced model of the farm household decision variable that reflect household intertemporal decisions in the factor markets. That is, renting-in agricultural land or hiring out labour is a dynamic decision with varying intertemporal transaction costs. This changes all the variables in equation (iii), where the dynamic choice variables are specified as $(A^{i}{}_{jt})$ for land rented-in and $(L^{o}{}_{jt})$ for labour hired out. Where $j$ is for the household and $t$ is for time, applied to all variables in the equation.

In addition to applying the dynamic farm household decisions to trade agricultural land $(A^{i}{}_{jt})$ or labour $(L^{o}{}_{jt})$, I also apply the state-contingent approach to production under uncertainty (O'Donnell & Griffiths, 2006; Quiggin & Chambers, 2006). The theory indicates that farm households make input decisions before the state of nature is revealed or environmental outcome is known. However, such decisions are not just stochastic but also depend on the probability of an outcome in the state of nature, where the probability is partly a function of household experience over time. Thus, farm households make state-contingent land and labour choices that aim at minimising both production and consumption shocks, *ex-ante* and *ex-post* the events (Dercon, 2002; Holden & Quiggin, 2017). Farm households make these state-contingent input choices like renting-in agricultural land or hiring out labour in a way that does not only reduce risk but also substitute risk (Holden & Quiggin, 2017). Overall, the theory applied in this thesis is the farm household model with dynamic household decisions that are state-contingent to the revealed state of nature, previous policy mix, and experience in the factor markets. In line with the discussed conceptual and theoretical framework, all the four research papers compiled in this thesis use data from two sources, which I discuss in the next section.

## 4. Survey methods and data

The work in this thesis combines the nationally representative household survey data and the 10-year district-level rainfall data from Malawi. The survey data is from three-panel rounds of the Malawi Living Standards Measurement Surveys (LSMS) conducted in (i) March 2010 to March 2011; (ii) April to December 2013; and (iii) April 2016 to April 2017. The Living Standards Measurement Surveys (LSMS) are a series of data collection processes conducted by the National Statistics Offices of most developing countries and facilitated by the World Bank–LSMS Department. The objective of collecting this data is to periodically assess the changes in the living conditions of people in developing countries. Thus, the LSMS data covers the household, agricultural and community characteristics (National Statistics Office, 2017a).

In Malawi, the survey is conducted every five years and mainly focus on cross-sectional data. The recent cross-sectional survey rounds were conducted in 2010 and 2016, which randomly sampled at least 12 thousand households across urban and rural areas of Malawi (National Statistics Office, 2017a). Although the survey interval is 5 years in Malawi, in 2013 the World Bank–LSMS team introduced a short panel in between the cross-sectional survey rounds to increase the use of the LSMS data. In Malawi, they used the 2010 cross-sectional survey round as the baseline year to identify 3,246 households from 204 (out of 768) nationally representative Enumeration Areas (EAs). The identified households in these EAs were followed in 2013 and 2016 survey rounds.

Since the LSMS survey process tracks individuals within a household, if one member has split-off, the new household is automatically incorporated in the sample when they are traced. Therefore, the survey round in 2013 tracked 3,104 households from 3,246 that represent almost 4 percent attrition rate. However, due to members splitting off, the sample size increased to 4,000 households in 2013 (National Statistics Office, 2014). Combining the panel and cross-section survey in 2016, the LSMS team considered it feasible and efficient to reduce the panel sample from 204 EAs to 104 nationally representative EAs. From these EAs, they identified 1,990 households that were interviewed in 2013, of which they traced 1,908 in 2016, representing a 4 percent attrition rate. But with split-off members, the sample increased to 2,508 households (National Statistics Office, 2017a).

Considering the magnitude of the LSMS survey questionnaire and the sample size, the low attrition rate in Malawi allows for more effective use of the panel data compared to the cross-section data. Therefore, the survey data used in this thesis is the open-access panel data that was released by the Malawi National Statistics Office and the World Bank–LSMS team (https://microdata.worldbank.org/index.php/catalog/2939). In this data, the respective sample size for each survey round were 1,619 households from 2010 round; 1,990 households from 2013 round; and 2,508 households from 2016 round (National Statistics Office, 2017b). In addition to using the unbalanced panel data in the first paper, I also constructed a balanced panel data for analysing household dynamic decisions while accounting for any attrition bias in the analysis.

To complement the LSMS survey data, I used the 10-year monthly district-level rainfall data sourced upon request from the Department of Climate Change and Meteorological Services in Malawi (http://www.metmalawi.gov.mw/). The objective of using this data was to assess spatial rainfall variations over a long period, as opposed to using the rainfall data reported in each LSMS survey round. Thus, I requested and accessed monthly rainfall data from January 2007 to December 2017 across different weather stations in the 28 districts of Malawi. This data was matched with household data and depicted within-region rainfall variations or shocks.

In Malawi, the districts are grouped into three regions namely Northern (6 districts); Central (9 districts); and Southern (13 districts). With the district monthly data, I was able to generate short-term and medium-term spatial rainfall shock variables that happen in the early to mid-seasons, following a unimodal rainfall pattern that spans from November to April in Malawi. Use of such variables was more relevant in assessing the lagged rainfall shock effects on farm household decision to rent-in agricultural land or hire out labour for agricultural casual work.

By merging the nationally representative household survey data with district-level rainfall data, I was able to assess household-level decision variables in relation to community, district and regional level variables. The well-disaggregated land sources and use of labour in the LSMS survey data further helped in categorising household decisions in line with the farm household model. Studies that have analysed coverage of LSMS data on land markets support the use of this data when assessing the demand for agricultural land, as it adequately captures data from tenants compared to the landlord households (Deininger et al., 2017; Ricker-Gilbert et al., 2019). Thus, assessing land transactions on the demand side using the LSMS panel data should reveal new empirical evidence and possibly relevant policy issues in the land rental markets developing in Malawi. With this data, the next sections summaries the scientific contributions in this thesis before presenting the policy implications, limitation and future research.

## 5. Scientific contributions

The four research papers in this thesis respond to several empirical questions relevant in the current policy debates on land markets and efficient allocation of factors of production in Sub-Saharan Africa (SSA). The specific questions for this thesis are (i) what are the important spatial and intertemporal changes in land shadow prices that affect patterns of land valuation and transactions? (ii) what is the dynamic nature of transaction costs in the land rental markets developing in Malawi? (iii) how are transaction costs affecting entry and extent of participation (amount of land rented-in) amongst potential tenant households? (iv) are spatial variations in downside and upside lagged rainfall shocks kick-starting access to rented land among potential tenant households? (v) is more family labour relative to agricultural land (falling land to labour ratio due to land scarcity) a push factor associated with the household entry and the extent of participation in agricultural land rental and seasonal labour markets? and (vi) how are land rental markets influencing the decision to trade family labour for casual work in seasonal agricultural labour markets? In line with these questions, the sub-sections below summarise the objectives, theory, methods and main findings from each of the four research papers compiled in this thesis.

***Paper I: Urban proximity, demand for land and land shadow prices in Malawi***

Understanding the changing trends in the land values or prices is important for having insights on land productivity, profitability, land market forces of demand and supply, and overall economic development (Coomes et al., 2018). When recorded land prices observed from actual land transactions are not publicly accessible because of thin and spatially dispersed markets, Coomes et al. (2018) indicated that implicit land prices should reflect land values that are important for assessing demand for land and related land market transactions. To contribute to this understanding, this paper assesses the important spatial and intertemporal changes in farmland shadow prices, within the broader political economy perspective that shape patterns of land valuation and transactions.

In the paper, we specifically analyse the Willingness-To-Accept (WTA) land sales and rental prices and their ratio across space and overtime on owned land at the farm household level. We assume that the ratio of the sales to rental prices should reflect the long-term expected returns to land compared to short-term gains. The ratio should also reflect the impact of converting land from agricultural to non-agricultural purposes, especially near urban centres. We also propose that farm household-level population pressure has a spatial effect on household shadow prices in peri-urban and rural areas. We use the unbalanced panel data from the Malawi Living Standards Measurement Survey (LSMS) collected in 2010, 2013 and 2016 survey rounds.

Building on the von Thünen theory of agricultural investments and economic rent across space (Sinclair, 1967), and the Capozza and Helsley (1989) stylized urban growth model, we focus on the policy changes that aimed at integrating the rural resources and communities to the global agricultural value chains in developing countries. This followed the recent discussions on "land grabs" in Africa associated with the 2007–08 spike in energy and food prices that created speculations for a roaming food crisis (Byerlee & Deininger, 2013; Cotula, 2013; White et al., 2012). Under this policy wave, Malawi like most African countries committed to providing land to large scale commercial investors under the Greenbelt initiative (Chinsinga, 2017).

This policy direction faced a lot of political discussions, which challenged the implementation of this policy, especially after the death of the championing president in 2012. Thus, in 2013, there was a change in political will towards such large-scale land transfers although demand for agricultural land continues in Malawi. We, therefore, assess how such policy changes and farm household-level population pressure have influenced household shadow land prices across space and over time. We split the sample of farm households into quintiles based on distance from the nearest major city area zone and use the Hedonic Price Method to analyse the changes in the land shadow prices. We considered 2013 as the transitioning year in the policy shift.

The results indicate that generally, farmland shadow prices decrease with distance from urban centres while being positively correlated with farm household-level population pressure, especially in urban proximity. However, between 2010 and 2013, farmland shadow prices increased more sharply in rural areas compared to peri-urban areas. By 2016, the increasing trend in shadow sales prices had reversed to a similar trend as in 2010, where the shadow sales prices in urban proximity were three times higher than in rural areas. On the contrary, shadow rental prices continued to increase even after 2013, especially in rural areas.

In summary, the results imply that the sharp increase in demand for large-scale land transfers affected smallholders' land valuation, even in remote rural areas of Malawi. This is in addition to the local level population pressure that indicates a growing demand for agricultural land through both sales and rental markets in peri-urban and rural areas.

***Paper II: Non-convex transaction costs and land rental market participation in Malawi***

The market theory in SSA suggests that high and non-linear transaction costs characterise factor markets across space and over time (Fafchamps, 2004; Holden et al., 2010). In these markets, the transaction costs are non-linear and high from varying transportation costs and information asymmetry. The market theory further suggests that market participants invest in inter-personal networks of information, trust and reputation upon entering the factor markets in SSA (Fafchamps, 2004). These networks are important for searching, negotiating and enforcing contracts over time. Therefore, such inter-personal networks can lead to intertemporal, non-linear and non-convex transaction costs in factor markets.

Non-convex transaction costs imply marginally decreasing costs mainly from participants overcoming market entry barriers and with repeated engagements over time (Fafchamps, 2004). With such non-convex transaction costs, participation in the market can be state-dependent from networks of trust and reputation that facilitates access to market information. Despite the theoretical understanding of factor markets in SSA, the extent to which non-convex transaction costs characterise land markets, and whether such land transactions are state-dependent on previous participation remains an open empirical question in SSA.

Using the farm household model and the dynamic non-linear transaction costs theory, this paper contributes to the above question. In the paper, we use three rounds of the Malawi Living Standards Measurement Survey conducted in 2010, 2013 and 2016. We constructed a three-year balanced panel data and applied the dynamic random effects panel probit and Tobit models for entry and extent of participation (Wooldridge, 2010). Our analysis focused on the extent to which non-linear and non-convex transaction costs ration potential tenants' entry and extent of participation. We further assessed whether the extent of participation (amount of land rented in) is state-dependent on previous engagement in the markets.

We observe that high and non-linear transaction costs potentially ration market participation in the land rental markets developing in Malawi. The results point towards thin land rental markets that hinder efficient resource recombination across farms, thereby constraining land-use efficiency. Although the transactions are high and non-linear, we also observed that they are non-convex over time. The observed non-convexity point towards transaction costs that exhibit reducing trend overtime if farm households overcome the first hurdle of entering the land rental market. Over time, such non-convex transaction costs should improve access to rented land despite the dominance of short-term and fixed-rentals contracts in Malawi. However, we did not observe that the extent of participation (amount of land rented-in) is state-dependent on previous engagements in the rental markets.

***Paper III: Can rainfall shocks enhance access to rented land? Evidence from Malawi***

With non-missing land rental markets in SSA, farm households are now strategically reallocating their land and non-land resources through participation in the land rental markets developing in countries across SSA. Scholarly papers show that farm households use the land rental markets as a coping strategy *ex-post* downside rainfall shocks in form of distress renting out of agricultural land (Gebregziabher & Holden, 2011; Kusunose & Lybbert, 2014). Despite evidence on distress supply of rented agricultural land after rainfall shocks, the corresponding effect on the uptake or demand for the supplied agricultural land has not been subject to much research in the land rental markets literature. This is in addition to the generally limited evidence on the spatial variation effect of rainfall shocks on the household decision to rent-in farmland. Thus, if the rainfall shocks are shifting the supply of agricultural land, we consider understanding how tenant households are utilizing these opportunities as a missing link in the land rental markets literature.

We assess whether spatial variations in downside and upside lagged rainfall shock effects are kick-starting access to rented land among tenant households. That is by shifting supply through distress rentals and hence creating opportunities for renting-in agricultural land across agro-ecological zones. The analysis in this paper applies the state-contingent framework for risky input choice within a farm household decision model (Holden & Quiggin, 2017; Quiggin & Chambers, 2006). Furthermore, the farm household decision to participate in the land rental market is modelled subject to district-wise rainfall shock variables that depict regional level and spatial effects across different agro-ecological zones in Malawi.

We use the three-year household balanced panel data from the Malawi Living Standards Measurement Surveys conducted in 2010, 2013 and 2016. The survey data was combined with 10-year monthly rainfall data that captured district-level weather shocks while showing the within region variations, across the three regions of Malawi. By construction, we use the one-year and two-year lagged early to mid-season rainfall deviation variables. These are deviations from the 10-year mean values at district level following a unimodal rainfall pattern that runs from November to April in Malawi. To assess entry and extent of market participation (amount of land rented-in at the farm households level given in hectares), we used the correlated and dynamic random-effects panel probit and Tobit models (Chamberlain, 1982; Mundlak, 1978; Wooldridge, 2010).

The results reveal spatial differences across the regions that exhibit different agro-ecological zones, population density and land rental market activity. Overall, we only observe the significant effect of the downside but not the upside lagged rainfall shock effects in the regions. In the Central Region of Malawi, where land rental markets are most active, the one-year and two-year lagged downside rainfall shocks are associated with increased access to rented land, even after controlling for entry barriers related to market information transaction costs.

For the more land constrained Southern Region of Malawi, with less prevalence of land rental markets, the results show that the two-year lagged downside rainfall shock effects can reduce access to rented land among potential tenants. Both entry and extent of participation reduce with a two-year lag shock effect in this region. However, farm households with experience in the market within the Southern region were more likely to also participate in the subsequent years. These are possible market entry barriers that call for policy interventions that can assist access and use of agricultural land amidst recurring downside rainfall shocks.

***Paper IV: The falling land to labour ratios and agricultural trade response strategies in Malawi***

Owned agricultural land relative to labour endowment (land to labour ratio) at the farm household level continues to fall in most countries across Sub-Saharan Africa (SSA), because of increase in population pressure and urbanisation rates (Chamberlin et al., 2014; Headey & Jayne, 2014). Traditionally, farm households have been responding to this land scarcity challenge by shifting labour within the agricultural sector, mainly by doing casual work in seasonal agricultural labour markets. This has been partly because of missing, absent or thin land markets that could facilitate the use of land and non-land factors of production (Ellis, 2000; Jayne et al., 2014). However, land rental markets are now developing and giving opportunities for farm households to achieve closer to desired access to land, considering the persistent evidence of high and non-linear transaction costs that characterise factor markets in SSA (Fafchamps, 2004; Ricker-Gilbert & Chamberlin, 2018).

In this paper, I focus on the farm households who are relatively labour rich compared to owned agricultural land (relative more family labour to owned farmland), who can either rent-in the land or hire-out the labour, as the trade response strategies to the growing land scarcity challenge. The focus on the relative labour rich households is because of the increase in farm household-level population pressure and landlessness that is mostly leaving households with relatively more labour to owned farmland in SSA (Jayne et al., 2014).

I jointly assess whether the falling owned land to labour endowment ratio is a push factor associated with household entry and the extent of participation in agricultural land rental and seasonal labour markets. In a recursive model, I further assess how the developing land rental markets are influencing the farm household decision to hire out labour for casual work, commonly known as *ganyu* in Malawi. Hiring out labour for casual work in SSA is considered as a livelihood strategy but also an income or food consumption coping strategy (Van Hoyweghen et al., 2020). Thus, I also assess the extent to which asset wealth to labour endowment ratio is influencing the trade decision in these factor markets, as the livelihood response strategy to the increase in land scarcity challenges in Malawi.

I use the two-year household balanced panel data, constructed from the Malawi Living Standards Measurement Survey conducted in 2013 and 2016. The survey data is combined with the 10-year district-level rainfall data. To estimate the joint decision, I use the bivariate and recursive bivariate models for entry into factor markets while jointly using the Tobit and fractional probit models for the extent of participation. The Tobit model assesses the amount of land rented-in (measured in hectares) while the fractional probit model measures the share of adult equivalent labour hired out in seasonal agricultural labour markets and doing casual work. Considering the simultaneity and endogeneity issues in the systems approach, I used the correlated random effects model and the conditional mixed process estimation methods that apply full information maximum likelihood method (Chamberlain, 1982; Kassouf & Hoffmann, 2006; Mundlak, 1978; Roodman, 2011; Wooldridge, 2010).

The results indicate that the falling owned land to labour endowment ratio is a push factor for farm households to participate in either land rental or seasonal agricultural labour markets. However, if a farm household rents in agricultural land, the probability of hiring out labour for short-term casual work reduces by 38 percentage points at one percent significance level. This shows that land rental markets can improve the probability of using labour on owned farm for medium to long-term gains as opposed to short-term gains doing *ganyu* work. Using asset wealth to labour endowment ratio, it is the wealthier farm households who are more likely to participate in the land rental markets. The very poor in asset wealth relative to labour and the majority of the smallholder farmers are more likely to hire out labour for casual work. A higher probability of smallholder farmers hiring out labour for casual work could be a sign of household liquidity constraints related to agricultural operational and other household needs, or higher friction or transaction costs in the land rental markets compared to the labour markets. These are the issues that agricultural policy discussions and land-use strategies should continue to emphasize while aiming at reducing the friction in the factor markets in Malawi.

## 6. Policy contributions and conclusion

In Malawi and other Sub-Saharan African countries, much of the agricultural land policy discussions in the past decade has focused on the recent large-scale land transfers within the agricultural sector. This has overlooked the modalities of transferring land to smallholder farm households in Sub-Saharan Africa (SSA). Thus, the first recommendation in this thesis is on the need to re-focus the discussion to improving farm household access to agricultural land in rural, peri-urban and urban areas. This follows our observation that farm household level population pressure continues to drive land shadow values or prices in paper one. Such policy discussions should be important considering the growing population density and the increase in urbanisation rates in Malawi and countries across SSA.

Again, the increase in agricultural land shadow values in peri-urban areas and shadow rental values in rural areas observed in paper one, demonstrate a growing trend in land values or prices among smallholder farmers. This trend points towards possible transferring of land to within the agricultural sector or reallocation of agricultural land for non-agricultural purposes, especially in peri-urban areas. With such developments, there is a need for the government to develop, update and implement the land use policy and land use maps in peri-urban and rural areas, in ways that should sustain agricultural productivity. This is because agriculture remains a central source of food supply and livelihood in both rural and urban areas of Malawi.

One strategy in the land use policy can be to promote land rental markets as an affordable avenue for accessing agricultural land, especially for land constrained and potential tenants among smallholder farm households. But then, how can the policymakers promote such land markets? I contribute to this question based on the empirical evidence in paper two. From paper two, we observed that over time, high and non-linear transaction costs related to accessing land rental market information continue to ration the participation of potential tenants or farm households renting-in land in Malawi.

To promote participation in the land rental markets, there is a need for policy strategies that can improve access to land market information and possibly facilitate the orchestration of partners given the spatial nature of land rental markets. This comes from the observation that non-convex transaction costs characterise land rental markets developing in Malawi. The non-convex transaction costs imply marginally decreasing costs overtime from market participants overcoming entry into the land rental markets and developing networks of information, trust and reputation that can easily facilitate access to land market information. With non-convex transaction costs, the policy strategies can include the use of low-cost and community-level information dissemination channels like the pluralistic agricultural extension and information systems in Malawi.

Considering the importance of improving access to land rental market information, it is also important to understand when and who is in most need of such information in the market. In paper three we observed that lagged downside rainfall shocks are associated with promoting participation in land rental markets where such markets are more active while being associated with reducing participation where land rental markets are less active. Such spatial variation effects call for the need to include land rental market information in climate response strategies at the local or community level. Improving access to land market information in areas most affected by downside rainfall shocks can promote participation in the land rental markets to be more competitive for those supplying in distress and those demand agricultural land aftershocks. Thus, deliberate land campaigns in rural areas should be promoted to improve access to land aftershocks.

Land markets develop to enhance allocative efficiency of both land and non-land factors of production. To what extent are the developing rental markets achieving this in Malawi? Paper four partly tackle this issue by assessing jointly the household land and labour allocation decisions. While the results in paper four showed that renting-in the land can reduce the probability of hiring out labour for casual work, the poor and majority of the smallholder farmers in Malawi are still rationed from renting-in agricultural land and being pushed to hiring out labour for short-term wage returns. Such a higher probability of smallholder farmers hiring out labour for casual work concurs with the observation in paper two on high and non-linear transaction costs that characterise land rental markets in Malawi. This is in addition to the limited asset capital wealth or liquidity constraints that can push households to hire out labour for short-term gains.

In conclusion, the empirical evidence presented in this thesis strongly points to the need for tailor-made policy strategies that can reduce friction or transaction costs in the land markets while also easing the liquidity constraints among productive and progressing smallholder farmers, who are willing to rent-in agricultural land. The policy strategies can include promoting land rental market campaigns in rural areas, improving access to land market information on available agricultural land, land-use changes and land market values at the community level. Malawi can also aim at establishing a land bank that can facilitate access to capital for land rental transactions or implement subsidies that support agricultural operations. Such policy considerations can promote the land rental markets as an affordable avenue of accessing land in rural areas and among smallholder farmers. In general, this can help to sustain rural livelihoods and contribute to both rural and urban transformation, as land scarcity challenges continue in Malawi.

## 7. Limitation and future research

The empirical work in this thesis has assessed changing trends in land sales and rental shadow prices, the land rental market transactions, and agricultural factor market decisions nexus or linkages. However, an important limitation in the analysis was encountered due to the inadequacy of the data in capturing the households renting out land or landlord households. With the Malawi Living Standards Measurement Survey (LSMS) data, the sample size for households renting out the land was too small to do meaningful analytical or comparative work. Therefore, there is need for further research that should include landlords or the supply side of the land market transactions. Using matched tenant and landlord data, future research can also assess the characteristics of landlords and tenants in the land rental and sales markets across space and over time in Malawi.

At the end of this research work, I reckon I might be left with the need to contribute to the understanding of "whether it is the poor households renting out the land that are also hiring out the labour; or whether it is the wealthier tenants renting-in land that are also hiring-in labour". Such research can further contribute to a broader understanding of changing trends in demand for agricultural land, opportunities and constraints in the land rental markets in Malawi and across other countries in Sub-Saharan Africa.

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# Paper One

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# Urban proximity, demand for land and land shadow prices in Malawi

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ABSTRACT

We assess the spatial and intertemporal variation in farmland prices using per hectare minimum willingness to accept (WTA) sales and rental (shadow) prices in Malawi. We use three rounds of nationally representative farm household panel data from the Living Standards Measurement Surveys (LSMS), collected in 2010, 2013 and 2016. The sample is split in quintiles based on distance from the nearest major city, building on the land valuation and transaction cost theory, and agrarian political economy perspectives on global and national land transactions. Generally, farmland shadow prices decrease with distance from urban areas. However, farmland shadow sales prices increased more sharply between 2010 and 2013 in rural areas (+100 % vs +30 % in urban proximity). The results indicate that the sharp increase in demand for large-scale land transfers following the sharp increase in energy and food prices also affected rural smallholders' land valuation, even in remote rural areas of Malawi. Conversely, by 2016 land shadow sales prices were again, like in 2010, about three times as high in areas near urban centres compared to remote rural areas. Even though sales prices declined in remote rural areas from 2013 to 2016, rental prices remained high. Using farm household-level population pressure variable, we show that local population pressure is a driver of farmland shadow prices, indicating land scarcity challenges, growing demand for land, and poorly developed land markets. With increasing land scarcity, land markets are becoming more important and need to be factored in when formulating development policies that aim to improve access to land in both peri-urban and rural areas.

## 1. Introduction

African cities are growing rapidly. Both population growth and rural-urban migration drive this urbanisation (Jedwab et al., 2015). The United Nations (UN) report shows that the proportion of urban to total population in Sub-Saharan Africa (SSA) is expected to increase by 19 percentage points between 2014 and 2050 (United Nations, 2014). This increase in urban population has resulted in some African countries reclassifying their urban boundaries through outward expansion into rural space (Manda, 2013). Considering that most land in SSA is under rural agricultural use, the changes in demand for land have contributed to the growth of land markets in Africa (Holden et al., 2010). When these markets work well, they contribute to the transfer of land to more efficient producers at prices that make buyers and sellers better off (ibid). These markets are crucial to facilitate the necessary future rural and urban transformation processes, especially in SSA. However, these markets are only emerging in most African countries despite land scarcity challenges, due to land tenure restrictions and other institutional, economic and biophysical characteristics (Binswanger and Rosenzweig, 1986; Holden et al., 2010).

According to Byerlee and Deininger (2013); Deininger and Byerlee (2011) and White et al. (2012), the world demand for agricultural land increased after 2008, especially in SSA following the sharp increase in world energy and food prices in 2007–2008 period. These authors indicated that the recent "land grab" fears in Africa is associated with this sharp increase in demand for large-scale land transfers, especially in areas with weak land rights and tenure institutions, and for marginalised groups with weak land rights. However, White et al. (2012) indicated that the policy responses and political discussion around these "land grabs" had challenged agents involved in these large-scale land transfers, thereby constraining the supply responses to this demand for agricultural land in SSA.[1] On the other hand, studies on land use and urban proximity in Africa indicated that increasing demand for land nearer urban centres is mainly a function of population growth, migration, economic development and accessibility to the city (Briggs, 1991; Kleemann et al., 2017).

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[1] The policy responses include the World Bank seven principles for responsible agro-investments and the Land Governance Assessment Framework (LGAF) that were implemented in many African countries (Deininger, 2011; Deininger et al., 2014) while the political discussions include the civil society movements on land grabs in Africa (Campesina, 2011).

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Despite the existing literature, smallholder agriculture land values and prices have not yet been subject to much research in SSA. Coomes et al. (2018) and Plantinga et al. (2002) indicated that where land price data is available, studying land prices may give valuable insights on land productivity, profitability, changes in demand and supply, urban development, and overall economic growth. Coomes et al. (2018) further pointed out that where recorded land prices are not available, the use of implicit prices is also vital for understanding land market forces.

Therefore, our objective is to assess the effect of changing demands for agricultural land on farmland shadow prices (Willingness-to-Accept (WTA) sales and rental prices and their ratio) across space and over time. The ratio of prices should reflect long-term relative to short-term expected profitability or returns to land among respondent households as well as the impact of converting land from agricultural to non-agricultural purposes near urban centres. We also propose that farm household-level population pressure might have an effect on household shadow prices for land across space, in a country dominated by smallholder agriculture and where land markets still are thin and characterised by high transaction costs. This should make land shadow prices sensitive to high and growing population density and the agricultural policy that strongly emphasizes household food security (Chirwa and Dorward, 2013; Government of Malawi, 2016c).

Our study uses the household survey responses to farmland shadow sales and rental prices for all land parcels of a nationally representative sample, from the Living Standards Measurement Surveys (LSMS), collected in 2010, 2013 and 2016 in Malawi. Land, being a capital asset, a key production factor and a private good, should be considerably easier to value than many of the public goods that are valued using the Contingent Valuation Method (CVM) (Horowitz and McConnell, 2002; Roka and Palmquist, 1997). We recognise that use of shadow (hypothetical) prices reflect the land value based on familiarity with land attributes by individual owners, which might be different from revealed preferences when one uses actual or observed market prices (Carson et al., 2001). Thus, we propose that the use of CVM and WTA prices should give a good picture of perceived farmland values or shadow prices at the household level for the years we have the data, in line with changing demands for agricultural land in Malawi. The use of such prices is preferable because of thin land markets in Malawi (Lunduka et al., 2009). The alternative use of few recorded land prices from actual land transfers is unlikely to give a good representation of non-traded land in Malawi.

We are only aware of two other studies that used contingent land valuation methods (CVM) to study drivers of farmland values in Africa and attitudes towards legalization of land sales in Ethiopia and Tanzania (Holden and Bezu, 2016; Wineman and Jayne, 2017). By using a nationally representative household panel data from Malawi, our study adds to this limited literature. We aim to demonstrate the important spatial and intertemporal changes in farmland shadow prices, within the broader political economy perspective that shapes patterns of land valuation in SSA.

We have organised the remaining paper in seven sections. Section two presents the conceptual framework on land valuation within the agrarian political economy perspective and states the hypotheses. Within section two, we also briefly discuss the Malawi case and urbanisation rates related to changing demands for land. In section three, we present the survey methods and data while in section four we discuss the estimation method. Section five gives descriptive statistics. We present and discuss the results in section six, and we conclude in section seven.

## 2. Conceptual framework and hypotheses

### 2.1. Theory of land valuation

The von Thünen theory of agricultural investments and economic rent across space (Sinclair, 1967), and the Capozza and Helsley (1989) stylized urban growth model generally indicates that farmland prices decrease with increasing distance from urban centres because of transportation costs and availability of output markets in urban areas. The classical von Thünen theory states that agricultural land values or prices are a function of economic rent or profit from agricultural use that is estimated as a function of distance to a central market place (Sinclair, 1967). Although the von Thünen theory provides the basis for agricultural land valuation, Sinclair (1967) indicated that industrialisation and increase in urban population– that can result in urbanisation and urban sprawl, can also influence rural agricultural land use values even before the actual development of urban infrastructure. That is, a high probability of conversion of land use from rural to urban creates expectations that influence land-use values.

In line with the von Thünen theory, the Capozza and Helsley (1989) stylized urban growth model fully integrates land valuation in urban and rural areas. The model categorizes the unit land price into urban, peri-urban and rural areas. The price per unit of land in urban areas is mainly valued based on the cost of converting the land use or development cost that captures capital improvements on land; and the value of accessibility to the Central Business District (CBD) or transport cost. The unit land price in peri-urban areas is mainly a function of agriculture land quality or economic rent; and the expected increase in land value built on the trend of spatial expansion of urban areas in line with Sinclair (1967). Beyond the urban fringe or in rural areas, per unit land prices are only a function of the economic rent, which is the return from farm investments as indicated in the von Thünen theory (Anderson, 2012).

The underlying assumption of the classical land valuation models is that markets exist and that individual households freely trade their products, especially agricultural products. However, theory and evidence show that agricultural markets are characterised by high transaction costs beyond transport costs, especially in Sub-Saharan Africa (Fafchamps, 2004). Land markets are usually thin or missing because of the immobility and spatial dispersion of land, poor infrastructure, seasonality of agriculture, information asymmetries and institutions that shape patterns of trade (Binswanger and Rosenzweig, 1986; Fafchamps, 2004). The implication is that individual households face high non-linear transaction costs in the land markets, especially in areas with low population densities and poor infrastructure, but also in areas with land scarcity such as Malawi where land market activity is increasing (Holden et al., 2010).

### 2.2. Agrarian political economy perspective

In his study, Cotula (2013) indicated that after the 2007–2008 spike in energy and food prices, a combination of policy and market forces made land, particularly in Africa, a more attractive investment option due to national and global concerns for long-term food and energy security. White et al. (2012) further indicated that the narratives on food, energy and climate "crisis"[2] led to a policy interest to integrate rural resources and communities (mostly in developing countries) to the global commodity value chains with an agri-business-oriented vision for agriculture.

Although studies in most SSA countries (including Malawi) have observed limited price transmission between global and domestic food prices (Benson et al., 2008; Cornia et al., 2016; Cotula, 2013), the sharp increase in demand for land, a ten-fold increase in large-scale investments and land transfers, commonly referred to as a "land grab" after 2007–2008, also created policy responses that influenced the direction of agricultural investments in most SSA countries (Cotula, 2013; White

[2] White et al. (2012) use crisis in quotes because this was a phenomenon based on anticipated global food and energy insecurity problems as well as the competing demands for land in environmental management and infrastructure development.

et al., 2012). High food and energy prices created expectations of high returns from growing food and energy crops and attracted many investors. It is not strange, however, that high food prices affect agricultural land values more broadly, thereby increasing agricultural land values across the globe. It was especially in SSA countries with weak land governance frameworks and abundant land that investors saw profitable investment opportunities (Byerlee and Deininger, 2013; Cotula, 2013). Although these issues cut across regions, Cotula (2013) indicated that context-specific factors also facilitated new agricultural investments, especially in economies with weak investment capacity. Thus, it should be worth investing in a deeper understanding the global and local impacts associated with the sharp increase in demand for agricultural land and how it affected local land valuation given the imperfect nature of land markets. In this paper, we therefore focus on Malawi, an agriculture-dependent country in SSA region.

### 2.3. The case of Malawi

Malawi is of particular interest in this study because the county's agricultural sector holds 56 percent of the total available land, contributes 80 percent to the export earnings and employs 64 percent of the country's workforce (Government of Malawi, 2002, 2017). Furthermore, the country has a strong policy priority towards enhancing agricultural production for both food security and nutrition (Government of Malawi, 2016c). In trying to ensure food security and income growth and to hedge agricultural production against rainfall shocks, Malawi is among the SSA countries that experienced a high demand for agricultural land from 2009. This demand was associated with the promotion of large-scale commercial farming, with links to smallholder out-grower contract farming under programs like the Greenbelt Initiative (GBI) and the G8′s New Alliance for Food Security and Nutrition (Chinsinga and Chasukwa, 2012; Gausi and Mlaka, 2015).

Chinsinga and Chasukwa (2012) reported that through the GBI, Malawi committed to offering local and international investors land lying within 20–30 Kms of the large water bodies (mainly the Lake Malawi), an area amounting to 1 million hectares for large-scale irrigation farming of high valued crops. Literature reports large-scale land deals under sugarcane production and other cash crops like paprika (Chinsinga, 2017; Chinsinga and Chasukwa, 2012). This policy direction shifted the demand for rural agricultural land beyond peri-urban areas by both local and foreign investors. Interestingly, the Malawi Government made this policy direction amidst prolonged legislative land policy reforms that were initiated in 1996 and recently enacted in 2016 (Government of Malawi, 2016a, 2016b). Furthermore, the Malawi Government pursued the GBI policy agenda in a country with a high population density (average of 185 persons per square Km), and a population projection that shows that the proportion of urban population to total population will double between 2014 and 2050, from both natural increase and rural-urban migration (Government of Malawi, 2019; Kalipeni, 1997; Manda, 2013; United Nations, 2014). This policy direction, therefore faced waves of political discussions on "land grab" until around 2013, following the death of the Malawian president in 2012 and a change in the country's leadership that shifted the political and economic will towards less support for the GBI (Chinsinga, 2017; Chinsinga and Chasukwa, 2012).

Despite the shift from GBI, the demand for agricultural land continues to grow in Malawi, especially in peri-urban areas. Manda (2013) reported that urbanisation rates (share of urban population to total population) in Malawi had facilitated reclassification of urban boundaries through horizontal expansion as opposed to vertical growth. Malawi has four major city zones across the country, plus town area zones in most districts (Manda, 2013). The city zones are Lilongwe, Blantyre, Mzuzu[3] and Zomba (Appendix – Fig. A1). Manda (2013) reported that all the four city zones continue to experience horizontal expansion from both population growth, migration and availability of farmland area. Such area expansion has resulted in an increased area under urban-rural space and land-scarcity challenges that are key for understanding the effects of spatial expansion of urban areas on farmland shadow prices, as well as the dynamic change effects of demand for agricultural land on land price trends in SSA.

**Table 1**
Median deflated WTA land prices over space and time.

| Variable | Statistic | EA id (number) | Distant range to the city (km) | 2010 | 2013 | 2016 |
|---|---|---|---|---|---|---|
| **CPI deflated WTA Prices (2010 base year)** | | | | | | |
| Deflated WTA sale price (MK)/Ha | Median | 1 – 22 | 0 – 0 | 7886 | 2478 | 4321 |
| | | 23 – 42 | 0 – 37 | 1513 | 2478 | 3116 |
| | | 43 – 62 | 40 – 80 | 950 | 1528 | 1800 |
| | | 63 – 82 | 80 – 140 | 751 | 1394 | 1299 |
| | | 82 – 102 | 161 – 379 | 562 | 1041 | 976 |
| Deflated WTA rent-out price (MK)/Ha | Median | 1 – 22 | 0 – 0 | 124 | 149 | 158 |
| | | 23 – 42 | 0 – 37 | 102 | 137 | 144 |
| | | 43 – 62 | 40 – 80 | 94 | 110 | 122 |
| | | 63 – 82 | 80 – 140 | 76 | 108 | 107 |
| | | 82 – 102 | 161 – 379 | 62 | 87 | 96 |
| Deflated WTA ratio-sales/rental price/Ha | Median | 1 – 22 | 0 – 0 | 36 | 20 | 20 |
| | | 23 – 42 | 0 – 37 | 15 | 19 | 20 |
| | | 43 – 62 | 40 – 80 | 10 | 16 | 14 |
| | | 63 – 82 | 80 – 140 | 10 | 12 | 11 |
| | | 82 – 102 | 161 – 379 | 10 | 11 | 10 |

### 2.4. Hypotheses

Based on our conceptual framework, we have formulated the following hypotheses that we aim to test and/or discuss in light of our data and econometric results;

H1: Land shadow prices increase with increasing farm household-level population pressure in rural as well as in peri-urban areas.

We build on the assumption that there are non-linear transaction costs that lead to imperfections in both land and non-land factor markets that cause these markets to be imperfect (thin, missing, seasonal and with limited competition in line with Binswanger and Rosenzweig (1986)). The large majority of land parcels are not traded but still have WTA (shadow) prices that are influenced by the household and location-specific resource characteristics as well as commodity prices such as food prices (Holden et al., 2010).

H2: High food and energy prices during the associated "land grab" period in Malawi (2007–2013) induced higher expected profitability in farming among smallholder farmers even in remote rural areas, thereby increasing the land shadow prices, and especially the shadow sales prices.

We assume the global demand for agricultural land and the Government initiated programs like the Green Belt Initiative (GBI) increased public awareness related to land use for commercial farming and hence speculations that influenced land shadow prices in Malawi. Programs like the GBI promoted large-scale land acquisitions especially in remote rural areas close to large water bodies, like the Lake Malawi, between 2007 and 2013 (Chinsinga, 2017).

H3: Rural land shadow prices have fallen after 2013 and fallen back towards the previous low level in rural areas by 2016.

We assume that the global political discussions that imposed restrictions on large-scale land transfers as well as the change in Malawi's leadership after 2013 reversed expectations and speculations on increasing land values in remote rural areas (Chinsinga, 2017; Gausi and Mlaka, 2015).

H4: Land shadow sales prices relative to rental prices are higher in peri-urban areas.

[3] Mzuzu city is within Mzimba district

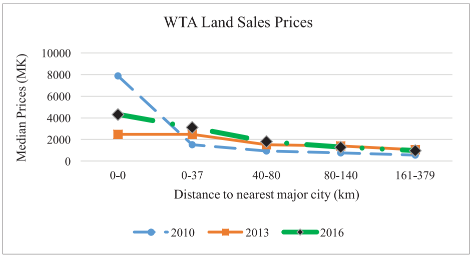


**Fig. 1.** Median deflated WTA land sales prices over space and time.

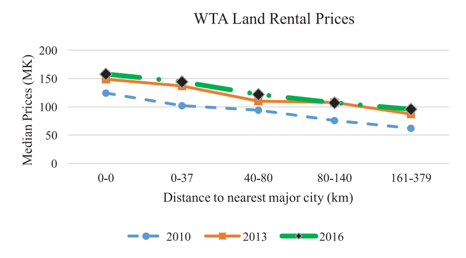


**Fig. 2.** Median deflated WTA land rental prices over space and time.

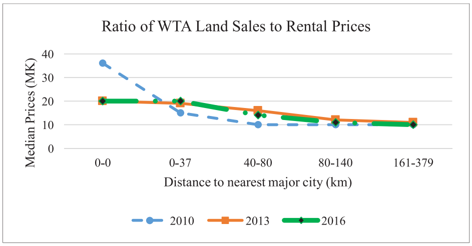


**Fig. 3.** The ratio of WTA land sales to rental prices over space and time.

We build this hypothesis on the assumption that the land shadow sales prices nearer urban centres are more associated with transforming land use from agricultural to non-agricultural purposes with higher potential land use values, whereas shadow rental prices primarily transfer land for agricultural purposes only.

## 3. Survey methods and data

To assess the spatial and intertemporal change patterns of land shadow prices, we use data from three-panel rounds of the Living Standards Measurement Survey–Integrated Surveys on Agriculture (LSMS-ISA) collected in 2010-11, 2013 and 2016-17 in Malawi (National Statistics Office, 2017). The total number of panel households in 2010, as the baseline year, was 1619 and increased in subsequent years from both households splitting and new households joining the survey. According to the Malawi National Statistics Office (NSO), this increased the number of households to 1908 in 2013 and to 2508 in 2016. In subsequent years, the number of Enumeration Areas (EAs) also increased from 98 in 2010 to 102 in 2013 and 2016. Across the survey years, only one household was missing between 2010 and 2013. However, there was a 4 percent attrition rate at the household level between 2013 and 2016. Our analysis maintained all the households that were available in each survey round. Thus, we maintained all the EAs and kept track of the number of times a household appeared across the survey years.

On the minimum WTA farmland prices, the survey was designed to obtain these for owned and not for rented-in, leased, encroached or borrowed land. In 2016, the survey design asked questions on minimum WTA sales and rental prices at the parcel level compared to plot level in the other years[4] . We aggregated the plot level responses from the first two survey rounds to the parcel level and did the analysis at the household parcel level. NSO used the global positioning system (GPS) to accurately measure the farmland area compared to farmers' estimates. The WTA prices were in Malawi Kwacha[5] and were calculated per hectare (ha) of GPS-measured area. We deflated these prices using a consumer price index (CPI)[6] with 2010 as the base year. After data cleaning and keeping household-parcel level data for the owned parcel land, the total number of observations used in this paper was 6557 household-parcels from 1131 households 1602 parcels in 2010, 1471 households 2245 parcels in 2013 and 1918 households 2710 parcels in 2016.

For this data, 0.07 percent of the sample gave a zero-valued shadow rental price and a positive shadow sales price for the same parcel. Furthermore, 0.9 percent had stated land shadow sales prices lower than the shadow rental prices for the same parcel of land, which we considered to be contradicting basic theory and likely to reflect a misunderstanding or data errors. We therefore dropped these outlier observations. Further inspection of the data using scatter and Kdensity graphs also revealed some unrealistically large outlier observations in sales, rental and ratio values. To reduce the noise in the data, we used graphs and visual inspection to determine the upper limit values within each quintile. Mainly, we inspected the scatter plots and the Kdensity graphs for the untransformed and natural-log transformed data and assessed the distribution of the data in the upper tail. To determine the cut-off points, we aimed at getting tails of similar length at both ends of the natural-log transformed distributions within each quintile and price category[7] . By controlling for the outliers, we dropped an average of one percent of the total sample for either sales, rental or ratio prices data. This was so small a share that it had no significant effect on our results.

For the spatial variables, we used the distance to the nearest major city obtained at Enumeration Area (EA) through focus group discussions. These groups consisted of community members of different age and gender, local leaders/chiefs, skilled and unskilled workers. These members should possess the relevant local knowledge, and there was no indication of group incentives to bias the distance estimate. We used this measure of distance in kilometre (km) for each EA listed in ascending order from the city zone for our analysis as a proxy for urban proximity. The EAs within the city zone had a zero distance, and those with the largest distances represented the most remote rural areas. We clustered our analysis at the EA level, and each EA had some variation in the number of household-parcel observations over time.

## 4. Estimation method

Following Rosen (1974), we used the Hedonic Price Method (HPM) to estimate the effect of changing demands on shadow or Willingness to Accept (WTA) land prices among smallholder farmers in Malawi. The hedonic pricing refers to implicit prices of differentiated products based

[4] Parcel is a continuous piece of land that is not separated by river or path wide enough to allow movement of an ox-cart or vehicle (National Statistics Office, 2017). A parcel can include several plots of different crops under different crop management systems.

[5] One US dollar to Malawi Kwacha (MK) was on average MK156.53 in 2011; MK369.18 in 2013 and MK726.04 in 2017 sourced at www.rbm.mw.

[6] The data on CPI was obtained from IMF website (International Monetary Fund, 2016)

[7] In the methodology, we controlled for outlier values within each quintile by inspecting the data distribution using the scatter and Kdensity graphs. The data distribution graphs are available from the authors upon request.

**Table 2**
Dynamic changes in deflated minimum WTA land prices-Natural log land prices. (Full model results are in Appendix Tables A3, A4 and A5).

| Variable (2010 base year) | EA and distance quintiles | | | | |
|---|---|---|---|---|---|
| **EAs** | **1 - 22** | **23 - 42** | **43 - 62** | **63 - 82** | **83 - 102** |
| **Distant range to the city** | **0 – 0 km** | **0 – 37 km** | **40 – 80 km** | **80 – 140 km** | **161 – 379 km** |
| **Sales model** | | | | | |
| *2010 base year* | | | | | |
| Household size to total farmland | 0.008**** | 0.008** | 0.010**** | 0.003 | 0.005**** |
| ratio (Number of persons per ha) | (0.0007) | (0.0029) | (0.0023) | (0.0019) | (0.0010) |
| 2013 year | −0.107 | 0.379**** | 0.362*** | 0.661**** | 0.339*** |
| | (0.2940) | (0.0852) | (0.1108) | (0.0919) | (0.1028) |
| 2016 year | 0.341 | 0.699**** | 0.484**** | 0.543**** | 0.409**** |
| | (0.2466) | (0.0886) | (0.0986) | (0.1105) | (0.1040) |
| Other Controls | Yes | Yes | Yes | Yes | Yes |
| Constant | 6.650**** | 7.311**** | 7.039**** | 6.910**** | 6.249**** |
| | (0.5779) | (0.2724) | (0.1912) | (0.3780) | (0.2290) |
| Observations | 392 | 1,070 | 1,851 | 1,598 | 1,574 |
| R-squared | 0.249 | 0.126 | 0.169 | 0.132 | 0.159 |
| Number of EA id | 22 | 20 | 20 | 20 | 20 |
| Calculated change: 2013 to 2016 | 0.448 | 0.320*** | 0.122 | −0.118 | 0.07 |
| | 0.3837 | 0.1229 | 0.1483 | 0.1437 | 0.1462 |
| **Rental model** | | | | | |
| *2010 base year* | | | | | |
| Household size to total farmland | 0.010**** | 0.006** | 0.008**** | 0.005**** | 0.004*** |
| ratio (Number of persons per ha) | (0.0013) | (0.0026) | (0.0014) | (0.0010) | (0.0012) |
| 2013 year | 0.186 | 0.102 | 0.085 | 0.340*** | 0.275*** |
| | (0.1088) | (0.0955) | (0.0755) | (0.1016) | (0.0901) |
| 2016 year | 0.196 | 0.264*** | 0.302**** | 0.459**** | 0.463**** |
| | (0.1591) | (0.0843) | (0.0754) | (0.0848) | (0.0714) |
| Other Controls | Yes | Yes | Yes | Yes | Yes |
| Constant | 4.027**** | 4.957**** | 4.950**** | 4.762**** | 3.987**** |
| | (0.2907) | (0.1731) | (0.1127) | (0.2316) | (0.2269) |
| Observations | 385 | 1,076 | 1,847 | 1602 | 1,575 |
| R-squared | 0.241 | 0.201 | 0.249 | 0.236 | 0.234 |
| Number of EAs | 22 | 20 | 20 | 20 | 20 |
| Calculated change: 2013 to 2016 | 0.01 | 0.162 | 0.217** | 0.119 | 0.188 |
| | 0.1927 | 0.1273 | 0.1067 | 0.1323 | 0.115 |
| **Land sales/rental price ratio model** | | | | | |
| *2010 base year* | | | | | |
| Household size to total farmland | −0.000 | 0.001 | 0.002** | −0.001 | 0.001** |
| ratio (Number of persons per ha) | (0.0009) | (0.0008) | (0.0011) | (0.0009) | (0.0003) |
| 2013 year | −0.252 | 0.319*** | 0.332*** | 0.310** | 0.071 |
| | (0.3129) | (0.0833) | (0.0924) | (0.1103) | (0.1223) |
| 2016 year | 0.088 | 0.396*** | 0.224 | 0.065 | −0.026 |
| | (0.2938) | (0.1075) | (0.1115) | (0.1091) | (0.0916) |
| Other Controls | Yes | Yes | Yes | Yes | Yes |
| Constant | 2.656**** | 2.293**** | 2.145**** | 2.390**** | 2.257**** |
| | (0.6046) | (0.2862) | (0.1515) | (0.3045) | (0.2346) |
| Observations | 386 | 1,060 | 1,833 | 1,585 | 1,564 |
| R-squared | 0.094 | 0.051 | 0.050 | 0.030 | 0.040 |
| Number of EAs | 22 | 19 | 20 | 20 | 20 |
| Calculated change: 2013 to 2016 | 0.34 | 0.077 | −0.108 | −0.245 | −0.097 |
| | 0.4292 | 0.136 | 0.1448 | 0.1551 | 0.1528 |

Note. Cluster robust standard errors in parentheses, clustered at EA level. Significance levels: **** $p < 0.001$, *** $p < 0.01$, ** $p < 0.05$. We calculated the change from 2013 to 2016 by comparing the computed mean differences after the regression results. We used the *t*-test to assess the significance level of the mean difference compared to zero.

on their attributes revealed by economic agents. HPM implies that the price of a heterogeneous good consisting of a set of distinct attributes $\mathbf{Z} = (z_1, z_2, \ldots\ldots, z_k)$, is a function of all these attributes – both intrinsic and extrinsic (Choumert and Phélinas, 2015).

In line with Palmquist (1989), agricultural or farmland is a heterogonous commodity where the market equilibrium price $P(\boldsymbol{Z})$ is an aggregate of implicit prices, $p_j(\boldsymbol{z})$, based on land attributes. The WTA prices are the implicit or land shadow prices, $p_j(\boldsymbol{z})$, for the parcels of the individual households based on their land and location-specific attributes. Maddison (2000) and Parsons (1990) emphasized that the function used to estimate hedonic prices should be additively separable in terms of structural attributes of land and that prices should be independent of quantity. We thus, separately analyse the rate of change in per hectare land sales and rental prices, and their ratio. We used a natural-log-linear function specified in Eqs. (1) and (2) below for the land shadow sales and rental prices and their ratio, respectively and the per hectare land shadow prices to control for total parcel area.

$$lnWTA_{ijk} = \alpha_0 + \beta_1 D_{jk} + \gamma_t + \boldsymbol{X_{ijk}\beta} + c_k + \varepsilon_{ijk} \quad (1)$$

$$lnRatioWTA_{ijk} = \alpha_0 + \beta_1 D_{jk} + \gamma_t + \boldsymbol{X_{ijk}\beta} + c_k + \varepsilon_{ijk} \quad (2)$$

From the model in Eq. (1), we specify $lnWTA_{ijk}$ as the natural-log of per hectare minimum land prices, a household is willing to accept in land sales or rent-out markets. The $lnRatioWTA_{ijk}$ in Eq. (2) is for the natural-log of the ratio of shadow sales to rental land prices[8] .

To assess the associated market, micro and macro policy effects, we used $D_{jk}$ in Eq.s (1) and (2) for household size to total farmland ratio (number of persons per ha) as an indicator of farm household-level

[8] As discussed in the data section, the estimation method controlled for the noise observed in the data and we used the natural-log transformation to improve the distribution of the data.

population pressure across space. We specify the variable in line with our theory of imperfect markets and high non-linear transaction costs when markets are thin or missing. The parameter $\gamma_t$ represents the correlation for the year dummy variables to capture the changing trends in line with policy and global macro-economic factors across space and over time. We assess these changes from 2010, 2013 and 2016 data and consider 2013 to be a reference point regarding the changes in policy direction in political and economic support on large-scale land investments in Malawi.

In the model, we control for $X_{ijk}$ that represent less dynamic and relatively stable land characteristics, household characteristics, and community control variables at the EA panel level. These included; parcel area (GPS measured area); soil type (sandy, loam, clay, other types) for individual parcels at household level; one-year lagged drought/irregular rains experience at household level as an indicator of weather-related shock, distance to major weekly markets at community level; sex, age and education of the household head; distance to a baseline dwelling location to control for household re-allocating between survey periods; the number of times a household appeared across the survey years; and total livestock units for household wealth.

We included the distance to weekly markets at the community level as a measure of access to established or mobile[9] markets that are assumed to gradually change with the expansion of urban area zones. That is, the distance can reduce if urbanisation or expansion of the city area zones results in building new permanent markets or increase if the land is converted to other non-commercial use, thereby shifting mobile weekly markets to other places. Appendix Table A1 provides a full description of the variables included in the model. The error term is $c_k + \varepsilon_{ijk}$ and all the variables are for parcel household *i-j* from EA *k*. The estimated coefficients are $\alpha_0$ , $\gamma$ and $\boldsymbol{\beta}$ for all variables listed above. The $c_k$ is for EA time-invariant unobserved heterogeneity and the $\varepsilon_{ijk}$ is the idiosyncratic error term.

To facilitate the assessment of the dynamic change patterns in per hectare minimum WTA land sales and rental prices, and their ratio, we estimated the rate of change in land prices between 2010, 2013 and 2016 within and across quintiles. We use the linear fixed effects estimator with heteroskedastic error term that we clustered at EA level[10] . Our analysis compared the year variable across five quintiles of distance to an EA from the nearest major city and within the quintiles for the spatial and intertemporal changes, respectively. By using the EA fixed effects estimator, our model controlled for time-invariant EA-level average household-parcel level characteristics. However, we do not control for time-invariant specific parcel-level variables across households, like soil type and land to labour ratios. This implies that we assess the spatial as well as the intertemporal variations in household-level variables within an enumeration area while controlling for specific parcel-level variables. Based on the data period in this paper, we do not expect much intertemporal change in parcel-level variables like soil type within the EAs.

To define the EA quintiles, we used the distance from the city zones that ranged from 0 to 379 km in our data. We grouped the 102 EAs into five categories of 20 EAs each except for the first group that had 22 EAs because we observed 26 EAs within the 0 − 2 km radius from the city zone area. The grouping was to ensure our analysis focuses on land price changes from the peri-urban to rural areas. The EAs were therefore given ordered numbers based on their increasing distance from the nearest city zone. Therefore, the quintiles were; (1) EAs 1–22 within 0 − 0 km; (2) EAs 23–42 within 0 − 37 km; (3) EAs 43–62 within 40 − 80 km; (4) EAs 63–82 within 80 − 140 km; and (5) EAs 83–102 within 161 − 379 km. The use of quintiles was mainly to capture the radial distribution of land prices.

## 5. Descriptive statistics

We present the summary statistics for the changes in median WTA (shadow) land prices in Table 1 and Figs. 1, 2 and 3 to provide numerical median values and visual price patterns. The table and the figures report median untransformed but deflated prices in each quintile of distance to a nearest major city. We use this in contrast to the mean values that would be more affected by the skewness of prices and outlier influence that may be stronger with data from contingent valuation methods (Holden and Bezu, 2016), and as observed in our data. Following the urban growth theory, land prices in the city may respond to development costs. That is, the land price captures the transformation costs into non-agricultural land use with much higher returns to land, compared to land prices in peri-urban and rural areas where agriculture land use remains dominant.

Fig. 1 illustrates that land shadow sales prices from peri-urban to rural areas made close to a parallel shift from 2010 to 2013 while the tendency of higher shadow sales price increase near urban areas became stronger again in 2016. Table 1 also illustrates this, with the land shadow sales prices being about three times as high close to urban areas as compared to remote rural areas. We observe an almost similar parallel upward shift in shadow rental prices from 2010 to 2013 in Fig. 2 and that the change from 2013 to 2016 is minimal across the quintiles. From 2013 to 2016, the shadow rental prices remain relatively higher compared to the shadow sales prices that appeared to have declined to some degree beyond 80 km distance.

Table 1 shows that land shadow rental prices respond much less to urban proximity than land shadow sales prices. This also results in larger ratios between these prices closer to urban areas (Fig. 3). While the land shadow sales prices were on average 63 percent higher in near urban areas (second quintile) as compared to remote rural areas between 2010 and 2013, shadow rental prices were, on average, only 36 percent higher near urban areas in the same period. It appears that this ratio is on the increase near urban areas but that the increasing ratio has expanded from the near urban areas from 2010 to 2013 and 2016. We suggest that it was the macro-economic changes like high food and energy prices that triggered speculative demands for land at large-scale as well as the high food prices that affected smallholder households' WTA selling (shadow) prices for land from 2010 to 2013 as discussed in section two.

The summary statistics for all the explanatory variables are presented in Appendix Table A2 to accommodate for the quintile statistics. As an indicator of farm household-level population pressure, Table A2 shows that the mean household size to total owned farmland ratio ranged from 8 to 17 persons per ha with an overall higher ratio within the 37 km radius or in peri-urban areas. However, there were variations across space and over time, as observed from the standard deviations for the mean values. Among the spatial control variables, the mean parcel land holding size across the quintiles ranged from 0.3 to 0.5 ha with larger parcel areas in more remote rural areas. The statistics also show varying distances to weekly markets over time, especially in peri-urban areas. The share of female-headed households was between 17 and 32 percent across the quintiles.

## 6. Results and discussion

Table 2 below presents the main regression results in the form of key variables associated with the spatial and intertemporal land shadow prices. We present the full model results in the Appendix Tables A3, A4 and A5. In this section, we assess our hypotheses based on the key regression results presented in Table 2 below.

[9] In Malawi it is common to have an open space area designated as a market which is mostly operational one day per week. Traders gather in these markets for a day before moving to the next market within the same week. These are referred to as established mobile weekly markets.

[10] Since the LSMS data collection method tracks the possible splitting of households, this leads to an increase in the number of households in subsequent years and since we used data from both stable and split households. We used clustering at enumeration area and corrected standard errors accordingly.

For the first hypothesis (H1), we stated that the "land shadow prices increase with increasing farm household-level population pressure in rural as well as in peri-urban areas". The results in Table 2 show that farm household-level population pressure correlates positively with both land shadow sales and rental prices. For a one-unit increase in household size to total farmland ratio (number of persons per ha), the increase in WTA prices or land shadow prices ranges between 0.3 to 1 percent across the quintiles. The percent changes in both sales and rental shadow prices are relatively higher in peri-urban and the intermediate quintiles compared to more remote areas. These results may signify the importance of agriculture for own food production even in near urban areas as it is an important policy objective for households to be self-sufficient in staple food (maize) production in Malawi, amidst high transaction costs in agricultural markets (Chirwa and Dorward, 2013). Thus, we cannot reject hypothesis one (H1) and conclude that farmland shadow prices are increasing across the peri-urban and rural areas and that own agricultural production is still important for food security and a driver of land shadow prices in Malawi.[11]

Figs. 1 and 2 and Table 1 in section 5, together with time dummy variables in Table 2 below, provide relevant evidence to assess hypothesis two (H2). We hypothesized that the "high food and energy prices during the associated "land grab" period in Malawi (2007–2013) induced higher expected profitability in farming among smallholder farmers even in remote rural areas, thereby increasing the land shadow prices, and especially the shadow sales prices". The results indicate that between 2010 and 2013, the increase in land shadow sales prices is significant from peri-urban to rural area quintiles but not within the city zone. This effect is higher at a distance above 80 km radius compared to areas close to the city. The results seem to indicate that the macro-economic price increase and the sharp increase in investor demand for land, also penetrated the smallholder agricultural sector all the way into distant rural areas in Malawi. It is possible that the significant increase in the ratio between the land shadow sales and rental prices is also a result of this macro shock, which may have affected the land shadow sales values more strongly in areas not too far from urban centres. Thus, we cannot reject hypothesis two (H2) and conclude that WTA or land shadow prices among smallholder farmers (also in remote rural areas in Malawi) responded to changing demands in the period associated with "land grabs" in Africa.

For hypothesis three (H3), we stated that the "rural land shadow prices have fallen after 2013 and fallen back towards the previous low level in rural areas by 2016″. To assess this hypothesis, we refer to Fig. 1 and the calculated change from 2013 to 2016 in Table 2. These demonstrate that land shadow sales prices have remained stable or showed a slight decline in the more remote rural areas compared to peri-urban areas. For the shadow rental prices, we observed a general increase from 2013 to 2016 from peri-urban to rural areas but mainly within the intermediate quintiles. Therefore, we reject our hypothesis three (H3). The persistent high or increasing land shadow prices indicate that, despite the fall of world prices and policies that constrained the supply of land in rural areas of SSA, there are other upward push factors that have prevented the land shadow sales and rental prices from having fallen back to earlier levels. We controlled for one of the upward push factors in the form of the farm household-level population pressure that we observed to be increasing farmland shadow prices in peri-urban and rural areas of Malawi in this study. Although there is limited evidence on price transmission between global and domestic food markets in Africa, Jayne et al. (2008) indicated that agricultural policies that emphasize the use of fertiliser (like in Malawi) are generally vulnerable to energy price shocks. That is, an increase in oil price can increase the cost of imported fertiliser which can lead to limited supply, use, lower yields or higher output prices. In either case, farmers are forced to intensify land use and hence attach more value to owned farmland for food production. Thus, our results could imply these competing and growing demand for agricultural land in both peri-urban and rural areas.

Considering the importance of agricultural land in Malawi, we stated hypothesis four (H4) as the "land shadow sales prices relative to rental prices are higher in peri-urban areas". From the results, we note that the increase in the ratio of the sales to rental shadow prices between 2010 and 2013 expanded further into rural areas. This trend had been partly reversed by 2016. We consider the higher changes in the ratio values close to urban areas to indicate that land shadow sales prices near urban centres may be more associated with transforming land use from agricultural to non-agricultural purposes or new investment in agriculture for urban farming –like poultry, vegetable and flower farms (Sinclair, 1967). Such demand may explain the higher and increasing gap between shadow sales and rental prices, as we do not think the ratio would have changed if the purpose remained for traditional agricultural use only, and without new investments. Therefore, the data supports hypothesis four (H4).

## 7. Conclusion and policy implications

The sharp increase in world energy and food prices in the 2007–2008 period is associated with the sharp increase in demand for land in the 2008–2013 period which also affected demand for agricultural land in Africa. We utilized three rounds of nationally representative household-parcel level data (LSMS-ISA) from Malawi, that asked landowners about their minimum Willingness-to-Accept (WTA) selling and rent-out prices for their land. Building on the von Thünen theory, the urban growth model and transaction cost theory, we studied the effects of these global energy and food price shocks on farmland shadow sales and rental prices, and the price ratio in peri-urban and rural areas, within the broader agrarian political economy perspective that jointly shape land valuation.

Our study indicated that the global price shocks penetrated the smallholder sector and had strong positive effects on farmland shadow prices even in remote rural areas of Malawi in the period 2010-2013. However, with the falling energy and food prices, and changes in agricultural policy direction after 2013, the farmland shadow sales prices also reduced but less so than we had expected. Our study demonstrates that other factors, i.e. population pressure at farm household level contribute to explaining why the land shadow prices continued to remain high in 2016.

While much of the land policy focus in the past decade has been on the recent large-scale land transfers within the agricultural sector in Africa, we see that the farmland shadow prices within the smallholder agricultural sector in Malawi are also affected by the grinding effects of population growth and proximity to urban areas. With growing land scarcity, Malawi needs to factor in the emerging land markets when formulating rural and urban development policies. Policy considerations can be on whether land markets can be an affordable avenue for accessing land by land-scarce households or youths, or whether interventions are needed to enhance access to land for specific groups or purposes. Such policy considerations can contribute to both rural and urban transformation in Malawi.

## CRediT authorship contribution statement

**Sarah E. Tione:** Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Writing - original draft, Writing -

[11] Apart from using cluster robust standard errors, we also applied bootstrapping as robustness check to obtain standard errors with clustering alternatively at EA and household levels. With bootstrapped standard errors, the key variables remained highly significant except for the household level population pressure variable in the last quintile or remote rural areas. This could be because of less population pressure in remote rural areas as observed in the summary statistics compared to peri-urban and intermediate rural areas. This does not affect our conclusion on hypothesis one, however.

review & editing, Visualization. **Stein T. Holden:** Conceptualization, Methodology, Validation, Resources, Writing - review & editing, Visualization, Supervision, Project administration, Funding acquisition.

## Declaration of Competing Interest

No conflict and the usual disclaimer apply.

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## Appendix A

**Table A1**
Description of variables.

| Variable | Descriptions | Unit |
|---|---|---|
| Deflated WTA sale price (MK)/Ha | Consumer Price Index (CPI) deflated WTA land sales price for each parcel at the household level. | Malawi Kwacha(MK)/ha |
| Deflated WTA rent-out price (MK)/Ha | CPI deflated WTA land rent-out price for each parcel at the household level | MK/ha |
| Deflated WTA ratio-sales/rental price/Ha | CPI deflated WTA land sales to rent out price ratio for each parcel at the household level | |
| Distance (KM) to a nearest major city) | Distance from a nearest major city in Malawi (Blantyre, Lilongwe, Zomba and Mzuzu) to an Enumeration Area (EA). The estimated distance was through a focus group discussion, and it is a group estimate. We used this variable to define the quintile (five groups) from city to rural areas. Different units were used to measure distant at EA, and we converted them to km. | Kilometer (KM) |
| Distance from 2010 household dwelling (KM) | The NSO reported that 54 percent of households tracked in 2016 had moved from the baseline house location in 2010. The variable shows the distance between the house locations in 2010 compared to 2013 or 2016, mainly for the tracked households. | KM |
| Household size to total farmland ratio (number of persons per hectare) | The variable is an indicator of household farm-level population pressure. That is the number of households' members divided by total owned farm size measure in hectares. Although the data was at the household parcel, we summed up the parcel area and used total owned farm size for this variable. | Number/ha |
| GPS measured farmland parcel area (ha) | Individual parcel area owned by the household. GPS was used to measure each. | ha |
| One year lagged household drought/irregular experience (1 = Yes) | The variable captures if households experienced drought or irregular rains in the previous rainy season that affected them. The response was a binary with 1 = Yes | Dummy |
| Sex of Household Head (1 = Female) | Household member identified as heading the family with 1 = Female | Dummy |
| Education of Household Head (Years) | Number of schooling years attained by the household head (continuous variable) | Years |
| Age of household head | Age of household head as a continues variable | Years |
| Distance to Weekly market (KM) | Distance to weekly markets where households can either buy inputs or sell their produce in a week. The estimated distance was through focus group discussions at Enumeration Area, and we converted all unit measures into km. The variable captures both established as well as weekly mobile markets that are common in Malawi. | KM |
| Total Livestock Units | A sum of all livestock units based on livestock unit's conversion figures for different types of animals | Number |
| One year lagged Total Livestock Units | Livestock units owned by a household 12 months before the survey period | Number |
| Soil type | Categories of soil per parcel into sandy, loamy, clay and other classes. | Number |
| Number of interviews per household across survey years | Categorical variable ranging from 1 to 3 for the number of times a household appear in the data for the years 201, 2013 and 2016, since our data includes both stable and splitting households plus new households joining the survey. | Number |

**Table A2**
Summary statistics over space and time.

| Variable | Statistic | Distance (km) | 2010 | 2013 | 2016 | Variable | Statistics | Distance (km) | 2010 | 2013 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CPI deflated WTA Prices (2000 base year)** | | | | | | **Control Variables** | | | | | |
| Deflated WTA sale price (MK)/Ha | Median | D: 0 – 0 | 7886 | 2478 | 4321 | Sex of Household Head (1 = Female) | Percent | D: 0 – 0 | 9.57 | 14.03 | 19.17 |
| | | D: 0 – 37 | 1513 | 2478 | 3116 | | | D: 0 – 37 | 19.39 | 24.48 | 32.03 |
| | | D: 40 – 80 | 950 | 1528 | 1800 | | | D: 40 – 80 | 27.00 | 28.27 | 30.71 |
| | | D: 80 – 140 | 751 | 1394 | 1299 | | | D: 80 – 140 | 20.96 | 16.92 | 19.18 |
| | | D: 161 – 379 | 562 | 1041 | 976 | | | D: 161 – 379 | 19.70 | 23.88 | 30.55 |
| Deflated WTA rent-out price (MK)/Ha | Median | D: 0 – 0 | 124 | 149 | 158 | Age of household head | Mean | D: 0 – 0 | 39 | 44 | 48 |
| | | D: 0 – 37 | 102 | 137 | 144 | | | D: 0 – 37 | 44 | 46 | 47 |
| | | D: 40 – 80 | 94 | 110 | 122 | | | D: 40 – 80 | 47 | 48 | 49 |
| | | D: 80 – 140 | 76 | 108 | 107 | | | D: 80 – 140 | 43 | 45 | 47 |
| | | D: 161 – 379 | 62 | 87 | 96 | | | D: 161 – 379 | 44 | 45 | 46 |
| Deflated WTA ratio-sales/rental price/Ha | Median | D: 0 – 0 | 36 | 20 | 20 | Education of Household Head (Years) | Mean | D: 0 – 0 | 7.21 | 7.76 | 6.73 |
| | | D: 0 – 37 | 15 | 19 | 20 | | | D: 0 – 37 | 5.12 | 5.34 | 5.34 |
| | | D: 40 – 80 | 10 | 16 | 14 | | | D: 40 – 80 | 4.31 | 4.76 | 4.54 |
| | | D: 80 – 140 | 10 | 12 | 11 | | | D: 80 – 140 | 4.88 | 5.20 | 5.18 |
| | | D: 161 – 379 | 10 | 11 | 10 | | | D: 161 – 379 | 4.96 | 4.71 | 4.96 |
| **Key Explanatory Variables** | | | | | | | | | | | |
| Household size to the total farmland ratio (number of persons per ha) | Mean (std. dev.) | D: 0 – 0 | 18.45 | 20.37 | 16.22 | Total Livestock Units | Mean (Std. dev.) | D: 0 – 0 | 0.19 | 0.31 | 0.60 |
| | | | (20.2) | (63.5) | (18.7) | | | | (0.43) | (0.51) | (1.80) |
| | | D: 0 – 37 | 12.78 | 16.34 | 14.31 | | | D: 0 – 37 | 0.35 | 0.33 | 0.33 |
| | | | (16.6) | (40.1) | (21.0) | | | | (0.85) | (0.79) | (0.85) |
| | | D: 40 – 80 | 8.20 | 11.55 | 9.85 | | | D: 40 – 80 | 0.34 | 0.36 | 0.35 |
| | | | (7.6) | (29.3) | (12.9) | | | | (0.70) | (0.88) | (0.88) |
| | | D: 80 – 140 | 10.05 | 16.60 | 8.58 | | | D: 80 – 140 | 0.34 | 0.73 | 0.89 |
| | | | (29.8) | (69.6) | (20.3) | | | | (0.69) | (3.68) | (6.36) |
| | | D: 161 – 379 | 11.39 | 10.69 | 9.82 | | | D: 161 – 379 | 0.47 | 0.49 | 0.52 |
| | | | (36.7) | (10.3) | (11.7) | | | | (0.99) | (1.08) | (1.19) |
| **Control Variables** | | | | | | | | | | | |
| GPS measured farmland parcel area (Ha) | Mean (Std. dev.) | D: 0 – 0 | 0.39 | 0.41 | 0.45 | Lag Total Livestock Units | Mean (Std. dev.) | D: 0 – 0 | 0.24 | 0.14 | 0.32 |
| | | | (0.25) | (0.41) | (0.48) | | | | (0.40) | (0.26) | (0.64) |
| | | D: 0 – 37 | 0.39 | 0.30 | 0.31 | | | D: 0 – 37 | 0.24 | 0.19 | 0.25 |
| | | | (0.36) | (0.23) | (0.32) | | | | (0.51) | (0.41) | (5.17) |
| | | D: 40 – 80 | 0.38 | 0.35 | 0.37 | | | D: 40 – 80 | 0.31 | 0.28 | 0.31 |
| | | | (0.29) | (0.32) | (0.37) | | | | (0.54) | (0.45) | (0.46) |
| | | D: 80 – 140 | 0.41 | 0.43 | 0.53 | | | D: 80 – 140 | 0.28 | 0.15 | 0.35 |
| | | | (0.34) | (0.38) | (0.46) | | | | (0.47) | (0.40) | (1.12) |
| | | D: 161 – 379 | 0.44 | 0.43 | 0.46 | | | D: 161 – 379 | 0.38 | 0.20 | 0.29 |
| | | | (0.40) | (0.39) | (0.42) | | | | (0.70) | (0.51) | (0.84) |
| Distance to Weekly market (KM) | Mean | D: 0 – 0 | 6.23 | 13.46 | 4.21 | One year lagged household drought/irregular experience (1 = Yes) | Percent | D: 0 – 0 | 20.53 | 14.06 | 27.22 |
| | | D: 0 – 37 | 2.72 | 2.14 | 6.18 | | | D: 0 – 37 | 51.58 | 37.23 | 55.53 |
| | | D: 40 – 80 | 4.39 | 4.57 | 5.67 | | | D: 40 – 80 | 47.93 | 36.11 | 40.97 |
| | | D: 80 – 140 | 3.58 | 3.80 | 3.37 | | | D: 80 – 140 | 55.86 | 31.71 | 50.11 |
| | | D: 161 – 379 | 5.25 | 4.58 | 5.50 | | | D: 161 – 379 | 54.89 | 29.73 | 41.96 |
| Distance (KM) to a nearest major city) | Mean | D: 0 – 0 | 0.00 | 0.00 | 0.00 | Distance from 2010 household dwelling (KM) | Mean | D: 0 – 0 | – | 32.33 | 52.24 |
| | | D: 0 – 37 | 27.31 | 27.75 | 27.25 | | | D: 0 – 37 | – | 4.72 | 5.24 |
| | | D: 40 – 80 | 61.31 | 60.08 | 60.09 | | | D: 40 – 80 | – | 4.86 | 4.95 |
| | | D: 80 – 140 | 109.76 | 109.67 | 110.00 | | | D: 80 – 140 | – | 3.12 | 5.83 |
| | | D: 161 – 379 | 229.34 | 222.82 | 217.56 | | | D: 161 – 379 | – | 4.22 | 2.43 |
| Sample Size | N | D: 0 – 0 | 53 | 147 | 195 | | | | | | |
| | | D: 0 – 37 | 237 | 359 | 487 | | | | | | |
| | | D: 40 – 80 | 484 | 624 | 763 | | | | | | |
| | | D: 80 – 140 | 419 | 571 | 626 | | | | | | |
| | | D: 161 – 379 | 407 | 544 | 633 | | | | | | |

Note: The number of EAs in each distance quintile is **(1)** EA 1–22 for 0 – 0 km; **(2)** EA 23–42 for 0–37 km; **(3)** EA 43–62 for 40–80 km; **(4)** EA 63–82 for 80–140 km; **(5)** EA 83–102 for.161–379 km.

**Table A3**
: Dynamic changes in deflated minimum WTA land prices (Natural-log prices)–Hedonic Price Model with linear fixed effect estimator.

| Number of EA | Model A: 0 < EA No. < = 22 | | | Model B: 22 < EA No. < = 42 | | |
|---|---|---|---|---|---|---|
| **Distance to nearest major city (km)** | **0 to 0 km** | | | **0 to 37 km** | | |
| **VARIABLES** | **1a: Sales Prices** | **2a: Rental Prices** | **3a: Ratio Prices** | **1b: Sales Prices** | **2b:Rental Prices** | **3b:Ratio Prices** |
| Household size to total farmland ratio | **0.008****** | **0.010****** | −0.000 | **0.008**** | **0.006**** | 0.001 |
| (Number of persons per ha) | **(0.0007)** | **(0.0013)** | (0.0009) | **(0.0029)** | **(0.0026)** | (0.0008) |
| weekly market distance (KM) | −0.002 | **−0.016*** | 0.010 | 0.003 | −0.003 | **0.014**** |
| | (0.0126) | **(0.0075)** | (0.0088) | (0.0046) | (0.0034) | **(0.0052)** |
| Farmland parcel area (Hectares) | **−0.685****** | **−0.494**** | −0.082 | **−0.668***** | **−0.915****** | 0.127 |
| | **(0.1699)** | **(0.1838)** | (0.0912) | **(0.1815)** | **(0.1372)** | (0.0853) |
| distance to IHS3location (KM) | **−0.003***** | −0.000 | **−0.002**** | −0.005 | −0.001 | −0.004 |
| | **(0.0008)** | (0.0003) | **(0.0008)** | (0.0032) | (0.0014) | (0.0026) |
| Total Livestock Units | **0.036*** | 0.031 | 0.015 | 0.011 | 0.017 | −0.036 |
| | **(0.0180)** | (0.0201) | (0.0216) | (0.0411) | (0.0192) | (0.0255) |
| Lag-total livestock units | −0.001 | −0.056 | 0.088 | 0.002 | **0.002*** | 0.001 |
| | (0.1291) | (0.0648) | (0.0896) | (0.0018) | **(0.0008)** | (0.0010) |
| Household head sex (1 = Female) | 0.034 | 0.171 | −0.005 | **−0.154***** | **−0.125*** | −0.083 |
| | (0.1311) | (0.1133) | (0.1192) | **(0.0521)** | **(0.0695)** | (0.0774) |
| Household head age | 0.002 | 0.004 | −0.004 | 0.004 | 0.001 | 0.001 |
| | (0.0061) | (0.0037) | (0.0063) | (0.0030) | (0.0016) | (0.0020) |
| Household head education (Years) | 0.000 | **0.029*** | −0.011 | 0.006 | 0.001 | 0.007 |
| | (0.0230) | **(0.0153)** | (0.0180) | (0.0135) | (0.0077) | (0.0137) |
| One year lagged household drought/irregular | −0.088 | −0.043 | −0.047 | **−0.166*** | −0.056 | −0.075 |
| experience (1 = Yes) | (0.1689) | (0.1028) | (0.1937) | **(0.0873)** | (0.0586) | (0.0782) |
| Soil Type - Compared to sandy soil | | | | | | |
| Loam soil | 0.016 | 0.173 | −0.157 | 0.072 | −0.071 | 0.116 |
| | (0.1411) | (0.1339) | (0.1186) | (0.0974) | (0.0613) | (0.0954) |
| Clay soil | −0.102 | 0.161 | −0.256 | 0.155 | −0.060 | **0.233**** |
| | (0.2036) | (0.1154) | (0.2229) | (0.1176) | (0.0703) | **(0.1042)** |
| Other types | 0.132 | 0.114 | 0.080 | 0.070 | **−0.281**** | **0.399**** |
| | (0.4679) | (0.2770) | (0.3277) | (0.1897) | **(0.1121)** | **(0.1706)** |
| Region (Compared to Central region) | | | | | | |
| Northern region | 0.652 | −0.007 | 0.489 | **2.451***** | **2.650****** | −0.304 |
| | (0.5253) | (0.2300) | (0.3625) | **(0.6502)** | **(0.3225)** | (0.5207) |
| Southern region | **1.257***** | −0.073 | **1.204***** | | | |
| | **(0.4036)** | (0.1187) | **(0.3392)** | | | |
| 2013.year | −0.107 | 0.186 | −0.252 | **0.379****** | 0.102 | **0.319***** |
| | (0.2940) | (0.1088) | (0.3129) | **(0.0852)** | (0.0955) | **(0.0833)** |
| 2016.year | 0.341 | 0.196 | 0.088 | **0.699****** | **0.264***** | **0.396***** |
| | (0.2466) | (0.1591) | (0.2938) | **(0.0886)** | **(0.0843)** | **(0.1075)** |
| Number of interviews per household | **0.480****** | **0.148*** | **0.239***** | −0.056 | −0.004 | −0.002 |
| Across survey years | **(0.0883)** | **(0.0742)** | **(0.0751)** | (0.0608) | (0.0437) | (0.0618) |
| Constant | 6.650**** | 4.027**** | 2.656**** | 7.311**** | 4.957**** | 2.293**** |
| | (0.5779) | (0.2907) | (0.6046) | (0.2724) | (0.1731) | (0.2862) |
| Observations | 392 | 385 | 386 | 1,070 | 1,076 | 1,060 |
| R-squared | 0.249 | 0.241 | 0.094 | 0.126 | 0.201 | 0.051 |
| Number of EA id | 22 | 22 | 22 | 20 | 20 | 19 |

Note: Cluster robust standard errors in parentheses, clustered at enumeration area. **** p < 0.001, *** p < 0.01, ** p < 0.05, * p < 0.1.

**Table A4**
Dynamic changes in deflated minimum WTA land prices (Natural-log prices)–Hedonic Price Model with linear fixed effect estimator.

| Number of EA | Model C: 42 < EA No. < = 62 | | | Model D: 62 < EA No. < = 82 | | |
|---|---|---|---|---|---|---|
| **Distance to a nearest major city (km)** | **40 to 80 km** | | | **80 to 140 km** | | |
| **VARIABLES** | **1c: Sales Prices** | **2c: Rental Prices** | **3c: Ratio Prices** | **1d: Sales Prices** | **2d:Rental Prices** | **3d:Ratio Prices** |
| Household size to total farmland ratio | 0.010**** | 0.008**** | 0.002** | 0.003* | 0.005**** | −0.001 |
| (Number of persons per ha) | (0.0023) | (0.0014) | (0.0011) | (0.0019) | (0.0010) | (0.0009) |
| weekly market distance (KM) | 0.011 | −0.018 | 0.031* | −0.007 | −0.008 | 0.004 |
| | (0.0206) | (0.0222) | (0.0173) | (0.0105) | (0.0112) | (0.0120) |
| Farmland parcel area (Hectares) | −0.966**** | −1.034**** | 0.085 | −0.699**** | −0.862**** | 0.146** |
| | (0.0802) | (0.0951) | (0.0713) | (0.1302) | (0.1051) | (0.0615) |
| distance to IHS3location (KM) | 0.002 | −0.000 | 0.003** | 0.001 | 0.001 | 0.001 |
| | (0.0018) | (0.0009) | (0.0013) | (0.0030) | (0.0012) | (0.0020) |
| Total Livestock Units | −0.022 | −0.058*** | 0.040 | −0.002 | 0.003 | −0.006 |
| | (0.0490) | (0.0188) | (0.0322) | (0.0046) | (0.0031) | (0.0054) |
| Lag-total livestock units | 0.073 | 0.055* | −0.015 | 0.057 | −0.007 | 0.085 |
| | (0.0560) | (0.0282) | (0.0540) | (0.0779) | (0.0515) | (0.0799) |
| Household head sex (1 = Female) | −0.229** | −0.039 | −0.148** | 0.029 | −0.041 | 0.084* |
| | (0.0803) | (0.0714) | (0.0592) | (0.0804) | (0.0524) | (0.0461) |
| Household head age | −0.003 | −0.002 | −0.000 | −0.001 | −0.003** | 0.002 |
| | (0.0022) | (0.0019) | (0.0017) | (0.0023) | (0.0012) | (0.0020) |
| Household head education (Years) | 0.028** | 0.006 | 0.022** | 0.009 | 0.005 | 0.006 |
| | (0.0119) | (0.0072) | (0.0103) | (0.0072) | (0.0051) | (0.0072) |
| One year lagged household drought/irregular | −0.065 | −0.111** | 0.015 | 0.126 | 0.078 | 0.092 |
| experience (1 = Yes) | (0.0817) | (0.0474) | (0.0784) | (0.0898) | (0.0475) | (0.0762) |
| Soil Type - Compared to sandy soil | | | | | | |
| Loam soil | 0.161** | 0.130* | −0.012 | 0.024 | 0.073 | −0.048 |
| | (0.0636) | (0.0737) | (0.0933) | (0.0959) | (0.0840) | (0.0746) |
| Clay soil | 0.056 | 0.023 | −0.019 | 0.029 | 0.038 | −0.017 |
| | (0.0622) | (0.0879) | (0.0938) | (0.1020) | (0.1050) | (0.0644) |
| Other types | 0.161 | 0.152 | −0.034 | 0.197* | 0.035 | 0.148 |
| | (0.1125) | (0.0949) | (0.1707) | (0.1080) | (0.1485) | (0.1971) |
| Regional (Compared to central region) | | | | | | |
| Northern region | −1.138* | 1.140**** | −2.262**** | | | |
| | (0.5587) | (0.2927) | (0.3900) | | | |
| Southern region | | | | −0.447 | −0.140 | −0.579 |
| | | | | (0.7177) | (0.3030) | (0.4667) |
| 2013.year | 0.362*** | 0.085 | 0.332*** | 0.661**** | 0.340*** | 0.310** |
| | (0.1108) | (0.0755) | (0.0924) | (0.0919) | (0.1016) | (0.1103) |
| 2016.year | 0.484**** | 0.302**** | 0.224* | 0.543**** | 0.459**** | 0.065 |
| | (0.0986) | (0.0754) | (0.1115) | (0.1105) | (0.0848) | (0.1091) |
| Number of interviews per household | 0.056 | 0.009 | 0.028 | 0.052 | 0.008 | 0.002 |
| Across survey years | (0.0559) | (0.0299) | (0.0406) | (0.0444) | (0.0518) | (0.0566) |
| Constant | 7.039**** | 4.950**** | 2.145**** | 6.910**** | 4.762**** | 2.390**** |
| | (0.1912) | (0.1127) | (0.1515) | (0.3780) | (0.2316) | (0.3045) |
| Observations | 1,851 | 1,847 | 1,833 | 1,598 | 1602 | 1,585 |
| R-squared | 0.169 | 0.249 | 0.050 | 0.132 | 0.236 | 0.030 |
| Number of EA id | 20 | 20 | 20 | 20 | 20 | 20 |

Note: Cluster robust standard errors in parentheses, clustered at enumeration area. **** $p < 0.001$, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

**Table A5**
Dynamic changes in deflated minimum WTA land prices (Natural-log prices)–Hedonic Price Model with linear fixed effect estimator.

| Number of EA | Model E: 82 < EA No. < = 102 | | |
|---|---|---|---|
| **Distance to a nearest major city (km)** | **161 to 379 km** | | |
| **VARIABLES** | **Model 1e - Sales Values** | **Model 2e - Rental Values** | **Model 3e - Ratio Value** |
| Household size to total farmland ratio | **0.005****** | **0.004***** | **0.001**** |
| (Number of persons per ha) | **(0.0010)** | **(0.0012)** | **(0.0003)** |
| weekly market distance (KM) | **−0.020*** | −0.001 | **−0.019*** |
| | **(0.0100)** | (0.0086) | **(0.0091)** |
| Farmland parcel area (Hectares) | **−0.812****** | **−0.846****** | −0.008 |
| | **(0.1383)** | **(0.1405)** | (0.0524) |
| distance to IHS3location (KM) | 0.001 | −0.003 | 0.003 |
| | (0.0023) | (0.0019) | (0.0023) |
| Total Livestock Units | **0.089**** | **0.040***** | **0.050*** |
| | **(0.0340)** | **(0.0135)** | **(0.0249)** |
| Lag-total livestock units | 0.110 | **0.063*** | 0.029 |
| | (0.0802) | **(0.0332)** | (0.0657) |
| Household head sex (1 = Female) | −0.000 | −0.054 | 0.046 |
| | (0.0866) | (0.0550) | (0.0724) |
| Household head age | **0.004**** | −0.001 | **0.005****** |
| | **(0.0016)** | (0.0015) | **(0.0013)** |
| Household head education (Years) | 0.016 | 0.002 | 0.012 |
| | (0.0105) | (0.0063) | (0.0091) |
| One year lagged household drought/ irregular | −0.033 | 0.025 | −0.048 |
| experience (1 = Yes) | (0.0718) | (0.0553) | (0.0580) |
| Soil Type - Compared to sandy soil | | | |
| Loam soil | 0.069 | −0.054 | **0.132**** |
| | (0.0836) | (0.0733) | **(0.0573)** |
| Clay soil | 0.041 | −0.063 | 0.077 |
| | (0.1013) | (0.1078) | (0.0672) |
| Other types | −0.198* | 0.060 | −0.207 |
| | (0.1107) | (0.0999) | (0.1659) |
| Regional Dummies | | | |
| Southern region | **1.734****** | **1.768****** | 0.058 |
| | **(0.2684)** | **(0.2420)** | (0.2885) |
| 2013.year | **0.339***** | **0.275***** | 0.071 |
| | **(0.1028)** | **(0.0901)** | (0.1223) |
| 2016.year | **0.409****** | **0.463****** | −0.026 |
| | **(0.1040)** | **(0.0714)** | (0.0916) |
| Number of interviews per household | −0.057 | 0.031 | −0.085 |
| Across survey years | (0.0762) | (0.0413) | (0.0614) |
| Constant | 6.249**** | 3.987**** | 2.257**** |
| | (0.2290) | (0.2269) | (0.2346) |
| Observations | 1,574 | 1,575 | 1,564 |
| R-squared | 0.159 | 0.234 | 0.040 |
| Number of EA id | 20 | 20 | 20 |

Note: Cluster robust standard errors in parentheses, clustered at enumeration area. **** $p < 0.001$, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

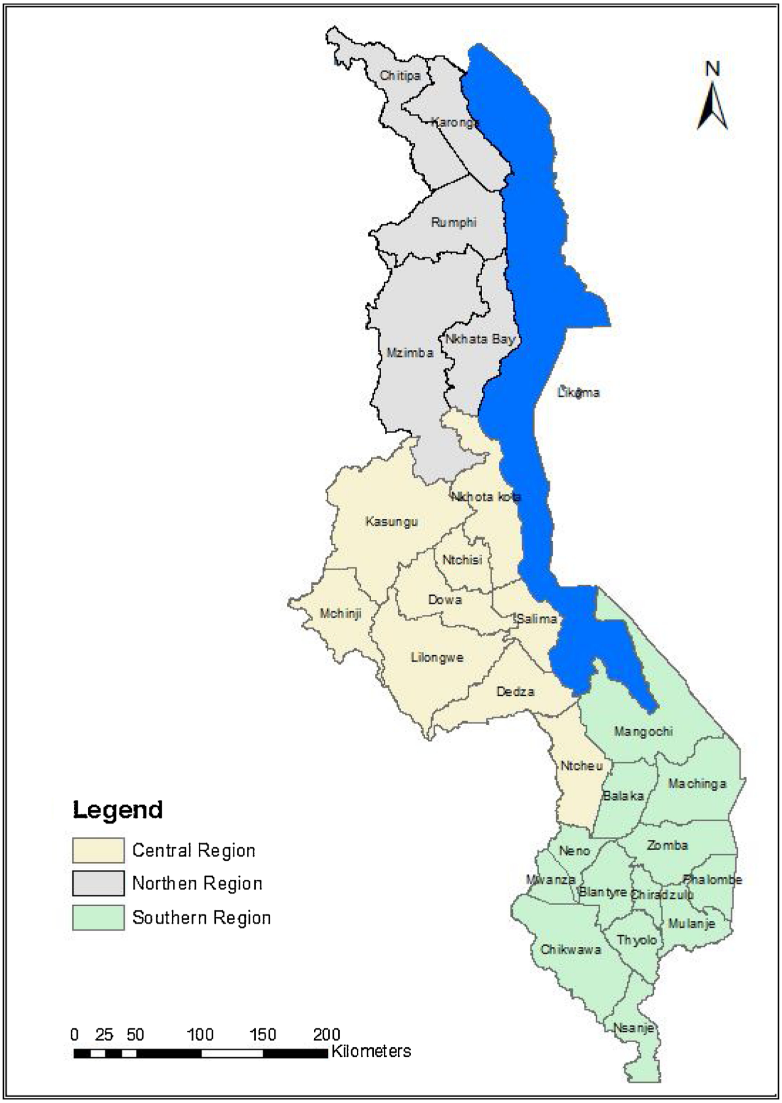


**Fig. A1.** Map of Malawi showing districts.

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# Paper Two

# Non-convex transaction costs and land rental market participation in Malawi

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## Abstract

We assess how non-convex transaction costs constrain access to and participation in the land rental market by smallholder farmers within Sub-Saharan Africa. The theory suggests a dynamic externality due to such transaction costs and that orchestrated participation can reduce such costs and enhance future participation. We use dynamic random effects probit and Tobit models with balanced panel data from Malawi to assess participation on the tenant side of the market. We observe that land rental market experience upon entry significantly increase participation in the subsequent years, implying dynamic non-convex transaction costs and possible entry barriers in the market.

**Keywords:** Land rental markets, Non-convex transaction costs, Dynamic random effects models, Malawi

**JEL Codes**: Q15, Q12

## 1. Introduction

Land markets develop as an efficiency-enhancing mechanism in allocating productive resources (de Janvry et al., 2002). Imperfections in the non-land factor markets create a rationale for land markets to balance factors of production across farms and in agricultural systems with low elasticities of substitution (Holden et al., 2010). Binswanger and Rosenzweig (1986) showed how the biophysical characteristics of land and non-land factors of production influence the factor market characteristics, distribution and redistribution of such factors among farm households in rural societies. These biophysical characteristics plus the institutional factors (cultural norms and political history), climatic conditions and population pressure potentially lead to non-missing but imperfect factor markets in rural societies (Binswanger & Rosenzweig, 1986; Holden et al., 2010). With imperfect factor markets that are spatially dispersed and not well integrated, market participants face varying non-linear transaction costs across space and over time (Holden et al., 2010). Thus, the extent to which participants transact and the associated transaction costs are key in explaining the allocative efficiency of factor markets (Baland et al., 2007; Bell & Sussangkarn, 1988; Deininger, 2003; Skoufias, 1995).

The varying non-linear transaction costs are with respect to the extent of factor market allocations among individuals, transportation costs and information asymmetry from policies and institutions that govern local access and use of productive resources (Fafchamps, 2004). Theory indicates that such non-linear transaction costs characterise both the land and non-land factor markets in Sub-Saharan Africa (SSA) and that such costs are high from policies, institutions and social factors that influence the degree of information asymmetry, access and use of production resources (Fafchamps, 2004; Holden et al., 2010). The theory also suggests that market participants overcome such market imperfections, especially pertaining to information asymmetry by establishing localised and information networks that are inter-personal when searching and negotiating, monitoring and enforcing market contracts (Fafchamps & Minten, 2001; Fafchamps, 2004). That is, upon entering the markets, participants invest in establishing the inter-personal networks of information, trust and reputation that are important for formulating and enforcing contracts. In line with Fafchamps (2004) and Holden et al. (2010), such initial investment costs can be high and non-linear upon entry but reduce over time from repeated engagements, thereby resulting in intertemporal non-linear and non-convex transaction costs.

Non-convex transaction costs imply marginally decreasing costs mainly from participants overcoming the first hurdle related to market entry and with repeated market engagements over time (Fafchamps, 2004). With repeated engagements, searching and contracting costs reduce over time hence giving an advantage to experienced market participants compared to new entrants. With non-convex transaction costs, repeated engagements also imply that participation in the factor market can be state-dependent, where the previous status of a market participant is considered important for subsequent market transactions. Overall, both policies and institutional factors that govern the use and trade of production resources can influence transaction costs in a way that either promote or constrain participation in the markets.

Despite theory indicating that factor markets in SSA are characterised by non-linear and non-convex transaction costs, empirical evidence on the extent to which non-convex transaction costs characterise or restrict participation in the land markets that are developing in SSA remains limited. Reviewed literature indicated that the land markets and mainly the land rental markets that are developing in SSA, are facilitating efficient allocation of land and non-land resources to more efficient producers and improving household income and welfare depending on the context (Gebru et al., 2019; Holden et al., 2010; Kijima & Tabetando, 2020; Ricker-Gilbert et al., 2019). Holden et al. (2010) and Ricker-Gilbert and Chamberlin (2018) also showed that these rental markets are constrained by high and non-linear transaction costs. However, the extent to which such transaction costs are non-convex, or state-dependent remains an empirical question. Thus, assessing the non-convexity of transaction costs should be key for improving the allocative efficiency of land markets, more so the land rental markets that are more prevailing in SSA.

We are only aware of studies in Ethiopia that have assessed the non-convexity of transaction costs on land rental markets with dominant sharecropping and kin member land rental contracts (Gebru et al., 2019; Holden et al., 2007). We are not aware of any study that has assessed non-convexity of transaction costs in the land rental markets dominated by fixed and short-term contracts that are mainly developing in SSA. This could be because such short-term and fixed land rental contracts are considered less dependent on networks of trust and reputation in contract formulation, monitoring and enforcement (Alston et al., 1984). However, with market imperfections in SSA, assessing the non-convexity of transaction costs in the land rental markets should be key for understanding contract formulation with respect to search and negotiation costs. Such empirical evidence should be emphasized when developing policies that can lift entry barriers and further enhance the allocative efficiency of production resources through markets. Thus, we add to this limited literature by assessing the extent to which non-convex transaction costs encourage or restricts entry and extent of participation in land rental markets that are developing in SSA.

We use three-panel rounds of the Malawi Living Standards Measurement Survey (LSMS) data collected in 2010, 2013 and 2016, from which we constructed a balanced household panel data. Malawi is a country in SSA with emerging spatially dispersed land rental markets, dominated by short-term and fixed-rent contracts under customary land tenure systems (Lunduka et al., 2009). The country has an instituted legal framework that allows households to trade their private or customary land according to land-use guidelines compared to other countries that strictly limit land market activities in SSA (Government of Malawi, 2002; Government of Malawi, 2016). For instance, the legal framework in Ethiopia prohibits land sales and only allows renting up to 50 percent of owned land per household (Holden & Ghebru, 2016). Also, the farming system in Malawi gives an advantage to using this data as it is dominated by a hand hoe that requires human labour compared to animal drought and other highly mechanised farming systems (Takane, 2008). Such use of human labour should be important for understanding the extent to which land rental markets equilibrate the land to non-land factor ratio at the household level. Furthermore, studies on land rental markets in Malawi shows a positive impact on household income and welfare (Chamberlin & Ricker-Gilbert, 2016; Ricker-Gilbert et al., 2019). However, no study has assessed the non-linearity and non-convexity of land rental markets that are developing in this country. Thus, the focus on transaction costs in this paper should be important for the development policy in Malawi and lessons for the region as land rental markets develop in SSA.

We hypothesize that land rental markets ration the participation of potential tenants, and such participation is state-dependent on repeated engagements, observed from the tenant household side[1]. We assume that households with experience in the land rental markets have an advantage in search costs and negotiating contracts, which works to the disadvantage of new entrants in the market even with non-linear transaction costs. The sub-section on the theoretical model

[1] We focus on the tenant side of the land rental market mainly because of the LSMS data constraints on capturing landlord households. In our data, out of a balanced panel data of 1480 households, the classification in 2010 was 7.3% tenants and 0.1% landlords; in 2013 it was 10.1% tenants and 0.5% landlords; and in 2016 it was 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. See Deininger et al. (2017) for a full discussion on the limitations of the LSMS data on capturing landlord households.

below elaborates more on this assumption and the non-linearity of transaction costs. To our knowledge, this is the first empirical study on dynamic and non-convex transaction costs in the land rental markets literature within SSA that uses nationally representative household panel data, with a focus on land rental markets dominated by short-term and fixed land rental contracts.

We use the farm household model and the theory of dynamic non-linear transaction costs in the land rental markets (Holden et al., 2007; Holden et al., 2010). We estimate our results using the dynamic random effects probit and Tobit models (Wooldridge, 2010). With the dynamic models, we use the initial and lagged participation in the land rental markets to assess the specified hypotheses. In line with Wooldridge (2010), the initial participation dependent variable should be important for controlling the unobservable factors that may influence entry in the market including an initial investment in networks of information, trust and reputation. Furthermore, we evaluate the non-linearity of transaction costs based on the extent of participation in land rental markets with respect to owned land given in hectares (ha), observed from the tenant household side.

We have organised the rest of the paper as follows. The next section presents the theoretical framework and hypotheses section. This is followed by a section on estimation method and data. After describing the data, we present the descriptive statistics, results and discussion sections before concluding the paper.

## 2. Theoretical model and hypotheses

Fundamentally, under a fixed-rent contract, 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 by both parties. The minimum conditions for a fixed rent contract are the duration of the contract and payment period. Thus, the theoretical model applied in this paper integrates the farm household model with a dynamic non-linear transaction costs model (Holden et al., 2007; Holden et al., 2010).

We consider a farm household endowed with land $(\bar{A})$ and labour $(\bar{L})$ and with the potential to trade these resources in a market. Focusing on a potential tenant household, such a household will aim at maximizing income utility $(Max\, U = U[Y])$ from renting in the land and achieving the desired resource use level on own-farm (Holden et al., 2010). Assuming net use of labour on the farm and non-linear transaction costs from imperfect factor markets as discussed above, equation (1) specify the potential tenant farm household objective function.

$$\max_{A^i,L} U[Y] = U[P_q q(A,L) - \{\rho A^i + \eta(A^i) + \omega L + P_m M\}] \qquad \text{and } A^i \geq 0,\ L > 0 \qquad (1)$$

From the equation, $[Y]$ is the income function for a potential tenant household and the choice variables are renting-in the land $(A^i)$ and labour $(L)$ use on own-farm. The income is the net market equivalent output value from production revenue less expenditure. That is, $(P_q)$ is the output price while $q(A,L)$ is the production function where $(A)$ is the operational farmland that is equal to the total owned land $(\bar{A})$ plus rented-in land $(A^i)$, i.e. $[A = \bar{A} + A^i]$. The $[\rho A^i + \eta(A^i)]$ is the expenditure function for renting-in the land. That is, $(\rho)$ is the land rent that is assumed to be linear in the amount of land rented-in and $(\eta)$ is the non-linear transaction cost with respect to rented land among market participants. The theory assumes a linear unit land rent considering the initial fixed cost expected of any participant upon entry into the market while assuming that different individuals face varying non-linear transaction costs depending on the amount of land rented-in across space. On net labour use $(L)$, the parameter $(\omega)$ is for the market wage rate or shadow wage rate at the household level, and the $(\omega L)$ is a labour cost function aggregated at the household level. This net labour use-value implicitly captures both labour time used for work and leisure for all labour available at the household level (Singh et al., 1986). Furthermore, the function $(P_m M)$ is for expenditure on other market inputs $(M)$ with $(P_m)$ as the market input price.

Based on the income utility maximisation function and using the duality theory, we focus on the twice differentiable quasi-convex income function to assess the non-linearity in the transaction costs. When we normalise to one the output price $(P_q)$ and the other market input price $(P_m)$, the first-order condition (FOC) from equation (1) with respect to rented-in land $(A^i)$ is specified in equation (2).

$$\frac{\partial Y}{\partial A^i} = \frac{\partial q}{\partial A^i} - \rho - \frac{\partial \eta}{\partial A^i} \leq 0 \qquad \perp \qquad A^i \geq 0 \qquad (2)$$

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

From equation (2), the potential tenant will only trade if the marginal revenue from rented-in land $\left(\frac{\partial q}{\partial A^i}\right)$ is greater or equal to the marginal cost of renting-in land $\left(\rho + \frac{\partial \eta}{\partial A^i}\right)$, and will not trade if otherwise. To assess the non-linearity of the transaction costs in the land rental markets, the second-order condition (SOC) from equation (2) is given as $\left[\frac{\partial^2 q}{\partial A^{i^2}} \leq \frac{\partial^2 \eta}{\partial A^{i^2}}\right]$. That is, the extent of land trade adjustment depends on the level of varying non-linear transactions costs $\left(\frac{\partial^2 \eta}{\partial A^{i^2}}\right)$ hence resulting in a local maximum and not a global maximum solution (Carter & Yao, 2002).

Bliss and Stern (1982) indicated that in a well-functioning land rental market, the coefficient on own land is equal to minus one (-1) indicating linear costs. To assess such linearity in land rental market costs, we conduct a comparative analysis of the change in rented-in land ($A^i$) with respect to owned land ($\bar{A}$) or the rate of market adjustment at the household level $\left[\frac{\partial A^i}{\partial \bar{A}}\right]$. Assuming an interior solution ($A^i > 0$), the derivative function for the comparative analysis is given as $\left[\frac{\partial A^i}{\partial \bar{A}} = \frac{\partial^2 q}{\partial A^{i^2}} - \frac{\partial^2 \eta}{\partial A^{i^2}}\right]$ or simply given as $\left[q_{A^i \bar{A}} = q_{A^i A^i} - \eta_{A^i A^i}\right]$ based on the demand functions estimated from the FOC in equation (2). This implies that the rate of market adjustment at household level will only be linear $\left[\frac{\partial A^i}{\partial A} = -1\right]$ if the varying transaction costs are equal to zero ($\eta_{A^i A^i} = 0$). However, from the SOCs, the varying transaction costs are not equal to zero. Thus, the marginal change in rented-in land will increase (decrease) $\left[\frac{\partial A^i}{\partial A} > -1 \ or \left(\frac{\partial A^i}{\partial \bar{A}} < -1\right)\right]$ with increasing (decreasing) marginal change in varying transaction costs in absolute values. This results in non-linear and non-convex transaction costs across space. We have presented the detailed farm household model and detailed comparative statics in Appendix A.

Considering that the discussed farm household model is a static decision across space, our theoretical frameworks further apply the dynamic transaction cost model for tenant households (Holden et al., 2007). Equation (3) specifies the intertemporal decision to rent-in land among tenant households.

$$A_{jt}^{i} = \sum_{\mathcal{R}} A_{jt}^{\mathcal{R}} \left[c_0 + c_{jt}^{\mathcal{R}} \left( \bar{A}_{jt}, \bar{L}_{jt}, \int_{-\gamma}^{t} A_{jt-n}^{L}\, dt, \int_{-\Gamma}^{t} \varphi_t^{p}\, dt; z_{jt}^{h}, z_{jt}^{\varsigma}\right)\right] \quad (3)$$

The model indicates that amount of land rented-in ($A_{jt}^i$) by household *j* at time *t* is an aggregate of accessed land from one or several landlord households ($\mathcal{R}$), given as $\sum_{\mathcal{R}} A_{jt}^{\mathcal{R}}$ [.]. Access to rented land is further a function of transaction costs ($c$) which include an initial fixed cost ($c_0$) and a varying variable cost ($c_{jt}^{\mathcal{R}}$). The variable cost is a function of both observable and unobservable factors. These factors include the tenant household endowments of land ($\bar{A}_{jt}$) and labour ($\bar{L}_{jt}$), and previous participation in the land rental markets that is dynamic and non-linear ($\int_{-\gamma}^{t} A_{jt-n}^{L}\, dt$). The previous participation variable captures both the initial entry and lagged participation in the land rental market over time. Lastly, the model captures the dynamic effect of the policy mix ($\int_{-\Gamma}^{t} \varphi_t^p\, dt$) that influences transaction costs in the rental market over time. This model specification is conditional on household and community characteristics ($z_{jt}^h, z_{jt}^\varsigma$). Therefore, with this theoretical framework we hypothesize that;

H1. The entry of potential tenants into the land rental markets is rationed.

The initial search and negotiation costs should create a barrier to entry in the land rental markets from information asymmetry and such entry costs are higher when land rental markets are thinner like in Malawi.

H2. The extent of participation by tenants in the land rental markets increases with earlier participation and such participation is state-dependent.

Experience in land rental market should help in later participation decisions due to non-convex costs related to accessing relevant market information based on established networks of trust and reputation from previous years.

H3. The likelihood of entry into the land rental market declines with owned land size.

Farm households with more owned land are less likely to be potential tenants, especially in hand-hoe based farming systems like in Malawi where we assume no economies of scale.

H4. High non-linear transaction costs characterise the extent of participation by tenant households if the coefficient on owned land is close to 0.

In a well-functioning land rental markets with linear transaction costs, the coefficient on owned land is inverse and equal to minus one (-1).

### 3. Estimation method and data

To assess our hypotheses, we estimate the reduced form of the dynamic household participation decision $(A_{jt})$ model as specified in equation (4).

$$A_{jt}^{i} = \alpha + A_{jt-n,}^{i}\rho + \gamma \bar{A}_{jt} + \pi \bar{L}_{jt} + z_{jt}\beta + \tau + \mu_j + \varepsilon_{jt} \qquad (4)$$

The variable ($A_{jt}^i$) is for entry and extent of participation in the land rental market for household *j* and at time *t*. We assess the extent of market participation using the amount of rented land in hectares (ha) at the household level. Our parameters of interest in equation (4) are ($\rho$) for lagged participation variables and ($\gamma$) for the land endowment. The parameter ($\pi$) is for labour endowment while ($\beta$) is for household and community characteristics. The variable ($\tau$) is for yearly dummies that partially control for dynamic policy mix. The function ($\mu_j + \varepsilon_{jt}$) captures the additive error term where ($\mu_j$) is for time-constant unobserved heterogeneity and ($\varepsilon_{jt}$) is the idiosyncratic error that is independent and identically distributed.

From equation (4), the variable ($\bar{A}_{jt}$) is for owned farmland area in hectare (ha) for household $j$ and at time $t$. Owned farmland includes inherited land through customary systems or government distribution and purchases. We, therefore, use this definition of owned farmland area to assess participation decisions with respect to the land endowment. The variable excludes borrowed land, farmland for those on wage contract in estate farms providing tenant labour, encroached and rented-in land. These categories mainly imply operational farmland without secure tenure rights (Holden et al., 2013). We consider households accessing land from only the excluded sources to be landless in the ownership sense. In our context, landless households only hold an endogenous user right that does not include transfer rights or other more land tenure secure rights (Holden et al., 2013). Thus, our model includes a dummy for landless households to control for operational farmland but not the extent of owned land that we have already specified.

Furthermore, we include the ratio of owned farmland to labour units[2] (total adult equivalent labour units). Considering the dominant use of a hand hoe in Malawi that requires more human strength (Takane, 2008), we assume that more adult labour and particularly male labour may be associated with a higher demand for agricultural land. Hence, we also control for the share of male labour at the household level. Additionally, our model controls for other household and community characteristics. These include sex, age and education of the household head; consumer to worker ratio; and both the current and one-year lag Total Livestock Units (TLU) per labour unit ratio. We consider livestock to be an indicator of wealth that households can easily liquidate to support production and labour use decisions. At the community level, we include the distance to urban centres with a population of more than 20,000 people for proximity to urban areas.

[2] We calculated the labour units for household members present in the house for at least a month and excluded members who were away for 12 months.

To estimate equation (4), we use dynamic panel data models with binary and censored response variables (Wooldridge, 2010). Assuming data observation is from *t=0* so that $(A^i_{jt})$ is the first observation of outcome $(A^i)$, for *t*=1, …., T, the dynamic random effects probit model can be specified as;

$$P\left(A^i_{jt} = 1 \middle| A^i_{j,t-n}, \ldots, A^i_{jo}, z_j, \mu_j\right) = \Phi(z_{jt}\delta + A^i_{j,t-n}\rho + \mu_j) \tag{5}$$

Where $(A^i_{jt})$ is the dependent variable and the subscript $(t-n)$ is for the previous survey round denoted as $(n)$. The $(z_j)$ is a vector of explanatory variables and $\Phi$ is for a standard normal distribution function with the probability of success at time *t* and also the outcome from the previous $(t-n)$ period. The $(\mu_j)$ is for the unobserved heterogeneity. With this specification, one can test $H_0: \rho = 0$ to assess initial conditions and state dependency in the model, once we control for $\mu_j$. The model assumes $(\mu_j)$ to be additive and given as $\mu_j = \psi + \alpha_0 A^i_{jo} + z_j\alpha_1 + \epsilon_j$. Where $\epsilon_j \sim Normal(0, \sigma_\epsilon{}^2)$ and independent of $(A^i_{jo} + z_j)$. The $(\psi)$ is a constant. This structure allows the use of a likelihood function similar to random effect probit model if we add $(A^i_{jo})$ and $(z_j)$ to the list of explanatory variables, and have $x_{jt} = \{1, z_{jt}, A^i_{j,t-n}, A^i_{jo}, z_j\}$. By doing so, we control for the unobserved effects of $(\mu_j)$ and the initial household conditions (Wooldridge, 2010).

On the extent of participation, Wooldridge (2010) specifies the dynamic random effects Tobit model as indicated in equation (6).

$A^i_{jt} = max\left[0, z_j\delta + \rho A^i_{j,t-n} + \mu_j + \varepsilon_{jt}\right]$. For all *t* =1, ..., T and *j*=1,2,..,N households. (6)

The idiosyncratic error term is $\varepsilon_{jt} | \left(z_j, A^i_{j,t-n} \ldots A^i_{jo}, \mu_j\right) \sim Normal(0, \sigma_\varepsilon{}^2)$. Unlike the probit, the lagged outcome variable in Tobit model depends on whether $(A^i_{j,t-n})$ is equal to or greater than zero. Hence $(\rho A^i_{j,t-n})$ can be replaced with $\xi r_{jt-n} + \rho(1 - r_{jt-n})A^i_{j,t-n}$. Where $(r_{jt-n})$ is binary and equal to one if $A^i_{jt-n} = 0$ and zero otherwise. Like the probit, this reduces the list of explanatory variables to $x_{jt} = \{z_{jt}, A^i_{j,t-n}, A^i_{jo}, z_j\}$. With these model specifications, one can compute the conditional or unconditional partial average effects similar to the probit and Tobit models but only with balanced panel data (Wooldridge, 2010).

For our analysis, we constructed a three-year balanced panel data of 1,480 households from the 1,619 households in the 2010 baseline survey round. We used the Malawi Living Standards Measurement Surveys (LSMS) conducted in 2010, 2013 and 2016. By construction, we observed an 8.6 percent attrition rate that we used to test for attrition bias. We estimated the inverse mills ratio with a probit model presented in Appendix B, Table B1, which we included in our estimations. We did not observe an attrition bias effect in our analysis and hence we present the results that exclude the inverse mills ratio. Results with inverse mills ratio are available in Appendix B, Table B4 for comparison. Overall, our balanced data accounted for changes in household head over time, parcel-level information like sources of land, and parcel area in hectares (ha) measured using a global positioning system (GPS). As per the dynamic random effects model, we used the entry and extent of participation in the 2010 survey round as the initial year. At the same time, we used the 2010 participation as lagged participation variable in 2013, and the participation decision in 2013 as lagged participation variable in 2016 survey round.

## 4. Descriptive Statistics

From Table 1, the percent of households that participated in the land rental markets were 7.3, 10.1 and 8.9 for 2010, 2013 and 2016 survey rounds, respectively. The table shows that owned and operational farmland per household in our sample was on average 0.53 ha across the years. Among tenant households, the average rented-in land was 0.5 ha with the land endowment of 0.33 ha that is significantly lower than 0.52 ha owned land among non-tenant households. The percent of landless households among the tenant households was 48 percent, which was significantly higher than the 30 percent landless households among the non-tenant households. These statistics show 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. A possible extension of the paper would be to assess both the landlords and tenants using longitudinal data if available.

**Table 1: Summary statistics**

| Variable | Total sample | Average values all survey rounds<br>Tenant households (1) | Non-tenant households (2) | t-test (1 vs. 2) |
|---|---|---|---|---|
| ***Participation in the land rental market*** | | | | |
| Initial year (2010) – (*percent*) | 7.3 | | | |
| Subsequent year (2013)– (*percent*) | 10.1 | | | |
| Subsequent year (2016) – (*percent*) | 8.9 | | | |
| Initial year (2010) rented-in land | | | | |
| *mean* (*median*) in *ha* | 0.03 (0.00) | 0.45 (0.36) | | |
| Subsequent years rented-in land | | | | |
| *mean* (*median*) in *ha* | 0.05 (0.00) | 0.50 (0.36) | | |

| | | | | |
|---|---|---|---|---|
| ***Land area*** | | | | |
| Owned farmland | | | | |
| *mean* (*median*) in *ha* | 0.50 (0.35) | 0.33 (0.11) | 0.52 (0.36) | **** |
| Operational farmland | | | | |
| *mean* (*median*) in *ha* | 0.55 (0.40) | 0.82 (0.61) | 0.53 (0.37) | **** |
| Landless/zero own farmland (p*ercent*) | 31.53 | 48.07 | 29.94 | **** |
| ***Labour*** | | | | |
| Own farmland to labour ratio (*mean*) (*ha/adult equiv. labour unit*) | 0.18 | 0.10 | 0.18 | **** |
| Share of male labour (*mean*) | 40.67 | 41.04 | 40.63 | |
| ***Control Variables*** | | | | |
| Sex of HH head (*%Females*) | 23.65 | 14.65 | 24.51 | **** |
| Age of HH head (*mean –years*) | 45 | 42 | 45 | *** |
| Education of HH head (*mean –years*) | 6.15 | 7.11 | 6.06 | **** |
| Household size to labour ratio (*mean No. of persons/adult equiv. labour unit*) | 1.66 | 1.69 | 1.66 | |
| Total Livestock Units (TLU) to labour ratio (*mean TLU No./ labour unit*) | 0.11 | 0.13 | 0.11 | |
| One-year lag TLU | 0.07 | 0.09 | 0.07 | |
| Distance to urban center (*mean km*) | 28.38 | 30.89 | 28.14 | *** |
| **N** (Panel households) | **4440** (1480) | **389** | **4051** | |

**Land rental market participation in the initial year and subsequent years**

| | **2013 (%)** | | **2016 (%)** | | |
|---|---|---|---|---|---|
| **Initial year = 2010** | *No* | *Yes* | *No* | *Yes* | **Total (N)** |
| *No* | 93.15 | 6.85 | 93.22 | 6.78 | 1,372 |
| *Yes* | 49.07 | 50.93 | 63.89 | 36.11 | 110 |
| Total (N) | 1,331 | 149 | 1,348 | 132 | 1,480 |
| % | 89.93 | 10.07 | 91.08 | 8.92 | 100 |
| **Survey year = 2013** | **2016 (%)** | | | | |
| *No* | *No* | *Yes* | **Total (N)** | | |
| *Yes* | 94.9 | 5.1 | 1,331 | | |
| | 57.1 | 43.0 | 149 | | |
| Total (N) | 1,348 | 132 | 1,480 | | |
| % | 91.1 | 8.9 | 100 | | |

*Note:* The t-tests compare the overall differences in the tenant and non-tenant households. The asterisks denote levels of significance at **** = p<0.001, *** = p<0.01, ** = p<0.05, and * = p<0.1.

Table 1 further shows that the tenant households are operating an average of 0.82 ha, which is significantly larger than the average operational and owned farmland (0.53 ha) for non-tenant households. The data could imply that tenants are non-land resource-rich households (labour and capital), that could manage to increase their operational land size. Ricker-Gilbert et al. (2019) observed a similar distribution in Malawi using one-year matched landlord-tenant data in selected districts. On labour endowment, our data show no significant differences in the share of male labour between tenant and non-tenant households considered important for hand-hoe based farming systems like in Malawi. On the contrary, land relative to the labour endowment is higher for non-tenant households[3].

Table 1 also shows that tenant households are less likely to be headed by a female and that land rental markets are common in rural areas. A tenant household is more likely to be headed by a slightly younger person and a household head who is slightly more education than non-tenant households. Among the tenants and non-tenant households, there are no significant differences in consumer to worker ratio a possible indicator of households needs to be self-sufficient. To confirm the short-term and fixed-rent contracts in our data, we observed that almost all contracts were for one growing season or one calendar year. Only 4 percent of the households combined upfront cash payment with sharecropping contracts across the years and we maintained these households in our sample. Furthermore, Table 1 shows that the rate of market re-entry from the initial baseline year (2010) was 51 percent in 2013 and 36 percent in 2016. Those who participated in 2013, 43 percent also participated in 2016 survey round. This shows a land rental market with participation from both experienced participants and new entrants across the survey years, that is important for the dynamic assessment of the land rental market.

## 5. Results and discussion

Table 2 presents the average partial effects $[E(y|\boldsymbol{X})]$ from the dynamic random effects probit and Tobit models. Parsimonious models are followed by three models with additional controls for each of the probit and Tobit specifications. The first three models (P1 to P3 and T1 to T3) include initial participation, lagged participation and resource endowment variables only, while the fourth model (P4 and T4) includes all the other household and community control variables. Appendix B, Tables B2 and B3 present further details on conditional average partial effects $[E(y|\boldsymbol{X}, y > 0)]$ for the dynamic random effects Tobit model and coefficients for the dynamic random effects probit and Tobit models, respectively. We chose to focus on the unconditional

[3] 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. Such data required creating a new balanced panel that excludes landless households.

mean partial effects $[E(y|\boldsymbol{X})]$ for us to assess participation decisions that include potential tenant households in the land rental markets in line with our hypotheses.

To assess hypothesis one (H1), we evaluate the dynamic random effects probit model results presented in Table 2. The hypothesis stated that the entry of potential tenants into the land rental markets is rationed. From the table, we note a significant positive effect of initial year participation dummy and the lag participation variables, significant at 1 and 10 percent, respectively. The average marginal effects show that the initial participation year (2010) variable increase the probability of participation in later years by 11 percentage points (model P4). The lagged rent-in dummy increase participation by 6.8 percentage points but significant at the 10 percent level. The results imply that potential tenant households with experience, after getting over the first hurdle of entering into the market, are more likely to re-enter the market. This support the theory of non-convex transaction costs in the land rental markets developing in Malawi. Fafchamps (2004) indicated that entry into a market and establishing information networks is a sunk cost that potential traders must overcome and later use this information for future transactions. Thus, we cannot reject hypothesis one (H1) and conclude that entry of potential tenants into land rental markets is rationed by giving an advantage to participants with experience in the market compared to new entrants.

To assess hypothesis two (H2), we use the unconditional margins for initial and lagged participation variables from the Tobit model results. Hypothesis two stated that the extent of participation by tenants in the land rental markets increases with earlier participation and such participation is state-dependent. From T4 model results, we note that it is only the initial year participation variables (entry and extent of participation) that are significant but not the lagged participation variables. Considering the initial year variables, the marginal increase in the average amount of land area rented-in is 0.02-0.03 ha in model T4. By not observing a significant effect of lagged participation variables, our results show that it is mainly the initial entry and extent of participation in the market that increases the extent of participation in the subsequent years but not necessarily the market participant status in the years after entering the market in Malawi. These results confirm the challenge of getting over the first hurdle of entry into the market and that participation in subsequent years is a factor of initial market investment costs that are non-convex over time. Thus, the results give less support for state-dependent land rental markets after participants have entered the market which could imply high and non-linear transaction costs in the markets, which is our next discussion point.

**Table 2: Dynamic random effects probit and Tobit models for renting-in land (average partial effects – $[E(y|X)]$ for probit and Tobit) (Coefficient results are in Appendix B, Table B3)**

| VARIABLES | P1 | P2 | P3 | P4 | T1 | T2 | T3 | T4 |
|---|---|---|---|---|---|---|---|---|
| Initial year (2010) rent-in dummy | 0.129**** | 0.129**** | 0.135**** | 0.111**** | 0.035** | 0.035** | 0.036** | 0.023** |
| | (0.04) | (0.04) | (0.04) | (0.03) | (0.01) | (0.01) | (0.01) | (0.01) |
| Lag rent-in dummy | 0.083* | 0.080* | 0.073* | 0.068* | 0.022* | 0.021 | 0.019 | 0.015 |
| *(previous survey round)* | (0.04) | (0.04) | (0.04) | (0.04) | (0.01) | (0.01) | (0.01) | (0.01) |
| Initial year (2010) rent-in land (ha) | | | | | 0.049* | 0.051** | 0.053** | 0.032* |
| | | | | | (0.02) | (0.02) | (0.02) | (0.02) |
| Lag total rent-in land (ha) | | | | | 0.028 | 0.025 | 0.022 | 0.021 |
| *(previous survey round)* | | | | | (0.02) | (0.02) | (0.02) | (0.01) |
| Own farmland (ha) | -0.031*** | -0.019* | 0.006 | -0.006 | -0.011*** | -0.005 | 0.006 | 0.001 |
| | (0.01) | (0.01) | (0.02) | (0.02) | (0.00) | (0.00) | (0.01) | (0.01) |
| Landless/zero own farmland (1= yes) | | 0.027** | 0.021 | 0.040*** | | 0.013** | 0.011* | 0.015*** |
| | | (0.01) | (0.01) | (0.02) | | (0.01) | (0.01) | (0.01) |
| Own farmland to labour ratio | | | -0.091 | -0.110* | | | -0.040* | -0.039** |
| *(ha/adult equiv. labour unit)* | | | (0.06) | (0.07) | | | (0.02) | (0.02) |
| Share of male labour | | | 0.020 | 0.000 | | | 0.009 | -0.001 |
| | | | (0.02) | (0.03) | | | (0.01) | (0.01) |
| Share of purchased own farmland | | | -0.022 | -0.011 | | | -0.010 | -0.004 |
| | | | (0.03) | (0.03) | | | (0.01) | (0.01) |
| Sex of HH head (1=Female) | | | | -0.041*** | | | | -0.016*** |
| | | | | (0.02) | | | | (0.01) |
| Age of HH head (years) | | | | -0.001* | | | | -0.000 |
| | | | | (0.00) | | | | (0.00) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Education of HH head (years) | | | | -0.000 | | | | 0.000 |
| | | | | (0.00) | | | | (0.00) |
| Household size to labour ratio | | | | 0.019* | | | | 0.007* |
| *(No. of persons/adult equiv. labour unit)* | | | | (0.01) | | | | (0.00) |
| Total Livestock Units (TLU) to labour | | | | 0.005 | | | | 0.002 |
| ratio *(TLU No./ adult equiv. labour unit)* | | | | (0.00) | | | | (0.00) |
| One-year lag TLU to labour ratio | | | | 0.004 | | | | 0.002 |
| *(lag TLU No./ adult equiv. labour unit)* | | | | (0.00) | | | | (0.00) |
| Distance to urban centers (km) | | | | 0.002**** | | | | 0.001**** |
| | | | | (0.00) | | | | (0.00) |
| Regional dummy (1= Central) | | | | | | | | |
| 2. Northern region | | | | -0.105**** | | | | -0.037**** |
| | | | | (0.01) | | | | (0.01) |
| 3. Southern region | | | | -0.051**** | | | | -0.020**** |
| | | | | (0.01) | | | | (0.01) |
| 2016.year | -0.016* | -0.016* | -0.016* | -0.011 | -0.007* | -0.007* | -0.007* | -0.004 |
| | (0.01) | (0.01) | (0.01) | (0.01) | (0.00) | (0.00) | (0.00) | (0.00) |
| Constant | -1.735**** | -1.879**** | -1.951**** | -1.986**** | -1.226**** | -1.316**** | -1.339**** | -1.356**** |
| | (0.21) | (0.25) | (0.29) | (0.43) | (0.08) | (0.10) | (0.12) | (0.25) |
| lnsig2u | -0.547 | -0.496 | -0.372 | -0.531 | | | | |
| | (0.72) | (0.71) | (0.70) | (0.70) | | | | |
| sigma_u | | | | | 0.522**** | 0.538**** | 0.557**** | 0.480**** |
| | | | | | (0.12) | (0.11) | (0.11) | (0.11) |
| sigma_e | | | | | 0.708**** | 0.694**** | 0.681**** | 0.674**** |
| | | | | | (0.07) | (0.07) | (0.07) | (0.06) |
| Observations | 2,960 | 2,960 | 2,960 | 2,960 | 2,960 | 2,960 | 2,960 | 2,960 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Left Censored (_n) | | | | | 2,679 | 2,679 | 2,679 | 2,679 |
| Uncensored (_n) | | | | | 281 | 281 | 281 | 281 |
| Number of Panel households | 1,480 | 1,480 | 1,480 | 1,480 | 1,480 | 1,480 | 1,480 | 1,480 |

*Note*: The table presents Average Partial Effects. Specifically, the Tobit model presents the unconditional average partial effects. The asterisks denote **** = $p<0.001$, *** = $p<0.01$, ** = $p<0.05$, * = $p<0.1$. Standard errors in parentheses. For the probit model, the standard errors are cluster robust, clustered at the household level while the Tobit model presents normal standard errors.

For the third hypothesis (H3), we stated that the likelihood of entry into the land rental market declines with owned land size. To assess this hypothesis, we refer to the results from the probit model P1 presented in Table 2. The results indicate that a one ha increase in own farmland area reduces the probability of participation by 3 percentage points. However, given that the average farm size is below one hectare in our data, we consider this to be a very small effect. Thus, considering the percent of landless households in our sample, when we add the dummy for landless households in models P2-P4, we note a significant effect on being landless. By construction, the summary statistics showed that almost 32 percent of our sample are landless in the land ownership sense.

Since landless implies zero owned land, we tried to run the analysis without the landless dummy in models P2 to P4 to assess the independent effect of owned land. With this specification, the owned land variable was still not significant in all P2 to P4 models, hence supporting the need to separately assess the landless households. From the results, landless households have a 2-4 percentage point higher likelihood of accessing land in the rental market than households who own land. Our results imply that the rental market transfers land to landless households to some extent or that the landless households (in the ownership sense) are more willing to participate than those with some owned land.

Our observations concur with the study of Baland et al. (2007) in Uganda, who observed that landless households were able to purchase more land than those with initial land inheritance. Furthermore, the community members in Uganda were more willing to trade land to those with a low probability of inheriting the land, a sign of social-network based exchange that reduces transaction costs. Thus, our results only provide weak support for hypothesis three (H3) since owning land is not significant but being landless in the ownership sense. We proceed to inspect hypothesis four (H4) on the extent of market allocation (amount of land rented-in per household) using the dynamic Tobit models.

In H4 we stated that high non-linear transaction costs characterise the extent of participation by tenant households if the coefficient on owned land is close to 0. To assess this hypothesis, we compared the Tobit model results from Table 2 (unconditional margins) and Appendix B-Table B3 (conditional margins). From Table 2, the unconditional average partial effects of both owned farmland and the landless dummy are close to zero (0.01) while significantly different from zero. Contrasting these results with the conditional marginal effects, we note a significant change to only 0.02 ha (model T1-margins) for those who own land and 0.04 ha (model T4-

margins) for landless households. The small changes in land area rented-in from both the conditional and unconditional marginal effects indicate high non-linear transaction costs, even for households already participating in the market. Therefore, we cannot reject hypothesis four (H4) which implies the inefficient allocation of land rental markets in Malawi despite dynamic non-convex transaction costs.

## 6. Conclusion

Land markets, and more so land rental markets with short-term and fixed-rent contracts are developing in many countries across Sub-Saharan Africa (SSA). These markets are developing in a way that is facilitating the reallocation of productive resources among farm households faced with market imperfections. Theory of factor market indicates that upon entry, market participants in SSA invest in information, trust and reputation networks that lead to non-linear and dynamic non-convex transaction costs across space and over time. Where non-convex transaction costs imply marginally decreasing costs over time from repeated engagements. Participants invest in such networks if market information and contract formulation costs are high and state-dependent on the previous status of market participants upon entry into the market.

Despite the theory of transaction costs in factor markets within SSA, the extent to which such costs characterise or restrict participation in the land rental markets that are developing in this region remains an empirical question. In this paper, we contributed to this literature by assessing the extent to which non-linear and non-convex transaction costs ration potential tenants' entry into the land rental markets and whether the extent of participation is state-dependent on previous engagements in the market. We used a nationally representative balanced panel data, constructed from the Malawi Living Standards Measurement Surveys (LSMS) conducted in 2010, 2013 and 2016.

Our study revealed high non-linear transaction costs in the land rental markets developing in Malawi, an indicator of a thin land market that has a long way to go before it can ensure allocative efficiency. That is, non-linear transaction costs continue to constrain land-use efficiency and hinder efficient resource recombination across farms. However, the problem is likely to reduce over time as overcoming the first hurdle of entering the market reduces transaction costs and improves access to rented land despite the dominance of short-term and fixed-rent contracts. That is, potential landlords and tenants who have entered the markets are more likely to benefit from their experience and networks of information, trust and reputation in the market. Thus, policies that can reduce entry barriers associated with information asymmetry will be important for improving the allocative efficiency of land rental markets in Malawi. Use of low costs strategies that disseminate land market information at the community level can be relevant in improving access to rented land, especially for land constrained households.

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Non-convex transaction costs and land rental market participation in Malawi

## 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. 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 used 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 the amount of land and labour rented or hired out, respectively. The $\bar{A}$ is for all pieces of the 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 $[\bar{L} = L_u + L_e]$. Following Singh et al. (1986), the decision to trade resources in the market implicitly captures the time used for work and leisure at the household level. Furthermore, total labour endowment is equal to the total number of household individuals in adult equivalent, that assign total time to work and leisure (Singh et al., 1986). Thus, the intermediate 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 |

Following Singh et al. (1986), the problem for such a farm household is to maximise income $[Y]$ utility generated from using these resources. The utility function is given as $Max \; U = U[Y]$, where the function is a twice differential quasi concave function. Assuming a perfect market with linear market costs, equation (i) specifies the income utility function.

$$\underset{A^i,A^o,L^i,L^o}{\text{Max}} \; U[Y] = U[P_q q(A, L) - \rho A^i + \rho A^o - \omega L^i + \omega L^o - P_m M] \tag{i}$$

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

Where $A^i, A^o, L^i, L^o$ are the decision variables for renting or hiring in and out of land and labour, as discussed above. The $[Y]$ is the household income function that is twice differentiable and quasi-convex.

From equation (i), the ($\rho$) is the land rent or land price, and ($\omega$) is the wage rate in the 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 $(A)$ and labour $(L)$ use on own farm. The $(M)$ is for other market input with $(P_m)$ as the input market price. Thus, the income function $[Y]$ is the net market equivalent output value from production revenue less expenditure. The income function is assumed to be equivalent to the consumption goods acquired by the household either through their farm production or markets (Singh et al., 1986). The basic assumption in equation (i) 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.

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 contracts 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 (Binswanger & Rosenzweig, 1986; Fafchamps, 2004; Holden et al., 2010). Such transaction costs may 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). The agricultural output may also depend on individual household risk preferences and crop choices (Holden & Quiggin, 2016). Thus, we normalise to one the output $(P_q)$ and input $(P_m)$ prices for all goods, hence we dropped them going forward. With imperfect markets that lead non-linear transaction costs, the income utility function $[Max\, U = U(Y)]$ would be;

$$\underset{A^i,A^o,L^i,L^o}{\text{Max}} U[Y] = U[q(A,L) - \{\rho A^i + \eta(A^i)\} + \{\rho A^o - \theta(A^o)\} - \{\omega L^i + \tau(L^i)\} + \{\omega L - \varphi(L^o)\}] \qquad \text{(ii)}$$

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

In equation (ii), the land rent $(\rho)$ and the wage rate $(\omega)$ are assumed to be linear in the amount of land rented-in while having non-linear transaction cost with respect to land and labour. The theory assumes a linear constant land rent or wage rate considering the initial fixed cost expected of any participant upon entry into the market while assuming that different individuals face varying non-linear transaction costs depending on the amount of resources traded in the market. Thus, the parameters $(\eta)$, $(\theta)$, $(\tau)$ and $(\varphi)$ reflect varying non-linear transaction costs in land and labour markets.

For the transaction costs, we assume that the level of varying transaction costs for those renting-in land or hiring-in labour to be different from those renting-out land or hiring-out labour, respectively because of differences in market supply and demand functions. We further assume these costs to be higher for those renting-in land or hiring-in labour because households demanding land are more likely to incur higher search costs than those supplying the land (Binswanger & Rosenzweig, 1986). Thus, the new variables compared to equation (i) are ($\eta$) and ($\theta$) for transaction costs when renting-in or out the land while the ($\tau$) and ($\varphi$) are for transaction costs for hiring in and out labour, respectively. Where $(\eta) > (\theta)$ and $(\tau) > (\varphi)$ because of differences in supply and demand functions. All other variables remain as above. Thus, equation (ii) indicates that a household renting-in land will incur a cost, given as the sum of land rent plus transaction costs as a function of area rented-in. For households renting out land, they will gain land rent less transaction costs that are a function of land area transacted in the market. These conditions also apply to the labour market.

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 might 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 the one hand, spatial isolation and varying transportation distances determine linear land rent while information asymmetry and market fragmentation imply varying non-linear transaction costs. Thus, holding the labour decisions constant, the farm household objective function becomes;

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

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

Using duality theory and taking the derivatives of twice differential quasi-convex income function from equation (iii), the first-order conditions (FOCs) with respect to land and labour variables are;

*Rent-in land*

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

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 land rented in $\left(\frac{\partial q}{\partial A^i}\right)$ less land rent ($\rho$) 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 for renting land as specified in equation (v).

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

Equation (v) shows that a household renting-in the 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 the 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 the marginal cost of renting-in land.

*Rent out land*

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

Like in equation (iv), the non-linear transaction costs are not constant, and the marginal change in equation (vi) depends on the land area rented out. Solving equation (vi) and using the complementary slack conditions, equation (vii) derives the optimal conditions for renting out land as;

$$\rho - \frac{\partial \eta}{\partial A^o} \leq \frac{\partial q}{\partial A^o} \Rightarrow \frac{\partial q}{\partial A^o} \geq \rho - \frac{\partial \theta}{\partial A^o} \tag{vii}$$

$$\frac{\partial q}{\partial A^o} = \rho - \frac{\partial \theta}{\partial A^o} \quad \text{if } A^o > 0 \qquad \text{or} \qquad \frac{\partial q}{\partial A^o} > \rho - \frac{\partial \theta}{\partial A^o} \quad \text{if } A^o = 0$$

Equation (vii) indicates 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 less or equal to net return $\left(\rho - \frac{\partial \theta}{\partial A^o}\right)$ and that they will not rent out land if marginal benefit on land to be rented out is greater than the net return.

*Net farm labour use*

For labour use, we specify the optimal conditions in equation (viii).

$$\frac{\partial Y}{\partial L} = \frac{\partial q}{\partial L} - \omega < 0 \qquad \perp \qquad L > 0 \tag{viii}$$

i.e. $\frac{\partial q}{\partial L} = \omega \quad \text{if } L > 0$

The optimal labour conditions imply that the marginal revenue with respect to labour should be greater or equal to the market or shadow wage rate.

*Non-participating households*

Based on the FOCs in equations (v) and (vii), the optimal conditions for non-participating household or the shadow value with respect to the land endowment is given in equation (ix).

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

Equation (ix) indicates that non-participating households consider their shadow value to land to be greater than the net return from renting out the land and at the same time, less than the marginal cost of renting-in land. Hence, they fall within a threshold. Table 1 gives a summary of the optimal conditions for participating in the land markets.

**Table A1: Summary of household optimal decisions in the land markets**

| | 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.

Using equations (iv) and (vi), we derive the SOCs as follows;

*Net buyer of land*

$$\frac{\partial^2 Y}{\partial A^i \partial A^i} = \frac{\partial^2 q}{\partial A^i \partial A^i} - \frac{\partial^2 \eta}{\partial A^i \partial A^i} \leq 0 \qquad \text{or} \quad \frac{\partial^2 Y}{\partial A^i \partial A^i} = q_{A^i A^i} - \eta_{A^i A^i} \leq 0 \tag{x}$$

*Net seller of land*

$$\frac{\partial^2 Y}{\partial A^o \partial A^o} = \frac{\partial^2 q}{\partial A^o \partial A^o} - \frac{\partial^2 \theta}{\partial A^o \partial A^o} \leq 0 \qquad \text{or} \quad \frac{\partial^2 Y}{\partial A^o \partial A^o} = q_{A^0 A^0} - \theta_{A^0 A^0} \leq 0 \tag{xi}$$

*Cross derivatives*

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

If transaction costs are linear, the SOCs would be $\frac{\partial^2 q}{\partial A^{i^2}} \leq 0$ or $\frac{\partial^2 q}{\partial A^{o^2}} \leq 0$ (as expected). However, with non-linear transaction cost, the second-order conditions are $\frac{\partial^2 q}{\partial A^{i^2}} \leq \frac{\partial^2 \eta}{\partial A^{i^2}}$ and $\frac{\partial^2 q}{\partial A^{o^2}} \leq \frac{\partial^2 \theta}{\partial A^{o^2}}$. That is, the extent of resource trade adjustment depends on the level of varying non-linear transactions costs. Equations (xiii) and (xiv) presents a 2 by 2 Hessian matrix and its determinant for assessing the convexity of these transaction costs.

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

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

The $|H|$ implies that, depending on the extent of transaction costs, the Hessian matrix may not satisfy the sufficient conditions for a global maximum solution. Thus, to understand this convexity in transaction costs, we use the comparative statics. We assess that the marginal varying transaction costs are non-linear, that is $\frac{\partial A^i}{\partial \bar{A}} \neq -1$ and $\frac{\partial A^o}{\partial \bar{A}} \neq 1$ following Bliss and Stern (1982).

**Comparative statics**

Using Kuhn-Tucker conditions and solving the FOCs, one can determine the demand functions that 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 and input 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 derived from equations (iv) and (vi) 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 the endowment will be;

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

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

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

$$q_{A^i\bar{A}} = q_{A^iA^i} - \eta_{A^iA^i} \quad \text{and} \quad q_{A^o\bar{A}} = q_{A^oA^i} \tag{xvi}$$

Equation (xvi) indicates that the transaction costs will be equal to -1 iff $\eta_{A^iA^i} = 0$ and that rate of market adjustment depends on $q_{A^i\bar{A}} = q_{A^iA^i} - \eta_{A^iA^i}$. That is, the change will be either $\frac{\partial A^i}{\partial A} > -1$ if increasing marginal variable transaction costs or $\frac{\partial A^i}{\partial \bar{A}} < -1$ if decreasing marginal variable transaction costs.

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

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

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

$$q_{A^i\bar{A}} = q_{A^iA^o} \quad \text{and} \quad q_{A^o\bar{A}} = q_{A^oA^o} - \theta_{A^oA^o} \tag{xviii}$$

Where the solution is equal to 1 iff $\theta_{A^oA^o} = 0$. Thus, the rate of market adjustment depends on $q_{A^o\bar{A}} = q_{A^oA^o} - \theta_{A^oA^o}$ and the change will be either $\frac{\partial A^o}{\partial \bar{A}} > 1$ if increasing marginal variable transaction costs or $\frac{\partial A^o}{\partial \bar{A}} < 1$ if decreasing marginal variable transaction costs.

Overall, the model implies that land market transaction costs can increase to ration out potential participants or decrease to promote participation, subject to factors that influence transaction costs and access to information.

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**Appendix B**

**Table B1: Probit model for attrition bias from 2010 baseline year**

| | **Attrition Probit Model** | |
|---|---|---|
| **VARIABLES** | Coefficient | Robust standard error |
| Sex of HH head (1=female) | -0.176 | 0.15 |
| Age of HH head (years) | -0.004 | 0.00 |
| Household size | -0.120**** | 0.03 |
| Total Livestock Units (TLU) | -0.131 | 0.15 |
| One-year lag TLU | -0.106 | 0.23 |
| Reside (1= urban) | 1.092**** | 0.12 |
| Population density | -0.313**** | 0.05 |
| Constant | 0.118 | 0.22 |
| LR Chi (7) | 134.49 | |
| Prob > chi2 | 0.000 | |
| Observations | 1,619 | |

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

**Table B2: Dynamic random-effects Tobit models for renting-in land – conditional average partial effects [$E(y|X, y > 0)$]**

| VARIABLES | T1-Margins | T2-Margins | T3-Margins | T4-Margins |
|---|---|---|---|---|
| Initial year (2010) rent-in dummy | 0.071** | 0.071** | 0.073** | 0.054** |
| | (0.03) | (0.03) | (0.03) | (0.03) |
| Lag rent-in dummy | 0.044 | 0.042 | 0.039 | 0.036 |
| *(previous survey round)* | (0.03) | (0.03) | (0.03) | (0.02) |
| Initial year (2010) rent-in land (ha) | 0.099** | 0.103** | 0.108** | 0.077* |
| | (0.05) | (0.05) | (0.05) | (0.04) |
| Lag total rent-in land (ha) | 0.057 | 0.051 | 0.045 | 0.050 |
| *(previous survey round)* | (0.04) | (0.04) | (0.04) | (0.03) |
| Own farmland (ha) | -0.023*** | -0.010 | 0.012 | 0.002 |
| | (0.01) | (0.01) | (0.02) | (0.02) |
| Landless/zero own farmland (1= yes) | | 0.027** | 0.023* | 0.036*** |

| | | | | |
|---|---|---|---|---|
| | | (0.01) | (0.01) | (0.01) |
| Own farmland to labour ratio | | | -0.081* | -0.094** |
| *(ha/adult equiv. labour unit)* | | | (0.05) | (0.05) |
| Share of male labour | | | 0.019 | -0.002 |
| | | | (0.02) | (0.03) |
| Share of purchased own farmland | | | -0.020 | -0.009 |
| | | | (0.03) | (0.02) |
| Sex of HH head (1=female) | | | | -0.039*** |
| | | | | (0.01) |
| Age of HH head (years) | | | | -0.001 |
| | | | | (0.00) |
| Education of HH head (years) | | | | 0.000 |
| | | | | (0.00) |
| Household size to labour ratio | | | | 0.018* |
| *(No. of persons/adult equiv. labour unit)* | | | | (0.01) |
| Total Livestock Units (TLU) to labour | | | | 0.005 |
| ratio *(TLU No./ adult equiv. labour unit)* | | | | (0.01) |
| One-year lag TLU to labour ratio | | | | 0.005 |
| *(lag TLU No./ adult equiv. labour unit)* | | | | (0.01) |
| Distance to urban centers (km) | | | | 0.002**** |
| | | | | (0.00) |
| Regional dummy (Compared to Central) | | | | |
| Northern region | | | | -0.109**** |
| | | | | (0.02) |
| Southern region | | | | -0.041**** |
| | | | | (0.01) |
| Year 2016 | -0.015* | -0.015* | -0.015* | -0.010 |
| | (0.01) | (0.01) | (0.01) | (0.01) |
| Observations | 2,960 | 2,960 | 2,960 | 2,960 |
| Number of Panel households | 1,480 | 1,480 | 1,480 | 1,480 |

Note: Normal standard errors in parentheses. The asterisks denote levels of significance at **** = p<0.001, *** = p<0.01, ** = p<0.05, and * = p<0.1. The table omitted the constant, sigma_u, sigma_e and number of censored variables because the information is similar to that presented in table B3 below, with estimated coefficients.

**Table B3: Dynamic random effects probit and Tobit models for renting-in land (coefficients)**

| VARIABLES | P1 | P2 | P3 | P4 | T1 | T2 | T3 | T4 |
|---|---|---|---|---|---|---|---|---|
| Initial year (2010) rent-in dummy | 1.126** | 1.141** | 1.217** | 1.042** | 0.459** | 0.456** | 0.472** | 0.370** |
| | (0.45) | (0.45) | (0.49) | (0.41) | (0.19) | (0.19) | (0.19) | (0.17) |
| Lag rent-in dummy | 0.722** | 0.704** | 0.661** | 0.641** | 0.284 | 0.269 | 0.253 | 0.247 |
| *(previous survey round)* | (0.30) | (0.30) | (0.32) | (0.29) | (0.17) | (0.17) | (0.17) | (0.16) |
| Initial year (2010) rent-in land (ha) | | | | | 0.636** | 0.664** | 0.694** | 0.532* |
| | | | | | (0.32) | (0.31) | (0.31) | (0.29) |
| Lag total rent-in land (ha) | | | | | 0.366 | 0.327 | 0.291 | 0.340 |
| *(previous survey round)* | | | | | (0.24) | (0.23) | (0.23) | (0.22) |
| Own farmland (ha) | -0.274*** | -0.164 | 0.050 | -0.055 | -0.145*** | -0.066 | 0.076 | 0.016 |
| | (0.10) | (0.10) | (0.16) | (0.17) | (0.05) | (0.06) | (0.10) | (0.10) |
| Landless/zero own farmland (1= yes) | | 0.240** | 0.194 | 0.378*** | | 0.176** | 0.145* | 0.244*** |
| | | (0.12) | (0.13) | (0.14) | | (0.08) | (0.08) | (0.08) |
| Own farmland to labour ratio | | | -0.819 | -1.028 | | | -0.523* | -0.643** |
| *(ha/adult equiv. labour unit)* | | | (0.54) | (0.64) | | | (0.30) | (0.32) |
| Share of male labour | | | 0.184 | 0.002 | | | 0.121 | -0.013 |
| | | | (0.23) | (0.28) | | | (0.15) | (0.18) |
| Share of purchased own farmland | | | -0.198 | -0.103 | | | -0.131 | -0.062 |
| | | | (0.31) | (0.31) | | | (0.18) | (0.17) |
| Sex of HH head (1=female) | | | | -0.384*** | | | | -0.270*** |
| | | | | (0.15) | | | | (0.09) |
| Age of HH head (years) | | | | -0.006 | | | | -0.004 |
| | | | | (0.00) | | | | (0.00) |
| Education of HH head (years) | | | | -0.004 | | | | 0.001 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | (0.01) | | | | (0.01) |
| Household size to labour ratio | | | | 0.174* | | | | 0.121* |
| *(No. of persons/adult equiv. labour unit)* | | | | (0.10) | | | | (0.07) |
| Total Livestock Units (TLU) to labour | | | | 0.049 | | | | 0.034 |
| ratio *(TLU No./ adult equiv. labour unit)* | | | | (0.04) | | | | (0.04) |
| One-year lag TLU to labour ratio | | | | 0.041 | | | | 0.032 |
| *(lag TLU No./ adult equiv. labour unit)* | | | | (0.04) | | | | (0.04) |
| Distance to urban centers (km) | | | | 0.018**** | | | | 0.012**** |
| | | | | (0.00) | | | | (0.00) |
| Regional dummy (Compared to Central) | | | | | | | | |
| Northern region | | | | -1.300**** | | | | -0.842**** |
| | | | | (0.31) | | | | (0.16) |
| Southern region | | | | -0.429*** | | | | -0.266**** |
| | | | | (0.14) | | | | (0.07) |
| 2016.year | -0.138* | -0.144* | -0.143* | -0.103 | -0.096* | -0.097* | -0.094* | -0.068 |
| | (0.08) | (0.08) | (0.08) | (0.09) | (0.06) | (0.06) | (0.06) | (0.06) |
| Constant | -1.735**** | -1.879**** | -1.951**** | -1.986**** | -1.226**** | -1.316**** | -1.339**** | -1.356**** |
| | (0.21) | (0.25) | (0.29) | (0.43) | (0.08) | (0.10) | (0.12) | (0.25) |
| lnsig2u | -0.547 | -0.496 | -0.372 | -0.531 | | | | |
| | (0.72) | (0.71) | (0.70) | (0.70) | | | | |
| sigma_u | | | | | 0.522**** | 0.538**** | 0.557**** | 0.480**** |
| | | | | | (0.12) | (0.11) | (0.11) | (0.11) |
| sigma_e | | | | | 0.708**** | 0.694**** | 0.681**** | 0.674**** |
| | | | | | (0.07) | (0.07) | (0.07) | (0.06) |
| Observations | 2,960 | 2,960 | 2,960 | 2,960 | 2,960 | 2,960 | 2,960 | 2,960 |
| Left Censored (_n) | | | | | 2,679 | 2,679 | 2,679 | 2,679 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Uncensored (_n) | | | | | 281 | 281 | 281 | 281 |
| Number of Panel households | 1,480 | 1,480 | 1,480 | 1,480 | 1,480 | 1,480 | 1,480 | 1,480 |

Note: The asterisks denote levels of significance at **** = p<0.001, *** = p<0.01, ** = p<0.05, and * = p<0.1. Standard errors in parentheses. For the probit model, the standard errors are cluster robust, clustered at the household level. The Tobit model presents normal standard errors in the parenthesis.

**Table B4: Dynamic random effects probit and Tobit models for renting-in land (coefficients) – with inverse mills ratio**

| VARIABLES | P1 | P2 | P3 | P4 | T1 | T2 | T3 | T4 |
|---|---|---|---|---|---|---|---|---|
| Initial year (2010) rent-in dummy | 1.112** | 1.125** | 1.207** | 1.034** | 0.446** | 0.442** | 0.461** | 0.358** |
| | (0.45) | (0.45) | (0.49) | (0.42) | (0.19) | (0.19) | (0.19) | (0.18) |
| Lag rent-in dummy | 0.728** | 0.711** | 0.665** | 0.645** | 0.291* | 0.277 | 0.259 | 0.253 |
| *(previous survey round)* | (0.30) | (0.31) | (0.32) | (0.30) | (0.18) | (0.17) | (0.17) | (0.16) |
| Initial year (2010) rent-in land (ha) | | | | | 0.639** | 0.668** | 0.698** | 0.536* |
| | | | | | (0.32) | (0.31) | (0.31) | (0.29) |
| Lag total rent-in land (ha) | | | | | 0.365 | 0.326 | 0.290 | 0.340 |
| *(previous survey round)* | | | | | (0.24) | (0.23) | (0.23) | (0.22) |
| Own farmland (ha) | -0.278*** | -0.167 | 0.039 | -0.063 | -0.149*** | -0.069 | 0.065 | 0.007 |
| | (0.10) | (0.10) | (0.16) | (0.17) | (0.05) | (0.06) | (0.10) | (0.10) |
| Landless/zero own farmland (1= yes) | | 0.242** | 0.197 | 0.381*** | | 0.178** | 0.148* | 0.249*** |
| | | (0.12) | (0.13) | (0.14) | | (0.08) | (0.08) | (0.08) |
| Own farmland to labour ratio | | | -0.786 | -1.002 | | | -0.492 | -0.612* |
| *(ha/adult equiv. labour unit)* | | | (0.54) | (0.64) | | | (0.30) | (0.32) |
| Share of male labour | | | 0.183 | 0.001 | | | 0.120 | -0.013 |
| | | | (0.23) | (0.28) | | | (0.15) | (0.18) |
| Share of purchased own farmland | | | -0.196 | -0.100 | | | -0.128 | -0.057 |
| | | | (0.31) | (0.31) | | | (0.18) | (0.17) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sex of HH head (1=female) | | | | -0.383*** | | | | -0.269*** |
| | | | | (0.15) | | | | (0.09) |
| Age of HH head (years) | | | | -0.007* | | | | -0.004 |
| | | | | (0.00) | | | | (0.00) |
| Education of HH head (years) | | | | -0.004 | | | | 0.001 |
| | | | | (0.01) | | | | (0.01) |
| Household size to labour ratio | | | | 0.174* | | | | 0.121* |
| *(No. of persons/adult equiv. labour unit)* | | | | (0.10) | | | | (0.07) |
| Total Livestock Units (TLU) to labour | | | | 0.048 | | | | 0.034 |
| ratio *(TLU No./ adult equiv. labour unit)* | | | | (0.04) | | | | (0.04) |
| One-year lag TLU to labour ratio | | | | 0.040 | | | | 0.031 |
| *(lag TLU No./ adult equiv. labour unit)* | | | | (0.04) | | | | (0.04) |
| Distance to urban centers (km) | | | | 0.018**** | | | | 0.012**** |
| | | | | (0.00) | | | | (0.00) |
| Regional dummy (Compared to Central) | | | | | | | | |
| Northern region | | | | -1.285**** | | | | -0.825**** |
| | | | | (0.32) | | | | (0.16) |
| Southern region | | | | -0.431*** | | | | -0.269**** |
| | | | | (0.14) | | | | (0.07) |
| 2016.year | -0.138* | -0.144* | -0.142* | -0.103 | -0.096* | -0.097* | -0.094* | -0.067 |
| | (0.08) | (0.08) | (0.08) | (0.09) | (0.06) | (0.06) | (0.06) | (0.06) |
| Inverse mills ratio, attrition | 0.691 | 0.743 | 0.532 | 0.403 | 0.659 | 0.701 | 0.550 | 0.523 |
| | (0.89) | (0.89) | (0.89) | (1.13) | (0.66) | (0.66) | (0.67) | (0.70) |
| Constant | -2.253*** | -2.437**** | -2.352*** | -2.280** | -1.723**** | -1.845**** | -1.756**** | -1.741*** |
| | (0.73) | (0.74) | (0.76) | (0.94) | (0.51) | (0.51) | (0.52) | (0.58) |
| lnsig2u | -0.563 | -0.514 | -0.382 | -0.541 | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (0.73) | (0.72) | (0.71) | (0.71) | | | | |
| sigma_u | | | | | 0.517**** | 0.533**** | 0.553**** | 0.475**** |
| | | | | | (0.12) | (0.11) | (0.11) | (0.11) |
| sigma_e | | | | | 0.709**** | 0.696**** | 0.682**** | 0.676**** |
| | | | | | (0.07) | (0.07) | (0.07) | (0.06) |
| Observations | 2,960 | 2,960 | 2,960 | 2,960 | 2,960 | 2,960 | 2,960 | 2,960 |
| Left Censored (_n) | | | | | 2,679 | 2,679 | 2,679 | 2,679 |
| Uncensored (_n) | | | | | 281 | 281 | 281 | 281 |
| Number of Panel households | 1,480 | 1,480 | 1,480 | 1,480 | 1,480 | 1,480 | 1,480 | 1,480 |

Note: The asterisks denote levels of significance at **** = p<0.001, *** = p<0.01, ** = p<0.05, and * = p<0.1. Standard errors in parentheses. For the probit model, the standard errors are cluster robust, clustered at the household level. The Tobit model presents normal standard errors in the parenthesis.

# Paper Three

# Can rainfall shocks enhance access to rented land? Evidence from Malawi

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## Abstract

This study investigates the spatial downside and upside rainfall shock effects on tenant household renting behavior and access to rented land in the short-term and medium-term. We model the tenant households' demand decisions within the state-contingent framework with renting-in of land as a risky input choice. Our data is a three-year balanced panel constructed from the Malawi Living Standards Measurement Surveys, combined with the corresponding seasonal district-wise rainfall shock data across regional agro-ecological zones in Malawi. Using the correlated and dynamic random effects panel probit and Tobit models that control for unobserved heterogeneity, spatial heterogeneities were revealed. In the Central Region of Malawi, where land rental markets are most active, the one-year and two-year lagged downside rainfall shocks help tenant households to access land in the short-term and medium-term after a rainfall shock. For the more land constrained Southern Region of Malawi, with less prevalence of land rental markets, the two-year lagged downside rainfall shock is associated with less access to rented land. The results reveal surprising spatial variations that call for regional specific market-oriented, market-assisted or non-market policy strategies that can improve access to land amidst recurring rainfall shocks across space and over time.

**Keywords:** Rainfall shocks; Land rental markets; State-contingent framework; Malawi.

**JEL Codes**: Q51; Q15

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## 1. Introduction

The rainfall variations associated with climate change continue to expose farm households to production and consumption shocks in Sub-Saharan Africa (Asfaw et al., 2019; IPCC, 2014). The upside and downside variations that happen within and across production seasons are constantly affecting the decisions of farm households in this region. These are farm households that mainly depend on rainfed production while having poor access to weather-related information (Cooper et al., 2008). Such households also pursue food self-sufficiency objectives considering market imperfections, limited access to credit and insurance, limited off-farm opportunities and the growing land scarcity challenges in the region (Dercon, 2002; Holden et al., 2010; Jayne et al., 2014).

When confronted with rainfall-related shocks, literature shows that the farm households manage or cope with such shocks using different agricultural and non-agricultural strategies that are evolving (Alobo Loison, 2015; Asfaw et al., 2019; Cooper et al., 2008; Dercon, 2002). The choice of the strategy, combination and recombination of these strategies at the household level is mainly a function of resource endowments (land, labour and assets), political history and institutions that facilitate access and use of these resources (Winters et al., 2009). One such institution is a market, both for land and non-land factors of production.

With non-missing land markets in Sub-Saharan Africa (SSA), farm households are responding to the challenge of access and use of productive resources by participating in land rental markets developing in this region. The land markets theoretically develop as an efficiency-enhancing mechanism in the allocation of productive resources, amidst imperfections in the non-land factor markets (de Janvry et al., 2002; Holden et al., 2010). Although the literature shows that these land markets are thin, spatially dispersed (due to the immobility of land) and characterized by high transaction costs, their impact is positive on household income and welfare (Holden et al., 2010; Ricker-Gilbert & Chamberlin, 2018; Ricker-Gilbert et al., 2019). Empirical evidence also shows that farm households use these markets as a coping strategy in the form of distress land rentals after downside rainfall shocks (Gebregziabher & Holden, 2011; Kusunose & Lybbert, 2014).

Despite literature indicating that farm households are utilizing the land rental markets as a coping strategy *ex-post* the rainfall shocks, the corresponding spatial effect on the uptake of the supplied land has not been subject to much research in the land rental market literature. This is in addition to the general limited empirical evidence on the intertemporal and spatial effects of recurring rainfall variations or shocks on households' decisions to rent-in farmland. We are only aware of the study by Kusunose and Lybbert (2014) in Morocco that assessed how limited access to credit affect who can rent-in or rent-out farmland after a drought year. However, the study mainly focused on credit constraints and not the rainfall variations or shock effects on tenant households' renting behavior. Thus, to our knowledge, there is limited empirical evidence on how recurring rainfall variations or shocks are influencing the uptake of rented land across a heterogeneous group of farmers and over time. If the downside rainfall shocks are shifting the supply of land in the rental markets, we consider understanding the extent to which tenant households are utilizing these opportunities as a missing link in the land rental market literature. Therefore, we assess whether lagged rainfall shocks are kick-starting the land rental markets by shifting supply and hence affecting access to rented land across different agro-ecological zones.

In line with Quiggin and Chambers (2006) the decision to rent-in the land is state-contingent but also a risky input choice because tenant households make such a decision and cover costs before the state of nature is revealed. This implies that previous rainfall shocks that shift supply should be important for tenant household decisions in the subsequent years. With a production shock, farm households can experience the associated effect in the immediate future or beyond a single production season. Thus, the rainfall shocks that shift the supply of rented land could also result in both immediate and lasting effects beyond one production season across different agro-ecological zones.

Considering that land rental markets that are developing in SSA are thin and spatially dispersed, access to market information after the shocks should be key for participating in the subsequent years. Fafchamps (2004) indicated that overcoming the first hurdle of entering a factor market in SSA increases the likelihood of re-entering the market. This is mainly from reduced access to market information and contract formulation costs that are based on trust and reputation. Following this literature, we use the previous participation [1] in the land rental markets to control for transaction costs related to accessing market information or contract formulation. That is, tenant households with experience in the market should face relatively lower transaction costs

[1] Our analysis uses participation in the reference production season for each survey rounds that have a three-year production season gaps between the three survey rounds. We did not use the one-year lag participation variables as this was not observed in the data. However, the observed participation in the previous survey round should account for the lag entry and extent of participation across the survey years.

compared to new entrants (Gebru et al., 2019; Kusunose & Lybbert, 2014). This is also a possible entry barrier that we should control for when assessing the long-term lagged rainfall shock effects in the land rental markets. To our knowledge, our study is the first to present such an empirical understanding of the spatial effects of lagged rainfall shocks on uptake of rented land with a dynamic analysis that controls for transaction costs. We control for these transaction costs as they may ration participation in the markets or influence non-market response strategies to rainfall shocks among farm households. Such empirical evidence should be key for initiating policy discussions on land rental markets developing in SSA.

Our analysis uses rainfall data combined with household balanced panel data from Malawi, a country in SSA. The household data is from the Malawi Living Standards Measurement Surveys (LSMS) conducted in 2010, 2013 and 2016 from which we constructed a three-year balanced panel. The data from Malawi is suitable for this context because the country is an agricultural-based economy that heavily depends on a unimodal rainfall pattern for income and food security (Government of Malawi, 2016b). The diversity of agro-ecological zones across the three regions of the country also provide spatial variations in rainfall patterns (see Appendix A, Figure A2) that are important for understanding the associated effects on land rental markets developing in this country. Over the last two decades, the country has been experiencing not only frequent droughts but also floods that vary across the three regions of the country (Government of Malawi, 2016a; Katengeza et al., 2018). Furthermore, land rental markets are evolving as land scarcity challenges increase within and across regions in Malawi (Chamberlin & Ricker-Gilbert, 2016; Chinsinga, 2011; Ricker-Gilbert et al., 2014).

We measure rainfall shock as the district-level deviation of the total amount of rainfall observed in the early to mid-season periods $(x_i)$ from their 10-year period[2] mean $(\bar{x})$ values, i.e. $(x_i - \bar{x})$. See the maps of Malawi in Appendix A, Figures A1 and A2 for the regional and district boundaries plus weather stations across the country. The district-level deviation variable is an indicator of rainfall shocks that are covariate and affect many households at the same time within the district. The variable captures the within-region and not the within-district rainfall shock effects, hence it may not capture all the relevant rainfall variations or shocks at the household level. However, such district level and the within-region variations should capture

[2] We generated the 10-year mean by calculating the average for the seasonal variations for the past 10 years in the context of Malawi production seasons (2005/2006 to 2016/2017 production seasons).

the spatial farm household heterogeneity that is relevant for assessing the effect of rainfall shocks on participation decisions in the land rental markets.

Our assessment of spatial rainfall shock effects mainly focuses on the early to mid-season deviations in each production season. We chose early to mid-season periods based on the fact that early-season deviations can affect input use and crop germination while mid-season deviations can affect crop development and production compared to the late-season deviations that coincide with crop harvesting period (Government of Malawi, 2012). Thus, early to mid-season deviations should account for previous production shocks that can push other households to rent out the land hence offering the opportunity for tenant households to rent-in the land in subsequent years. In the Malawi context, we constructed the early-season period to correspond to the first three months (October to December) while the mid-season corresponds to the next two months (January and February) of the production season. We based this categorization on a unimodal rainfall pattern that goes from November to April. We included October in the early-season as a preparation month and also the time some areas in the country receive early rains but not effective planting rains (Government of Malawi, 2012).

In addition to assessing the early to mid-season deviations, our analysis split the rainfall deviations into downside (absolute negative) and upside (positive) values. The absolute downside deviation values should capture the implicit shift in supply reported in the literature as a driver of distress rentals among poor landlords (Gebregziabher & Holden, 2011). By including the upside deviations, we go beyond only focusing on the downside effect that is mostly reported in SSA. Thus, we propose that an increase in either lag downside or upside absolute rainfall deviation values, that happens early to mid-season increases entry and extent of tenant households' participation in the land rental markets across space. Our analysis uses the household random effects and dynamic random effects estimation methods that control for unobserved heterogeneity in household decisions plus unobservable initial market entry conditions that may ration participation across space and over time.

The rest of the paper proceeds as follows. The next section presents a conceptual framework underlying the recursive state-contingent decision in the land rental market before stating the specific hypotheses. We discuss the data and estimation methods in section three and present the descriptive statistics in section four. In section five, we present and discuss the results before concluding the paper in section six.

## 2. Conceptual framework and hypotheses

A farm household whose objective is to maximize utility based on their beliefs about the likelihoods and production outcomes under alternative states of nature make state-contingent input decisions accordingly (Quiggin & Chambers, 2006). Farm households make *ex-ante* input decisions before weather conditions are revealed based on their beliefs, expectations, preferences and consumption needs that are implicit in such decisions (Dercon & Christiaensen, 2011; Quiggin & Chambers, 2006). In an intertemporal setting with sequential decisions, households are repeatedly engaged in these decision processes and adjust their beliefs based on past experiences about states of nature and their past decisions outcome. Households acquire experience that shapes their subjective production risk assessment, input choices and consumption decisions, *ex-ante* and *ex-post* the production period. Land rental markets open an additional adjustment opportunity across farms in terms of balancing land and non-land resource use. Overall, the state-contingent framework indicates that household input use is decided before the state of nature is revealed to the farmer (Quiggin & Chambers, 2006).

According to Holden and Quiggin (2017) "any increase in exogenous risk, defined as the increase in the probability of a less favourable state of nature like drought or flood, leads to an increased share of risk substituting inputs in the vector of non-stochastic input mix for a given expected output". That is, in a state-contingent decision, farm households are more likely to allocate non-stochastic inputs like owned land in a way that reduces the production risks depending on their endowment and needs. However, renting-in the land is a state-contingent but risky decision because households have to invest their wealth in the decision before the state of nature is revealed compared to using only owned land. Dercon and Christiaensen (2011) further indicated that farm households make these state-contingent and risky input decisions based on expected consumption needs as an *ex-ante* risk management strategy to hedge against *ex-post* consumption shocks. Overall, the state-contingent decisions go beyond risk aversion to include risk-reducing mechanisms when the probability of accessing the input credit, insurance and consumer credit is low, as experienced in most countries in SSA (Dercon & Christiaensen, 2011; Holden & Quiggin, 2017). Figure 1 summarizes the recursive state-contingent decisions mainly for tenant household renting-in the land.

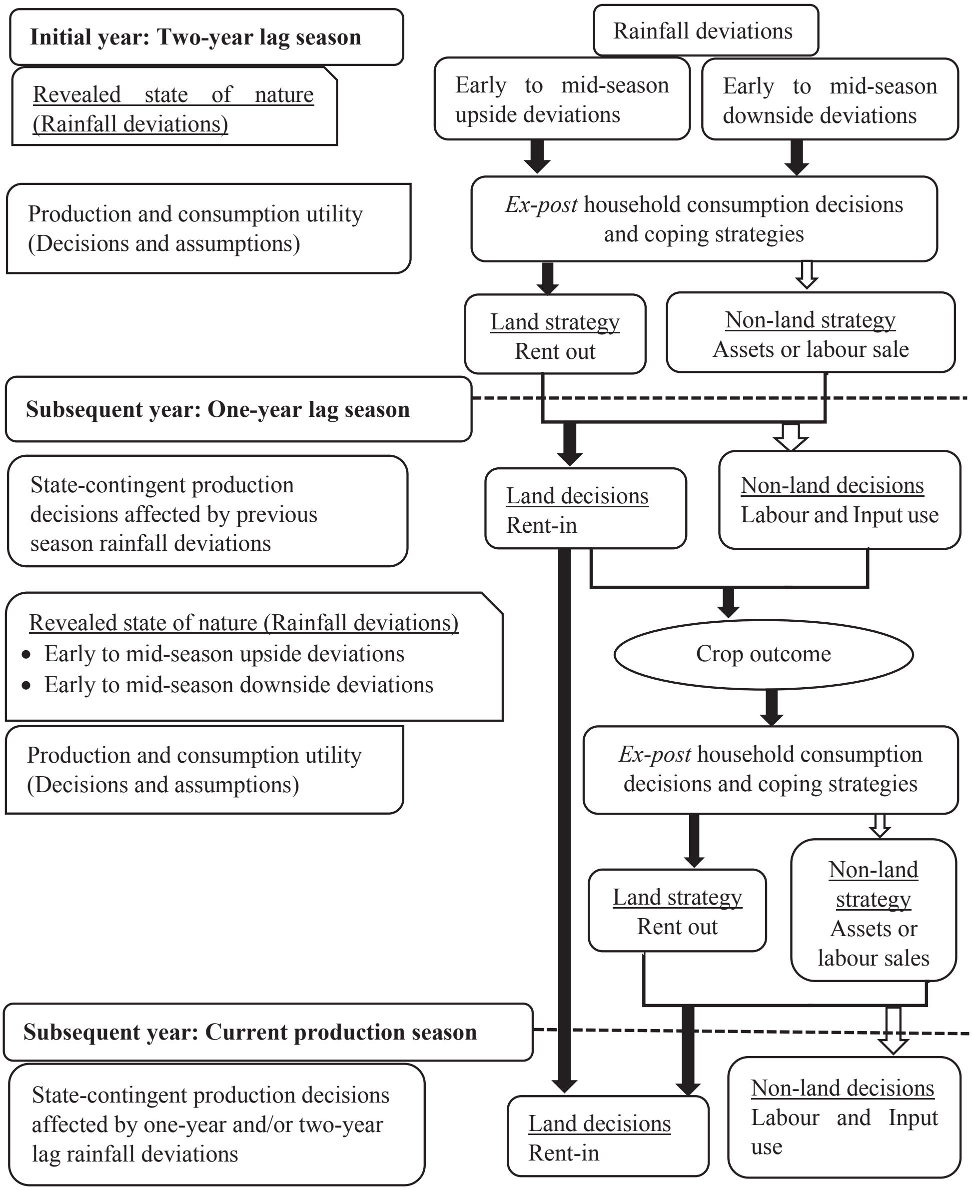


Figure 1: Recursive household state-contingent decisions for renting-in the land over time.

In Figure 1, we consider a rural farm household that heavily depends on a varying unimodal rainfall pattern, like in Malawi. Such a household is endowed with farmland ($\bar{A}$), labour ($\bar{L}$) and capital ($K$) factors of production. Markets for land and labour are non-missing but with imperfections (Binswanger & Rosenzweig, 1986; Holden et al., 2010). We assume that land is scarce and that there are limited off-farm opportunities except for seasonal casual labour on other farms within the communities (Jayne et al., 2014). Land constrained households may rent-in more land to ensure food self-sufficiency, increase income or production utility. We also assume that downside and upside rainfall shocks that lead to distress rentals result in favourable rental prices for tenant households. However, this effect does not affect transaction costs related to market information or contract formulation because of localized and not well-integrated land rental markets.

From Figure 1, the shaded arrows define the main pathways in which lag rainfall deviations can affect tenant household participation in the land rental markets. The figure shows that the initial year or the two-year lagged upside or downside deviations that can affect the household consumption needs, can push farm households to cope with such shocks by either renting out the land in distress or trading the non-land factors (assets and labour). Thus, in the subsequent year (one-year lag), the farm households who are capable of smoothing consumption, and with the ability to increase the operational farmland can rent-in the land or increase the amount of rented land. Such a decision is state-contingent where crop outcome is known after the state of nature is revealed.

Depending on the crop outcome after the state of nature is revealed in the subsequent year, households that are not able to cope with consumption shocks will again engage in either renting out the land or trading non-land factors. We hold the non-agricultural sector strategies constant due to limited opportunities amongst farm households in rural areas in SSA. Again, this allows potential tenants to rent-in the land in the subsequent year (current production season), implying the recursive state-contingent decisions that households continue to engage in overtime. Apart from the year to year effect, long-term shock effects beyond one production season can also push potential tenant households to re-enter the market from earlier participation in the markets. This implies that rainfall shocks can have both immediate and long-term effects in the land rental markets for tenant households, conditional on the supply. Therefore, we hypothesize that;

H1: One-year lag downside rainfall deviations (early to mid-season) increase entry and extent of tenant household participation in land rental markets in the subsequent year.

H2. One-year lag upside rainfall deviations (early to mid-season) increase entry and extent of subsequent year tenant household participation in land rental markets.

H3. Rainfall shocks trigger more land rental market participation beyond the immediate effect in the following year. We assume that if one-year lag rainfall deviations push tenant households' over the first hurdle of entering the market, such households are more likely to re-enter beyond the immediate effect from gaining the experience in the market.

## 3. Data and estimation methods

Our data is from three rounds of the Malawi Living Standards Measurement Surveys (LSMS). The survey periods were from (i) March 2010 to March 2011; (ii) April to December 2013; and (iii) April 2016 to April 2017. The survey data collection period coincided with the end of production period for a unimodal rainfall season in Malawi that starts from November to April. Thus, the reference production seasons for each survey round in our data were (i) November 2009 to April 2010; (ii) November 2012 to April 2013; and (iii) November 2015 to April 2016[3]. In 2010, the total number of surveyed households was 1,619 that we used to construct a balanced panel of 1,480 households. This represented an 8.6 percent attrition rate that we used to test for attrition bias in our results[4].

For the rainfall variables, we used monthly rainfall data (accessed in millimeter) from October 2006 to April 2017 observed at the district level weather stations across Malawi (Appendix A, Figure A2). We sourced the data upon official request to the Department of Climate Change and Metrological Services in Malawi (www.metmalawi.gov.mw). In Malawi, the administrative boundaries are categorized as national, regional, district and community. In total, the country has 28 districts that are grouped into 3 regions (see Figures A1 and A2 in Appendix A) that vary in rainfall pattern, population density and land distribution (Chinsinga, 2011; Government of Malawi, 2019). Thus, our focus in this paper is on district-level rainfall deviations that capture the within-region rainfall shock effects across different agro-ecological zones. For the early to mid-season lag rainfall deviation variables, we use the period from October to February in the previous seasons for each reference production period in the survey rounds. We further used the decimeter (dm) as a unit of measure[5] in our analysis to have suitable coefficient sizes when discussing our estimated results.

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[3] For the survey periods that crossed to the next production season like in 2010 and 2016 rounds, we verified that the reference production period remained the same for all households. For instance, if a household was interviewed in April 2017, the reference period remained 2015-16 production season and not 2016-17 production season.

[4] We did not observe any significant attrition bias effects in our results based on including the inverse mills ratio in our estimations. The results with inverse mills ratio are available from the authors upon request.

[5] We multiplied the millimetres by 0.01 to obtain the decimetre units (1dm = 100 millimetres)

As a risky state-contingent input decision subject to random states of nature (rainfall shocks), observable and unobservable heterogeneity affect tenant household participation decisions. Thus, we specify the decision to participate in the land rental markets ($R_{jt}$) as reduced functional form models of stochastic rainfall variables in equations (1) and (2). The equations are for both entry and extent of participation hence the parameter ($R_{jt}$) is for either the probit or censored Tobit models. Our study applies both the Correlated Random Effects (CRE) and the Dynamic Random Effects (DRE) probit and Tobit models to control for time-invariant unobservable household and farm heterogeneity because we have limited dependent variables (Wooldridge, 2010). The CRE approach in equation (1), first suggested by Mundlak (1978) and Chamberlain (1982), is equivalent to using the household fixed effect in models with continuous dependent variables. The DRE model specification in equation (2) is important for assessing the intertemporal rainfall shock effects because the model can also control for initial unobserved conditions in the decision or dependent variable. This specification requires balance panel data (Wooldridge, 2010) and hence the use of balanced panel data in our analyses.

CRE-models by region:

$$R_{jt}^{k} = \alpha + \lambda N_{t-1} + \varrho H_{t-1} + \gamma \bar{X}_j + \pi \hat{X}_j + \bar{Z}_j \beta + \hat{Z}_j \delta + \tau + \mu_j + \varepsilon_{jt} \qquad (1)$$

Dynamic RE-models by region:

$$R_{jt}^{k} = \alpha + \lambda N_{t-1} + \varrho H_{t-1} + \varphi X_{jt} + \phi Z_{jt} + \tau + R_{jt-n}\rho + \mu_j + \varepsilon_{jt} \qquad (2)$$

The parameters of interest in the equations are $\lambda$ and $\varrho$ for lag downside *(N)* and lag upside *(H)* absolute values of rainfall deviations from means that happens from early to mid-season, respectively. After a pooled analysis we noticed significant regional differences in the data, hence instead of just controlling for these differences with regional dummies, we found that region-wise models gave better results and revealed important spatial differences. However, based on the constructed household balanced panel data from the LSMS, the number of households renting in the land in the Northern Region of Malawi was too low to do meaningful analysis[6]. Thus, our analysis only focused on the Central and Southern Regions of Malawi.

[6] Only 11 households out of 525 sample (2 percent) in the Northern Region participated in the rental market against 250 households out of 1830 (14 percent) in the Central Region, and 133 households out of 2085 (6 percent) in the Southern Region.

Apart from dropping the Northern Region due to data limitations, the Central and Southern Regions also differ in population density, agro-ecological zones and land distribution which we consider important for assessing region-wise models that give spatial variations compared to a pooled analysis (Chinsinga, 2011; Government of Malawi, 2019; Kanyama-Phiri et al., 2000). We, therefore, run separate models for the Central and Southern Regions of Malawi to obtain region-specific coefficients. The superscript ($k$) in the equations (1) and (2) is either 1 for Central Region or 2 for Southern Region, for both probit and Tobit models.

Based on CRE specifications, equation (1) controls for the means ($\bar{X}_j, \bar{Z}_j$) and deviations from the mean ($\hat{X}_j, \hat{Z}_j$) of farm and households characteristics while the DRE model specification controls for the observed farm ($X_{jt}$) and household ($z_{jt}$) characteristics. From both equations (1) and (2), the $\tau$ is for time (year) dummies and the $\mu_j + \varepsilon_{jt}$ is the error term. We assume the error term to be additive in line with the specified random effects models (Wooldridge, 2010). The variable $\mu_j$ is the time constant unobserved heterogeneity at the household level and the variable $\varepsilon_{jt}$ is the idiosyncratic error that is independent and identically distributed. This specification applies to both the CRE and the DRE probit and Tobit models. However, the DRE model has a further specification for the variable $\mu_j$ in the error term.

According to Wooldridge (2010), the $\mu_j$ in the dynamic random effects (DRE) models with limited dependent variable is also additive and given as $\mu_j = \psi + \alpha_0 R_{j0} + z_j \alpha_1 + \epsilon_j$. Where $\psi$ is a constant and the variable $\epsilon_j$ is the error term independent of $R_{j0} + z_j$ and specified as $\epsilon_j \sim Normal(0, \sigma_\epsilon{}^2)$. The $R_{j0}$ is the initial year observation for the dependent variable and $z_j$ is for exogenous explanatory variables. This structure allows the use of a likelihood function similar to assessing the marginal effects in the random effect probit or Tobit models. However, the DRE model must include the lagged dependent variables to the list of explanatory variables. Specifically, for the probit model, we add the initial year and lag dependent binary variables to the list of explanatory variables, which changes to $x_{jt} = \{1, z_{jt}, R_{j,t-n}, R_{j0}, z_j\}$ as indicated in equation (2).

The Tobit models require that we replace $\alpha_0 R_{j0}$ with $\rho R_{j,t-n} = \omega r_{j,t-n} + \rho(1 - r_{j,t-n}) R_{j,t-n}$. Where $R_{j,t-n}$ is the lagged participation in the previous survey round ($n$) and the $r_{j,t-n}$ is a binary variable that is equal to one if $R_{j,t-n} = 0$ and zero otherwise. Like the probit, this reduces the Tobit explanatory variable list to $x_{jt} = \{z_{jt}, R_{j,t-n}, R_{j0}, z_j\}$. That is, we include both the initial year and lag observations for the entry and extent of participation in the dynamic random effects Tobit models (Wooldridge, 2010). By doing so, we control for the unobserved effect ($\mu_j$) and the initial household conditions that are likely to facilitate entry and extent of participation in the subsequent years. This include transaction costs related to accessing market information that households can easily acquire upon entering and gaining experience in the market.

Specifically, the data for equation (1) included the observed participation in all three survey rounds and the respective rainfall deviation variables. In equation (2) we included the lag of the dependent variable observed in the previous survey round $[R_{jt-n}]$ and not the one-year lagged participation which was not observed in the data. Following Wooldridge (2010), we used the observed participation in 2010 as the initial year in our data and also the lag participation variable for the 2013 survey round. Subsequently, we also included the observed participation in 2013 survey round as the lag participation variable in the 2016 survey round. Thus, the total number of observations for equation (1) in the Central and Southern Regions were 1830 and 2085, while for equation (2) the sample observations were 1220 and 1390, respectively. This is based on the three rounds of constructed balanced household panel from 610 Central Region households and 695 Sothern Region households.

The farm and household-level characteristics in the equations include owned farmland area (GPS measured); owned farmland to labour ratio; share of male labour; sex, age and education of household head; household size to labour ratio; Total Livestock Units (TLU); one-year lagged TLU, capital asset index to labour ratio and distance to urban centres. We considered owned farmland to be the land acquired through customary inheritance systems; government distribution and/or purchases. We considered acquiring land through borrowing, encroachment and farming under estate management to be an endogenous right in our model (Holden et al., 2013), hence we categorize such households as landless in the land ownership sense. We include the share of male labour because farming systems in Malawi are highly dominated by a hand-hoe that requires more physical strength and time on the farm, hence more male labour could be an advantage among farm households. Further, we estimated the capital asset index, that ranges from negative to positive values using the Factor Component Analysis (FCA) based on household ownership of durable assets and farm implements. Considering the long asset list used in FCA, we present these durable goods and farm implements in Appendix A.

## 4. Descriptive Statistics

The statistics on rainfall deviations in Figure 2 shows the early to mid-season average rainfall amount for the Central and Southern regions in Malawi over ten seasons (intertemporal rainfall distribution). The early to mid-season periods capture the average monthly rainfall amounts as defined above. The shaded bar graphs indicate the rainfall deviations in the previous two production seasons for each survey round while the empty bars reflect the reference production season in the survey periods. The horizontal lines represent the regional 10-year mean rainfall values for the period 2006–07 to 2016–17. With the horizontal line, the bars in the graph further show the average regional deviations from the means. We dropped the 2006-07 and 2016-17 production seasons in the figure to emphasize the period of interest in this analysis.

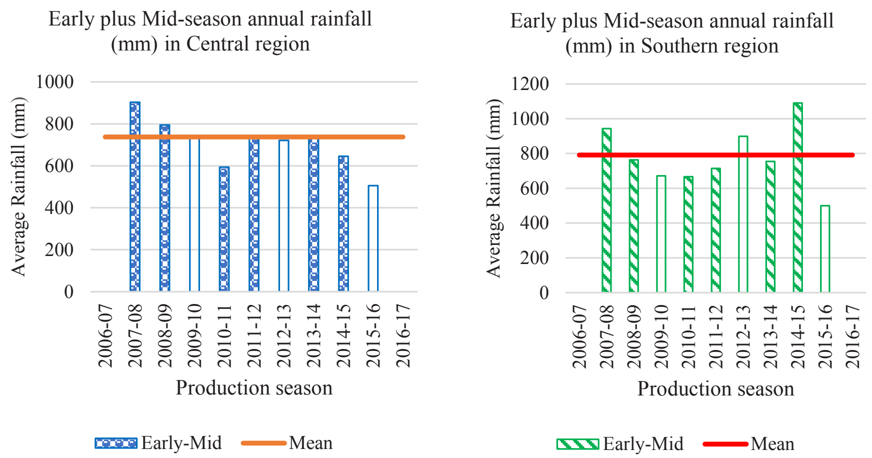


Figure 2: Regional early to mid-season annual rainfall (mm) for each survey round

From Figure 2, the 2007-08 season shows upside deviations in both regions while 2008-09 slightly vary across the regions. The rainfall seasons between 2010 and 2012 both exhibit a downside effect in both regions with a slightly higher downside effect in the Southern Region for the 2011-12 season. The rainfall seasons between 2013 and 2016 were characterized by both flood and drought in Malawi (Government of Malawi, 2015; Government of Malawi, 2016a). The upside deviations in 2014-15 production season reflect such flood effect that severely affected the Southern Region in January 2015. However, during the same time, the Central Region experienced relatively downside rainfall deviations. Overall, these are the rainfall deviations that support the need to understand their effect on farm household participation in the land rental markets.

Table 1 present statistics for the household and farm variables that we controlled for in our model summarized across all survey rounds and for each region. In the table, we first present the statistics for the overall sample and then present for the tenant and non-tenant households[7]. We use the t-test to show the overall mean differences between tenant and non-tenant households in our data. Since we control for previous participation in our analysis, we also present a detailed table on the extent of re-entry into the market in Appendix A, Table A1.

For the household variables, Table 1 shows that participation in the land rental markets is more prevalent in the Central Region (14 percent) compared to the Southern Region (6 percent). Tenant households in both regions rent-in an average of 0.5 ha which is almost equivalent to the average landholding size for non-tenant households in our data (0.6 ha and 0.5 ha in the Central and Southern Regions, respectively). In both regions, non-tenant households are relatively land rich and have a higher land to labour ratio compared to tenant households. However, we did not observe significant differences in the share of male labour that might be considered more important in a farming system that requires more human labour based on using a hand-hoe like in Malawi (Takane, 2008).

On the contrary, tenant households are rich in capital asset index to labour ratio and slightly more educated than the non-tenant households in both regions. In the Central Region, a tenant household is on average headed by a younger head. We also observed a significant household head gender difference in the Southern Region where tenant households are less likely to be headed by a female, despite the data indicating that female-headed households in both regions owned less land compared to male-headed households on average. The average community level distance to urban centres among tenant households is significantly higher than non-tenant households in both regions (significant at 5 percent in the Central Region and 10 percent in the Southern Region). On the extent of market re-entry, Appendix A-Table A1 shows that 51 and 64 percent of tenant households who participated in the baseline year (2010) also participated in 2013 and 2016 survey rounds, respectively.

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[7] Due to LSMS data constrains, we were not able to specify a landlord category hence we combined those renting out and not participating into non-tenant households. In our data, we constantly observed a very small percentage of households renting out land. That is, in 2010, we observed 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 in our data. We refer to Deininger et al. (2017) for a detailed discussion on LSMS data, land markets and capturing landlord households.

**Table 1: Descriptive statistics**

| | Central Average values across all years | | | | Southern Average values across all years | | | |
|---|---|---|---|---|---|---|---|---|
| VARIABLES | Total sample | Tenant household (1) | Non-tenant household (2) | ttest 1 vs. 2 | Total sample | Tenant household (3) | Non-tenant household (4) | ttest 3 vs. 4 |
| **Rental participation variables** | | | | | | | | |
| Rent-in dummy | 13.5 | | | | 6.3 | | | |
| Rent-in land (mean ha) | | 0.47 | | | | 0.52 | | |
| | | (0.03) | | | | (0.04) | | |
| **Farm and Household variables** | | | | | | | | |
| Own farmland (mean ha) | 0.56 | 0.36 | 0.59 | **** | 0.48 | 0.27 | 0.49 | **** |
| | (0.02) | (0.03) | (0.02) | | (0.01) | (0.04) | (0.01) | |
| Own farmland to labour ratio (mean) | 0.19 | 0.11 | 0.20 | **** | 0.18 | 0.09 | 0.18 | **** |
| (ha/adult equiv. labour unit) | (0.01) | (0.01) | (0.01) | | (0.01) | (0.02) | (0.01) | |
| Share of male labour (mean) | 0.42 | 0.42 | 0.42 | | 0.39 | 0.40 | 0.39 | |
| | (0.01) | (0.01) | (0.01) | | (0.00) | (0.02) | (0.01) | |
| Sex of HH head (1=Female) | 0.20 | 0.15 | 0.20 | * | 0.29 | 0.14 | 0.29 | **** |
| | (0.01) | (0.02) | (0.01) | | (0.01) | (0.03) | (0.01) | |
| Age of HH head (mean years) | 45 | 43 | 46 | *** | 44 | 42 | 44 | |
| | (0.36) | (0.81) | (0.39) | | (0.34) | (1.03) | (0.35) | |
| Education of HH head (mean years) | 6.33 | 7.20 | 6.19 | *** | 5.62 | 6.77 | 5.54 | *** |
| | (0.11) | (0.31) | (0.12) | | (0.10) | (0.47) | (0.10) | |
| Household size to labour ratio (mean) | 1.64 | 1.66 | 1.63 | | 1.70 | 1.74 | 1.69 | |
| (No. of persons/adult equiv. labour unit) | (0.01) | (0.02) | (0.01) | | (0.01) | (0.04) | (0.01) | |
| Total Livestock Units (TLU) to labour ratio | 0.11 | 0.15 | 0.11 | * | 0.11 | 0.10 | 0.11 | |
| (mean values) | (0.01) | (0.02) | (0.01) | | (0.02) | (0.02) | (0.02) | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| One-year lag TLU to labour ratio (mean) | 0.07 | 0.08 | 0.07 | | 0.08 | 0.02 | 0.08 | |
| (lag TLU No./ adult equiv. labour unit) | (0.01) | (0.01) | (0.01) | | (0.02) | (0.02) | (0.02) | |
| Capital asset index to labour ratio (mean) | -0.02 | 0.01 | -0.02 | ** | -0.06 | 0.02 | -0.06 | ** |
| | (0.01) | (0.02) | (0.01) | | (0.01) | (0.03) | (0.01) | |
| Distance to the urban center (mean km) | 27.4 | 29.9 | 27.0 | ** | 28.5 | 31.5 | 28.3 | * |
| | (0.39) | (0.92) | (0.42) | | (0.42) | (1.59) | (0.44) | |
| Observations **(N)** | 1830 | 247 | 1563 | | 2085 | 132 | 1953 | |

*Note:* The t-tests compare the overall mean over the years between the tenant and non-tenant households. The asterisks denote levels of significance at **** = p<0.001, *** = p<0.01, ** = p<0.05, and * = p<0.1. Standard errors in parenthesis.

Of those who participated in 2013, 43 percent also participated in 2016 survey round implying a market that facilitates access to land for both experienced tenants and new entrants. In general, these are the regional variations that are important for assessing the within-region spatial rainfall shock effects in our analysis. However, a research issue beyond this study would be to assess the spatial effect of population pressure on the development of land rental markets considering our observation that land rental markets are more active in the Central Region where population density is lower than the Southern Region (Government of Malawi, 2019).

## 5. Results and discussion

We present the key probit and Tobit model results in Table 2. The average marginal effects are for the Correlated Random Effects (CRE) and Dynamic Random Effect (DRE) probit and Tobit models for the Central and Southern Regions. The CRE and DRE Tobit models present the conditional average partial effects [$E(y|\boldsymbol{X}, y > 0)$]. The more detailed result tables for both the average marginal effects and the coefficients are found in Appendix A, Tables A2 to A9 for both regions. The detailed Appendix A tables first present the parsimonious random effects model which were our starting point in the analysis before estimating the CRE and DRE models. The combination of models helped to assess the robustness of the key results to the alternative model specifications. We discuss our hypotheses using the joint results from the CRE and DRE probit and Tobit models across the regions.

Our hypothesis H1 stated that one-year lag downside rainfall deviations (early to mid-season) increase entry and extent of tenant household participation in land rental markets in the subsequent year. For this hypothesis, we use both the CRE and DRE probit and Tobit results from both regions. The results from the Central Region CRE and DRE probit models show that one-year lag downside rainfall deviations significantly increase entry into the rental markets in the subsequent year. On average, if the one-year lag downside rainfall deviations (absolute values) increases by one dm (100 mm), entry into the land rental markets increase by 4 percentage points in the subsequent year (significant at 5 and 10 percent levels). However, on the extent of participation (amount of land rented-in at household level in hectares), the effect is only significant at the 10 percent level in the CRE Tobit model and is insignificant in the DRE Tobit. The one-year lagged variables were insignificant for the Southern Region. Thus, our results provide support for hypothesis H1 only in the Central Region.

Table 2: Regional probit and Tobit random effects models for renting-in land (Average partial effect for Tobit model – $[E(y|X, y > 0)]$): Full regional model results (coefficients and margins) are in Appendix A, Tables A2 to A9.

| | **Correlated Random Effects (CRE) and Dynamic Random Effects (DRE) models with control variables** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Central Region Models** | | | | **Southern Region Models** | | | |
| | **Probit Models** | | **Tobit Models** | | **Probit Models** | | **Tobit Models** | |
| **VARIABLES** | **CRE** | **DRE** | **CRE** | **DRE** | **CRE** | **DRE** | **CRE** | **DRE** |
| **One-year lag rainfall variables** | | | | | | | | |
| Positive deviation (dm) one-year lag | 0.00 | 0.00 | 0.00 | -0.00 | -0.00 | -0.01 | -0.01 | -0.01 |
| (Early plus mid-season) | (0.01) | (0.02) | (0.01) | (0.01) | (0.00) | (0.01) | (0.01) | (0.01) |
| Absolute Negative deviation (dm) one-year lag | 0.04** | 0.04* | 0.02* | 0.01 | -0.00 | -0.00 | 0.00 | -0.00 |
| (Early plus mid-season) | (0.02) | (0.02) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| **Two-year lag rainfall variables** | | | | | | | | |
| Positive deviation (dm) two-year lag | -0.01 | -0.02 | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 |
| (Early plus mid-season) | (0.01) | (0.02) | (0.01) | (0.02) | (0.01) | (0.01) | (0.01) | (0.01) |
| Absolute Negative deviation (dm) two-year lag | 0.03** | 0.03** | 0.02** | 0.02* | -0.03*** | -0.02** | -0.03** | -0.02* |
| (Early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| **Lag rental participation dummies** | | | | | | | | |
| Initial year (2010) rent-in dummy | | 0.08 | | 0.02 | | 0.09 | | 0.05 |
| | | (0.08) | | (0.04) | | (0.06) | | (0.03) |
| Lag rent-in dummy | | 0.14 | | 0.04 | | 0.10 | | 0.10**** |
| (previous survey round) | | (0.09) | | (0.04) | | (0.07) | | (0.03) |
| Initial year (2010) rent-in land (ha) | | | | 0.12* | | | | -0.04 |
| | | | | (0.06) | | | | (0.06) |
| Lag total rent-in land (ha) | | | | 0.05 | | | | 0.12*** |
| (previous survey round) | | | | (0.05) | | | | (0.04) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Farm and Household Characteristics** | | | | | | | | |
| Observed control variables | No | Yes | No | Yes | No | Yes | No | Yes |
| Mean of observed control variables | Yes | No | Yes | No | Yes | No | Yes | No |
| Deviations from the mean | Yes | No | Yes | No | Yes | No | Yes | No |
| **Year dummies** | | | | | | | | |
| 2013.year | -0.01 | | -0.01 | | 0.05*** | | 0.05** | |
| | (0.03) | | (0.02) | | (0.02) | | (0.03) | |
| 2016.year | -0.04* | -0.04 | -0.01 | -0.02 | 0.05** | 0.00 | 0.06** | 0.00 |
| | (0.02) | (0.03) | (0.02) | (0.02) | (0.02) | (0.03) | (0.03) | (0.03) |
| Constant | -1.73** | -1.66**** | -1.25** | -1.33**** | -0.91 | -1.87** | -0.65 | -1.28** |
| | (0.82) | (0.47) | (0.49) | (0.33) | (1.43) | (0.89) | (0.82) | (0.52) |
| lnsig2u | 0.12 | -1.85 | | | 0.96**** | -0.75 | | |
| | (0.23) | (2.75) | | | (0.26) | (1.70) | | |
| sigma_u | | | 0.60**** | 0.39** | | | 0.94**** | 0.00**** |
| | | | (0.05) | (0.18) | | | (0.10) | (0.00) |
| sigma_e | | | 0.57**** | 0.66**** | | | 0.62**** | 0.82**** |
| | | | (0.03) | (0.09) | | | (0.05) | (0.07) |
| Observations | 1,830 | 1,220 | 1,830 | 1,220 | 2085 | 1390 | 2,085 | 1,390 |
| Left Censored (_n) | | | 1,583 | 1,048 | | | 1,953 | 1,288 |
| Uncensored (_n) | | | 247 | 172 | | | 132 | 102 |
| Number of Panel households | 610 | 610 | 610 | 610 | 695 | 695 | 695 | 695 |

Note: The asterisks represent **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1. The parenthesis shows cluster robust standard errors for Probit models and Normal standard errors in for Tobit models. **The farm and household control variables include** (1) own farmland (ha), (2) own farmland to labour ratio *(ha/adult equiv. labour unit),* (3) share of male labour, (4) sex of HH head (1=Female), (5) age of HH head (years), (6) education of HH head (years), (7) household size to labour ratio *(No. of persons/adult equiv. labour unit)*, (8) Total Livestock Units (TLU) to labour ratio, (9) one-year lag TLU to labour ratio *(lag TLU No./ adult equiv. labour unit),* (10) capital asset to labour ratio, and (11) distance to the urban center (km).

On hypothesis H2, our results provide no support for the flood effect. The hypothesis was stated as one-year lag upside rainfall deviations (early to mid-season) increase entry and extent of subsequent year tenant household participation in land rental markets. This may be because the effect of the floods in the Central Region was not sufficiently severe, where land rental markets are more prevalent or that the flood effect observed in the Southern Region was not significantly important to affect land rental market participation where such markets are less prevalent. As observed in Figure 2 and as discussed in Katengeza et al. (2018), Malawi mostly experience downside shocks like drought or in-season dry spells but fewer severe floods. This takes our discussion to hypothesis three.

Hypothesis H3 stated that rainfall shocks trigger more land rental market participation beyond the immediate effect in the following year. We assess this hypothesis using the two-year lagged rainfall deviation variable results from the CRE and DRE models. Table 2 shows that a one dm absolute negative deviation in the two-year lagged rainfall variable resulted in a 3.0 percentage point increase in land rental market participation. In both the CRE and DRE probit models, this effect was significant at 5 percent level in the Central Region. Furthermore, the effect was also significant in the CRE and DRE Tobit models with an increase of 0.02 ha area rented in per dm rainfall deficit in both models (significant at 5 and 10 percent levels). This demonstrates robust support for hypothesis H3 in the Central Region.

In the Southern Region, the two-year lagged rainfall variable was on the contrary negatively and significantly associated with renting-in the land. Both the CRE and DRE probit and Tobit models provide strong evidence to reject hypothesis H3 in this region. It appears that such past rainfall shocks cause households to cling more to their limited land as a self-sufficiency food security strategy. However, households with experience in the markets are more likely to re-enter the land rental markets in this region, a possible indicator of demand by land constrained households over time. These are surprising findings considering that rainfall shocks further shrink the land rental markets in the Southern Region of Malawi where population pressure and land scarcity is high compared to the Central Region of Malawi. That is, land markets do not necessarily start to work better with the increase in population for this region. However, such a non-linear relationship between population pressure and land rental market activity requires further research.

## 6. Conclusion

Rainfall variations within and across production seasons, that result in either drought or floods, are recurring states of nature. In Sub-Saharan Africa (SSA), farm households renting out their land in distress as an *ex-post* coping strategy can be an outcome of such shocks. If rainfall shocks are shifting supply of rented land, the extent to which tenant households are utilizing these opportunities across space and over time is a missing link in the land rental market literature in SSA. In this paper, we assessed whether rainfall shocks are kick-starting the land rental markets by shifting the supply of rented land, thereby creating opportunities for tenant household to access land across space, observed from tenant households' side. We used three rounds of household balanced panel data constructed from the Malawi Living Standards Measurement Surveys (LSMS) conducted in 2010, 2013 and 2016 to investigate this. To assess the spatial rainfall shock effects, we combined the survey data with the corresponding district-level rainfall data that captured the within-region effect in Malawi.

Our analysis used the one-year and two-year lagged downside and upside deviations from average district-level rainfall data in the early to mid-season periods based on a unimodal rainfall pattern in Malawi. Using the state-contingent framework for risky input choice, we proposed that increase in either downside or upside absolute rainfall deviation values increases entry and extent of tenant households' participation in land rental markets in the subsequent years and across the regions. Our data revealed spatial heterogeneities when we categorized the sample into the three administrative regions of North, Central and South in Malawi. Further, we observed that land rental markets are most active in the Central Region followed by the Southern Region and least active in the Northern Region. We also found that our analysis of the relation between rainfall shocks and land rental market activity only made sense in the Central and Southern Regions and therefore we dropped the Northern Region sample. We estimated our results using both the correlated random effects and the dynamic random effects probit and Tobit models that control for unobserved heterogeneity and initial market entry conditions.

The results show that, where the land rental markets are most active, that is in the Central Region of Malawi, the one-year and two-year lagged downside rainfall shocks significantly increased tenant households' access to rented land. This implied both an immediate and a medium-term rainfall shock effect on land rental market participation in this region. However, we did not observe any similar effects from the lagged upside rainfall shocks in the two regions.

In the Southern Region where the farm sizes are very small from high population pressure and with less prevalence of land rental markets, the two-year lagged absolute negative rainfall shock was associated with less access to rented land, an indicator of households holding owned land for self-sufficiency objectives than trading in the market.

Overall, our results indicate that where land rental markets are most active, the rainfall shocks in the form of droughts are helping to kick-start tenant household participation. Such area-specific effect calls for orchestrated access to land rental market information as a climate response strategy that can improve land allocation through markets after rainfall shocks. Where land markets are more likely to shrink after rainfall shocks, non-market (government distribution) or market assisted (government facilitated purchases) policy strategies can help to facilitate access to land, especially for land constrained households. However, the heterogeneity in the results calls for more research on the rainfall shock effect, population growth and land market development nexus to understand further the spatial variation effects across farm households in Malawi.

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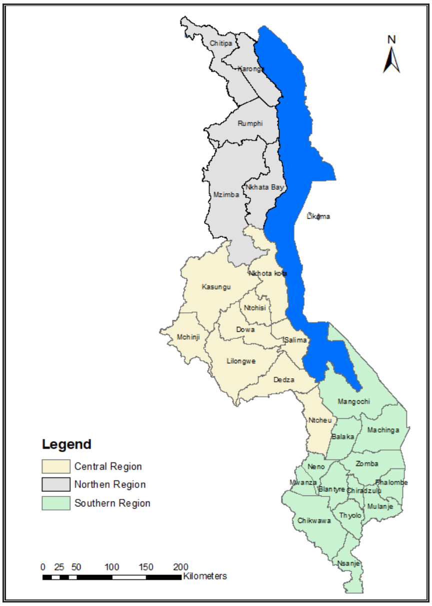
## Can rainfall shocks enhance access to rented land? Evidence from Malawi

### Appendix A

Map of Malawi



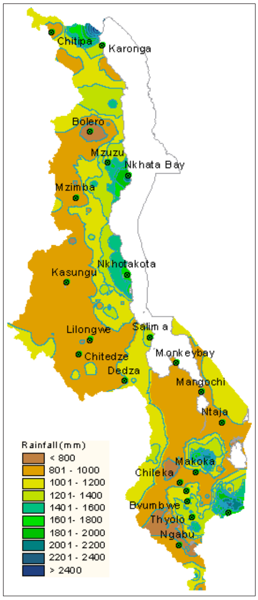




Figure A1: Map of Malawi showing districts Figure A2: Rainfall map with weather stations across Malawi
Source: Department of Climate Change and Meteorological Services: www.metmalawi.gov.mw

**Factor Component Analysis variables for Capital Asset index:**

**(i) Durable assets**

(1) Mortar/pestle (Mtondo), (2) Bed, (3) Table, (4) Chair, (5) Fan, (6) Air conditioner, (7) Radio ('wireless'), (8) Tape or CD/DVD player or HiFi, (9) Television, (9) VCR, (10) Sewing machine, (11) Kerosene/paraffin stove, (12) Electric or gas stove; (13) Hot plate, (14) Refrigerator, (15) Washing (16) Machine, (17) Bicycle, (18) Motorcycle/scooter, (19) Car, (20) Mini-bus, (21) Lorry, (22) Beer-brewing drum, (23) Upholstered chair, (24) Sofa set, (25) Coffee table (for the sitting room), (26) Cupboard, (27) Drawers, (28) Bureau, (29) Lantern (paraffin), (30) Desk, (31) Clock, (32) Iron (for pressing clothes), (33) Computer equipment & accessories, (34) Satellite dish, (35) Solar panel, (36) Generator, (37) Radio with flash drive/micro CD.

**(ii) Farm implements**

(1) Hand Hoe, (2) Slasher, (3) Axe, (4) Sprayer, (5) Panga Knife, (6) Sickle, (7) Treadle Pump, (8) Watering Can, (9) Ox Cart, (10) Ox Plough, (11) Tractor, (12) Tractor Plough, (13) Ridger, (14) Cultivator, (15) Motorised Pump, (16) Grain Mill, (17) Chicken House, (18) Livestock Kraal, (19) Poultry Kraal, (20) Storage House, (21) Granary, (22) Pig Sty.

**Table A1: Initial year and subsequent land rental market participation**

| Participation | 2013 (%) | | 2016 (%) | | Total (N) | Participation | 2016 (%) | | Total (N) |
|---|---|---|---|---|---|---|---|---|---|
| **Initial year = 2010** | *No* | *Yes* | *No* | *Yes* | | **Survey year = 2013** | *No* | *Yes* | |
| *No* | 93.3 | 6.8 | 93.2 | 6.8 | 1,372 | *No* | 94.9 | 5.1 | 1,331 |
| *Yes* | 49.1 | 50.9 | 63.9 | 35.1 | 108 | *Yes* | 57.1 | 43.0 | 149 |
| Total (N) | 1,331 | 149 | 1,348 | 132 | 1,480 | Total (N) | 1,348 | 132 | 1,480 |
| % | 89.9 | 10.1 | 91.1 | 8.9 | 100 | % | 91.1 | 8.9 | 100 |

## Central Region Results

**Table A2: Central Region Random Effect Probit Models for Renting-in Land (Average Partial Effects – [E(y|X)])**

| | Parsimonious Random Effects (RE) models | | Random Effects (RE) models with controls variables | | |
|---|---|---|---|---|---|
| **VARIABLES** | **RE** | **Dynamic RE (DRE)** | **RE** | **Correlated Random Effects (CRE)** | **Dynamic RE (DRE)** |
| **One-year lag rainfall variables** | | | | | |
| Positive deviation (dm) one-year lag | 0.00 | -0.01 | 0.00 | 0.00 | 0.00 |
| (early plus mid-season) | (0.01) | (0.02) | (0.01) | (0.01) | (0.02) |
| Absolute Negative deviation (dm) one-year lag | 0.04** | 0.05** | 0.04** | 0.04** | 0.04* |
| (early plus mid-season) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) |
| **Two-year lag rainfall variables** | | | | | |
| Positive deviation (dm) two-year lag | -0.01 | -0.03 | -0.01 | -0.01 | -0.02 |
| (Early plus mid-season) | (0.01) | (0.02) | (0.01) | (0.01) | (0.02) |

| | | | | | |
|---|---|---|---|---|---|
| Absolute Negative deviation (dm) two-year lag | 0.03** | 0.03*** | 0.03** | 0.03** | 0.03** |
| (Early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| **Lag rental participation dummies** | | | | | |
| Initial year (2010) rent-in dummy | | 0.08 | | | 0.08 |
| | | (0.07) | | | (0.08) |
| Lag rent-in dummy | | 0.17* | | | 0.14 |
| (previous survey round) | | (0.09) | | | (0.09) |
| **Farm and Household Characteristics** | | | | | |
| **Observed control variables** | | | | | |
| Own farmland (ha) | | | -0.01 | | -0.01 |
| | | | (0.03) | | (0.03) |
| Own farmland to labour ratio | | | -0.36*** | | -0.26** |
| (ha/adult equiv. labour unit) | | | (0.12) | | (0.13) |
| Share of male labour | | | -0.02 | | 0.01 |
| | | | (0.05) | | (0.05) |
| Sex of HH head (1=Female) | | | -0.02 | | -0.01 |
| | | | (0.03) | | (0.03) |
| Age of HH head (years) | | | -0.00* | | -0.00** |
| | | | (0.00) | | (0.00) |
| Education of HH head (years) | | | 0.00 | | -0.00 |
| | | | (0.00) | | (0.00) |
| Household size to labour ratio | | | 0.01 | | 0.02 |
| (No. of persons/adult equiv. labour unit) | | | (0.02) | | (0.02) |
| Total Livestock Units (TLU) to labour ratio | | | 0.05** | | 0.06*** |
| | | | (0.02) | | (0.02) |
| One-year lag TLU to labour ratio | | | 0.01 | | 0.01 |

| | | | |
|---|---|---|---|
| (lag TLU No./ adult equiv. labour unit) | (0.03) | | (0.03) |
| Capital asset index to labour ratio | 0.01 | | 0.01 |
| | (0.03) | | (0.03) |
| Distance to the urban center (km) | 0.00**** | | 0.00**** |
| | (0.00) | | (0.00) |
| **Mean of observed control variables** | | | |
| Own farmland (ha) | | -0.01 | |
| | | (0.04) | |
| Own farmland to labour ratio | | -0.34*** | |
| (ha/adult equiv. labour unit) | | (0.12) | |
| Share of male labour | | -0.06 | |
| | | (0.08) | |
| Sex of HH head (1=Female) | | -0.04 | |
| | | (0.04) | |
| Age of HH head (years) | | -0.00 | |
| | | (0.00) | |
| Education of HH head (years) | | 0.01* | |
| | | (0.00) | |
| Household size to labour ratio | | 0.00 | |
| (No. of persons/adult equiv. labour unit) | | (0.03) | |
| Total Livestock Units (TLU) to labour ratio | | 0.13**** | |
| | | (0.04) | |
| One-year lag TLU to labour ratio | | 0.03 | |
| (lag TLU No./ adult equiv. labour unit) | | (0.08) | |
| Capital asset index to labour ratio | | -0.01 | |
| | | (0.04) | |

| | |
|---|---|
| Distance to the urban center (km) | 0.00**** |
| | (0.00) |
| **Deviations from the mean** | |
| Own farmland (ha) | -0.03 |
| | (0.05) |
| Own farmland to labour ratio | -0.37** |
| (ha/adult equiv. labour unit) | (0.15) |
| Share of male labour | 0.01 |
| | (0.07) |
| Sex of HH head (1=Female) | -0.01 |
| | (0.04) |
| Age of HH head (years) | -0.00 |
| | (0.00) |
| Education of HH head (years) | 0.00 |
| | (0.00) |
| Household size to labour ratio | 0.01 |
| (No. of persons/adult equiv. labour unit) | (0.03) |
| Total Livestock Units (TLU) to labour ratio | 0.02 |
| | (0.02) |
| One-year lag TLU to labour ratio | -0.01 |
| (lag TLU No./ adult equiv. labour unit) | (0.04) |
| Capital asset index to labour ratio | -0.00 |
| | (0.04) |
| Distance to the urban center (km) | 0.00** |
| | (0.00) |
| **Year dummies** | |

| | | | | | |
|---|---|---|---|---|---|
| 2013.year | -0.01 | | -0.01 | -0.01 | |
| | (0.03) | | (0.03) | (0.03) | |
| 2016.year | -0.06*** | -0.06** | -0.04** | -0.04* | -0.04 |
| | (0.02) | (0.03) | (0.02) | (0.02) | (0.03) |
| N | 1,830 | 1,220 | 1,830 | 1,830 | 1,220 |

Note: The asterisks represent **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1. Cluster robust standard errors in parenthesis.

**Table A3: Central Region Random Effect Tobit Models for Renting-in Land (Average Partial Effects – $[E(y|X, y > 0)]$)**

| | Parsimonious Random Effects (RE) models | | Random Effects (RE) models with controls variables | | |
|---|---|---|---|---|---|
| **VARIABLES** | **RE** | **Dynamic RE (DRE)** | **RE** | **Correlated Random Effects (CRE)** | **Dynamic RE (DRE)** |
| **One-year lag rainfall variables** | | | | | |
| Positive deviation (dm) one-year lag | 0.00 | -0.01 | 0.00 | 0.00 | -0.00 |
| (early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| Absolute Negative deviation (dm) one-year lag | 0.02** | 0.02 | 0.02* | 0.02* | 0.01 |
| (early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| **Two-year lag rainfall variables** | | | | | |
| Positive deviation (dm) two-year lag | -0.01 | -0.02 | -0.01 | -0.01 | -0.01 |
| (Early plus mid-season) | (0.01) | (0.02) | (0.01) | (0.01) | (0.02) |
| Absolute Negative deviation (dm) two-year lag | 0.02* | 0.02** | 0.02** | 0.02** | 0.02* |
| (Early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| **Lag rental participation dummies** | | | | | |
| Initial year (2010) rent-in dummy | | 0.03 | | | 0.02 |
| | | (0.04) | | | (0.04) |

| | | | |
|---|---|---|---|
| Lag rent-in dummy | 0.05 | | 0.04 |
| (previous survey round) | (0.04) | | (0.04) |
| Initial year (2010) rent-in land (ha) | 0.12* | | 0.12* |
| | (0.07) | | (0.06) |
| Lag total rent-in land (ha) | 0.07 | | 0.05 |
| (previous survey round) | (0.06) | | (0.05) |
| **Farm and Household Characteristics** | | | |
| **Observed control variables** | | | |
| Own farmland (ha) | | -0.00 | 0.00 |
| | | (0.02) | (0.02) |
| Own farmland to labour ratio | | -0.27**** | -0.20*** |
| (ha/adult equiv. labour unit) | | (0.07) | (0.07) |
| Share of male labour | | 0.00 | 0.03 |
| | | (0.03) | (0.04) |
| Sex of HH head (1=Female) | | -0.02 | -0.01 |
| | | (0.02) | (0.02) |
| Age of HH head (years) | | -0.00 | -0.00 |
| | | (0.00) | (0.00) |
| Education of HH head (years) | | 0.00* | 0.00 |
| | | (0.00) | (0.00) |
| Household size to labour ratio | | 0.01 | 0.02 |
| (No. of persons/adult equiv. labour unit) | | (0.02) | (0.01) |
| Total Livestock Units (TLU) to labour ratio | | 0.04*** | 0.04*** |
| | | (0.01) | (0.02) |
| One-year lag TLU to labour ratio | | 0.01 | 0.01 |
| (lag TLU No./ adult equiv. labour unit) | | (0.03) | (0.03) |

| | | | |
|---|---|---|---|
| Capital asset index to labour ratio | 0.01 | | 0.01 |
| | (0.02) | | (0.02) |
| Distance to the urban center (km) | 0.00**** | | 0.00**** |
| | (0.00) | | (0.00) |
| **Mean of observed control variables** | | | |
| Own farmland (ha) | | 0.00 | |
| | | (0.03) | |
| Own farmland to labour ratio | | -0.26**** | |
| (ha/adult equiv. labour unit) | | (0.08) | |
| Share of male labour | | -0.02 | |
| | | (0.06) | |
| Sex of HH head (1=Female) | | -0.03 | |
| | | (0.03) | |
| Age of HH head (years) | | -0.00 | |
| | | (0.00) | |
| Education of HH head (years) | | 0.01** | |
| | | (0.00) | |
| Household size to labour ratio | | 0.01 | |
| (No. of persons/adult equiv. labour unit) | | (0.03) | |
| Total Livestock Units (TLU) to labour ratio | | 0.09*** | |
| | | (0.03) | |
| One-year lag TLU to labour ratio | | 0.03 | |
| (lag TLU No./ adult equiv. labour unit) | | (0.05) | |
| Capital asset index to labour ratio | | -0.00 | |
| | | (0.03) | |
| Distance to the urban center (km) | | 0.00**** | |

| | | | |
|---|---|---|---|
| | | | (0.00) |
| **Deviations from the mean** | | | |
| Own farmland (ha) | | | -0.02 |
| | | | (0.03) |
| Own farmland to labour ratio | | | -0.27*** |
| (ha/adult equiv. labour unit) | | | (0.09) |
| Share of male labour | | | 0.02 |
| | | | (0.04) |
| Sex of HH head (1=Female) | | | -0.01 |
| | | | (0.03) |
| Age of HH head (years) | | | -0.00 |
| | | | (0.00) |
| Education of HH head (years) | | | -0.00 |
| | | | (0.00) |
| Household size to labour ratio | | | 0.01 |
| (No. of persons/adult equiv. labour unit) | | | (0.02) |
| Total Livestock Units (TLU) to labour ratio | | | 0.02 |
| | | | (0.02) |
| One-year lag TLU to labour ratio | | | -0.01 |
| (lag TLU No./ adult equiv. labour unit) | | | (0.03) |
| Capital asset index to labour ratio | | | 0.01 |
| | | | (0.03) |
| Distance to the urban center (km) | | | 0.00** |
| | | | (0.00) |
| **Year dummies** | | | |
| 2013.year | -0.00 | -0.01 | -0.01 |

| | | | | | |
|---|---|---|---|---|---|
| | (0.02) | | (0.02) | (0.02) | |
| 2016.year | -0.03** | -0.03* | -0.02 | -0.01 | -0.02 |
| | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) |
| N | 1,830 | 1,220 | 1,830 | 1,830 | 1,220 |

Note: The table presents conditional margins for those participating in the market (y>0). The asterisks represent **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1. Normal standard errors in parenthesis.

### Table A4: Central Region Random Effect Probit Models for Renting-in Land (Coefficients)

| | Parsimonious Random Effects (RE) models | | Random Effects (RE) models with controls variables | | |
|---|---|---|---|---|---|
| **VARIABLES** | **RE** | **Dynamic RE (DRE)** | **RE** | **Correlated Random Effects (CRE)** | **Dynamic RE (DRE)** |
| **One-year lag rainfall variables** | | | | | |
| Positive deviation (dm) one-year lag | 0.00 | -0.04 | 0.01 | 0.00 | 0.02 |
| (early plus mid-season) | (0.08) | (0.09) | (0.08) | (0.08) | (0.09) |
| Absolute Negative deviation (dm) one-year lag | 0.28** | 0.26** | 0.27** | 0.26** | 0.22* |
| (early plus mid-season) | (0.11) | (0.11) | (0.11) | (0.11) | (0.12) |
| **Two-year lag rainfall variables** | | | | | |
| Positive deviation (dm) two-year lag | -0.04 | -0.14 | -0.07 | -0.06 | -0.10 |
| (Early plus mid-season) | (0.08) | (0.13) | (0.09) | (0.09) | (0.15) |
| Absolute Negative deviation (dm) two-year lag | 0.20** | 0.19*** | 0.23** | 0.24** | 0.20** |
| (Early plus mid-season) | (0.09) | (0.07) | (0.10) | (0.10) | (0.08) |
| **Lag rental participation dummies** | | | | | |
| Initial year (2010) rent-in dummy | | 0.45 | | | 0.49 |
| | | (0.43) | | | (0.52) |

| | | | |
|---|---|---|---|
| Lag rent-in dummy | 0.91** | | 0.79* |
| (previous survey round) | (0.36) | | (0.42) |
| **Farm and Household Characteristics** | | | |
| **Observed control variables** | | | |
| Own farmland (ha) | | -0.10 | -0.05 |
| | | (0.24) | (0.19) |
| Own farmland to labour ratio | | -2.58*** | -1.51* |
| (ha/adult equiv. labour unit) | | (0.91) | (0.82) |
| Share of male labour | | -0.11 | 0.07 |
| | | (0.37) | (0.31) |
| Sex of HH head (1=Female) | | -0.18 | -0.09 |
| | | (0.18) | (0.16) |
| Age of HH head (years) | | -0.01* | -0.01* |
| | | (0.01) | (0.00) |
| Education of HH head (years) | | 0.03 | -0.00 |
| | | (0.02) | (0.01) |
| Household size to labour ratio | | 0.06 | 0.09 |
| (No. of persons/adult equiv. labour unit) | | (0.17) | (0.11) |
| Total Livestock Units (TLU) to labour ratio | | 0.34** | 0.33** |
| | | (0.15) | (0.13) |
| One-year lag TLU to labour ratio | | 0.06 | 0.03 |
| (lag TLU No./ adult equiv. labour unit) | | (0.24) | (0.20) |
| Capital asset index to labour ratio | | 0.05 | 0.09 |
| | | (0.19) | (0.18) |
| Distance to the urban center (km) | | 0.02**** | 0.01*** |
| | | (0.00) | (0.01) |

| | |
|---|---|
| **Mean of observed control variables** | |
| Own farmland (ha) | -0.10 |
| | (0.26) |
| Own farmland to labour ratio | -2.50*** |
| (ha/adult equiv. labour unit) | (0.93) |
| Share of male labour | -0.44 |
| | (0.58) |
| Sex of HH head (1=Female) | -0.32 |
| | (0.27) |
| Age of HH head (years) | -0.01 |
| | (0.01) |
| Education of HH head (years) | 0.04* |
| | (0.02) |
| Household size to labour ratio | 0.01 |
| (No. of persons/adult equiv. labour unit) | (0.25) |
| Total Livestock Units (TLU) to labour ratio | 0.96**** |
| | (0.28) |
| One-year lag TLU to labour ratio | 0.19 |
| (lag TLU No./ adult equiv. labour unit) | (0.57) |
| Capital asset index to labour ratio | -0.08 |
| | (0.27) |
| Distance to the urban center (km) | 0.02**** |
| | (0.01) |
| **Deviations from the mean** | |
| Own farmland (ha) | -0.23 |
| | (0.36) |

| | | | | | |
|---|---|---|---|---|---|
| Own farmland to labour ratio | | | | -2.75** | |
| (ha/adult equiv. labour unit) | | | | (1.12) | |
| Share of male labour | | | | 0.07 | |
| | | | | (0.49) | |
| Sex of HH head (1=Female) | | | | -0.08 | |
| | | | | (0.27) | |
| Age of HH head (years) | | | | -0.01 | |
| | | | | (0.01) | |
| Education of HH head (years) | | | | 0.01 | |
| | | | | (0.03) | |
| Household size to labour ratio | | | | 0.10 | |
| (No. of persons/adult equiv. labour unit) | | | | (0.19) | |
| Total Livestock Units (TLU) to labour ratio | | | | 0.12 | |
| | | | | (0.12) | |
| One-year lag TLU to labour ratio | | | | -0.08 | |
| (lag TLU No./ adult equiv. labour unit) | | | | (0.27) | |
| Capital asset index to labour ratio | | | | -0.04 | |
| | | | | (0.30) | |
| Distance to the urban center (km) | | | | 0.02** | |
| | | | | (0.01) | |
| **Year dummies** | | | | | |
| 2013.year | -0.05 | | -0.09 | -0.07 | |
| | (0.18) | | (0.19) | (0.19) | |
| 2016.year | -0.42*** | -0.33** | -0.33** | -0.29* | -0.24 |
| | (0.15) | (0.15) | (0.16) | (0.17) | (0.15) |
| Constant | -1.83**** | -1.61**** | -1.81**** | -1.73** | -1.66**** |

| | | | | | |
|---|---|---|---|---|---|
| | (0.18) | (0.24) | (0.55) | (0.82) | (0.47) |
| lnsig2u | 0.21 | -2.58 | 0.13 | 0.12 | -1.85 |
| | (0.21) | (4.26) | (0.23) | (0.23) | (2.75) |
| Observations | 1,830 | 1,220 | 1,830 | 1,830 | 1,220 |
| Number of y3_hhid | 610 | 610 | 610 | 610 | 610 |

Note: The asterisks represent **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1. Cluster robust standard errors in parenthesis.

**Table A5: Central Region Random Effect Tobit Models for Renting-in Land (Coefficients)**

| | Parsimonious Random Effects (RE) models | | Random Effects (RE) models with controls variables | | |
|---|---|---|---|---|---|
| **VARIABLES** | **RE** | **Dynamic RE (DRE)** | **RE** | **Correlated Random Effects (CRE)** | **Dynamic RE (DRE)** |
| **One-year lag rainfall variables** | | | | | |
| Positive deviation (dm) one-year lag | 0.00 | -0.07 | 0.01 | 0.01 | -0.01 |
| (early plus mid-season) | (0.05) | (0.07) | (0.05) | (0.05) | (0.07) |
| Absolute Negative deviation (dm) one-year lag | 0.13** | 0.10 | 0.11* | 0.10* | 0.05 |
| (early plus mid-season) | (0.06) | (0.08) | (0.06) | (0.06) | (0.08) |
| **Two-year lag rainfall variables** | | | | | |
| Positive deviation (dm) two-year lag | -0.03 | -0.09 | -0.05 | -0.05 | -0.05 |
| (Early plus mid-season) | (0.05) | (0.09) | (0.05) | (0.05) | (0.09) |
| Absolute Negative deviation (dm) two-year lag | 0.10* | 0.12** | 0.11** | 0.11** | 0.11* |
| (Early plus mid-season) | (0.05) | (0.05) | (0.05) | (0.05) | (0.06) |
| **Lag rental participation dummies** | | | | | |
| Initial year (2010) rent-in dummy | | 0.15 | | | 0.12 |
| | | (0.22) | | | (0.21) |

| | | | |
|---|---|---|---|
| Lag rent-in dummy | 0.30 | | 0.24 |
| (previous survey round) | (0.23) | | (0.21) |
| Initial year (2010) rent-in land (ha) | 0.68* | | 0.70* |
| | (0.39) | | (0.37) |
| Lag total rent-in land (ha) | 0.39 | | 0.26 |
| (previous survey round) | (0.32) | | (0.29) |
| **Farm and Household Characteristics** | | | |
| **Observed control variables** | | | |
| Own farmland (ha) | | -0.01 | 0.02 |
| | | (0.12) | (0.12) |
| Own farmland to labour ratio | | -1.52**** | -1.17*** |
| (ha/adult equiv. labour unit) | | (0.41) | (0.42) |
| Share of male labour | | 0.03 | 0.15 |
| | | (0.20) | (0.23) |
| Sex of HH head (1=Female) | | -0.10 | -0.06 |
| | | (0.11) | (0.11) |
| Age of HH head (years) | | -0.00 | -0.00 |
| | | (0.00) | (0.00) |
| Education of HH head (years) | | 0.02* | 0.01 |
| | | (0.01) | (0.01) |
| Household size to labour ratio | | 0.06 | 0.10 |
| (No. of persons/adult equiv. labour unit) | | (0.09) | (0.08) |
| Total Livestock Units (TLU) to labour ratio | | 0.22*** | 0.24*** |
| | | (0.08) | (0.09) |
| One-year lag TLU to labour ratio | | 0.04 | 0.05 |
| (lag TLU No./ adult equiv. labour unit) | | (0.15) | (0.16) |

| | | | |
|---|---|---|---|
| Capital asset index to labour ratio | 0.07 | | 0.06 |
| | (0.11) | | (0.14) |
| Distance to the urban center (km) | 0.01**** | | 0.01**** |
| | (0.00) | | (0.00) |
| **Mean of observed control variables** | | | |
| Own farmland (ha) | | 0.01 | |
| | | (0.14) | |
| Own farmland to labour ratio | | -1.48**** | |
| (ha/adult equiv. labour unit) | | (0.45) | |
| Share of male labour | | -0.13 | |
| | | (0.32) | |
| Sex of HH head (1=Female) | | -0.17 | |
| | | (0.14) | |
| Age of HH head (years) | | -0.00 | |
| | | (0.00) | |
| Education of HH head (years) | | 0.03** | |
| | | (0.01) | |
| Household size to labour ratio | | 0.05 | |
| (No. of persons/adult equiv. labour unit) | | (0.16) | |
| Total Livestock Units (TLU) to labour ratio | | 0.52*** | |
| | | (0.16) | |
| One-year lag TLU to labour ratio | | 0.16 | |
| (lag TLU No./ adult equiv. labour unit) | | (0.30) | |
| Capital asset index to labour ratio | | -0.02 | |
| | | (0.17) | |
| Distance to the urban center (km) | | 0.01**** | |

| | | | |
|---|---|---|---|
| | | | (0.00) |
| **Deviations of the mean** | | | |
| Own farmland (ha) | | | -0.09 |
| | | | (0.17) |
| Own farmland to labour ratio | | | -1.55*** |
| (ha/adult equiv. labour unit) | | | (0.52) |
| Share of male labour | | | 0.12 |
| | | | (0.25) |
| Sex of HH head (1=Female) | | | -0.09 |
| | | | (0.18) |
| Age of HH head (years) | | | -0.01 |
| | | | (0.01) |
| Education of HH head (years) | | | -0.00 |
| | | | (0.01) |
| Household size to labour ratio | | | 0.08 |
| (No. of persons/adult equiv. labour unit) | | | (0.10) |
| Total Livestock Units (TLU) to labour ratio | | | 0.10 |
| | | | (0.09) |
| One-year lag TLU to labour ratio | | | -0.04 |
| (lag TLU No./ adult equiv. labour unit) | | | (0.16) |
| Capital asset index to labour ratio | | | 0.05 |
| | | | (0.16) |
| Distance to the urban center (km) | | | 0.01** |
| | | | (0.01) |
| **Year dummies** | | | |
| 2013.year | -0.02 | -0.04 | -0.03 |

| | | | | | |
|---|---|---|---|---|---|
| | (0.10) | | (0.10) | (0.10) | |
| 2016.year | -0.18** | -0.19* | -0.11 | -0.08 | -0.09 |
| | (0.09) | (0.10) | (0.09) | (0.10) | (0.10) |
| Constant | -1.09**** | -1.13**** | -1.21**** | -1.25** | -1.33**** |
| | (0.11) | (0.14) | (0.30) | (0.49) | (0.33) |
| sigma_u | 0.68**** | 0.36* | 0.61**** | 0.60**** | 0.39** |
| | (0.06) | (0.21) | (0.05) | (0.05) | (0.18) |
| sigma_e | 0.60**** | 0.72**** | 0.58**** | 0.57**** | 0.66**** |
| | (0.04) | (0.10) | (0.04) | (0.03) | (0.09) |
| Observations | 1,830 | 1,220 | 1,830 | 1,830 | 1,220 |
| Left Censored (_n) | 1,583 | 1,048 | 1,583 | 1,583 | 1,048 |
| Uncensored (_n) | 247 | 172 | 247 | 247 | 172 |
| Number of y3_hhid | 610 | 610 | 610 | 610 | 610 |

Note: The asterisks represent **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1. Normal standard errors in parenthesis.

## Southern Region Results

### Table A6: Southern Region Random Effect Probit Models for Renting-in Land (Average Partial Effects – [E(y|X)])

| | Parsimonious Random Effects (RE) models | | Random Effects (RE) models with controls variables | | |
|---|---|---|---|---|---|
| **VARIABLES** | **RE** | **Dynamic RE (DRE)** | **RE** | **Correlated Random Effects (CRE)** | **Dynamic RE (DRE)** |
| **One-year lag rainfall variables** | | | | | |
| Positive deviation (dm) one-year lag | -0.00 | -0.01 | -0.00 | -0.00 | -0.01 |
| (early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.00) | (0.01) |
| Absolute Negative deviation (dm) one-year lag | -0.00 | -0.00 | -0.00 | -0.00 | -0.00 |

| | | | | | |
|---|---|---|---|---|---|
| (early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| **Two-year lag rainfall variables** | | | | | |
| Positive deviation (dm) two-year lag | -0.00 | -0.01 | -0.01 | -0.01 | -0.01 |
| (Early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| Absolute Negative deviation (dm) two-year lag | -0.02** | -0.02* | -0.03*** | -0.03*** | -0.02** |
| (Early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| **Lag rental participation dummies** | | | | | |
| Initial year (2010) rent-in dummy | | 0.15*** | | | 0.09 |
| | | (0.05) | | | (0.06) |
| Lag rent-in dummy | | 0.06 | | | 0.10 |
| (previous survey round) | | (0.06) | | | (0.07) |
| **Farm and Household Characteristics** | | | | | |
| **Observed control variables** | | | | | |
| Own farmland (ha) | | | -0.07** | | -0.06* |
| | | | (0.03) | | (0.03) |
| Own farmland to labour ratio | | | 0.01 | | -0.01 |
| (ha/adult equiv. labour unit) | | | (0.09) | | (0.10) |
| Share of male labour | | | -0.04 | | 0.02 |
| | | | (0.03) | | (0.04) |
| Sex of HH head (1=Female) | | | -0.05*** | | -0.07*** |
| | | | (0.02) | | (0.02) |
| Age of HH head (years) | | | -0.00 | | -0.00 |
| | | | (0.00) | | (0.00) |
| Education of HH head (years) | | | -0.00 | | -0.00 |
| | | | (0.00) | | (0.00) |
| Household size to labour ratio | | | 0.02 | | 0.03** |

| | | | |
|---|---|---|---|
| (No. of persons/adult equiv. labour unit) | (0.01) | | (0.02) |
| Total Livestock Units (TLU) to labour ratio | -0.00 | | -0.01 |
| | (0.00) | | (0.01) |
| One-year lag TLU to labour ratio | 0.00 | | 0.00 |
| (lag TLU No./ adult equiv. labour unit) | (0.00) | | (0.00) |
| Capital asset index to labour ratio | 0.03* | | 0.03 |
| | (0.02) | | (0.02) |
| Distance to the urban center (km) | 0.00*** | | 0.00*** |
| | (0.00) | | (0.00) |
| **Mean of observed control variables** | | | |
| Own farmland (ha) | | -0.07* | |
| | | (0.04) | |
| Own farmland to labour ratio | | -0.01 | |
| (ha/adult equiv. labour unit) | | (0.11) | |
| Share of male labour | | -0.15** | |
| | | (0.06) | |
| Sex of HH head (1=Female) | | -0.10**** | |
| | | (0.03) | |
| Age of HH head (years) | | -0.00 | |
| | | (0.00) | |
| Education of HH head (years) | | 0.00 | |
| | | (0.00) | |
| Household size to labour ratio | | -0.01 | |
| (No. of persons/adult equiv. labour unit) | | (0.03) | |
| Total Livestock Units (TLU) to labour ratio | | -0.01 | |
| | | (0.00) | |

| | |
|---|---|
| One-year lag TLU to labour ratio | -0.00 |
| (lag TLU No./ adult equiv. labour unit) | (0.01) |
| Capital asset index to labour ratio | 0.02 |
| | (0.02) |
| Distance to the urban center (km) | 0.00*** |
| | (0.00) |
| **Deviations from the mean** | |
| Own farmland (ha) | -0.09** |
| | (0.04) |
| Own farmland to labour ratio | 0.04 |
| (ha/adult equiv. labour unit) | (0.10) |
| Share of male labour | 0.01 |
| | (0.04) |
| Sex of HH head (1=Female) | -0.01 |
| | (0.02) |
| Age of HH head (years) | 0.00 |
| | (0.00) |
| Education of HH head (years) | -0.00 |
| | (0.00) |
| Household size to labour ratio | 0.02 |
| (No. of persons/adult equiv. labour unit) | (0.02) |
| Total Livestock Units (TLU) to labour ratio | -0.00 |
| | (0.01) |
| One-year lag TLU to labour ratio | 0.00 |
| (lag TLU No./ adult equiv. labour unit) | (0.00) |
| Capital asset index to labour ratio | 0.04 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | (0.03) | |
| Distance to the urban center (km) | | | | 0.00 | |
| | | | | (0.00) | |
| **Year dummies** | | | | | |
| 2013.year | 0.05*** | | 0.05*** | 0.05*** | |
| | (0.02) | | (0.02) | (0.02) | |
| 2016.year | 0.04** | 0.00 | 0.05*** | 0.05** | 0.00 |
| | (0.02) | (0.03) | (0.02) | (0.02) | (0.03) |
| N | 2085 | 1390 | 2085 | 2085 | 1390 |

Note: The asterisks represent **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1. Cluster robust standard errors in parenthesis.

### Table A7: Southern Region Random Effect Tobit Models for Renting-in Land (Average Partial Effects – [$E(y|X, y > 0)$])

| | **Parsimonious Random Effects (RE) models** | | **Random Effects (RE) models with controls variables** | | |
|---|---|---|---|---|---|
| **VARIABLES** | **RE** | **Dynamic RE (DRE)** | **RE** | **Correlated Random Effects (CRE)** | **Dynamic RE (DRE)** |
| **One-year lag rainfall variables** | | | | | |
| Positive deviation (dm) one-year lag | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 |
| (early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| Absolute Negative deviation (dm) one-year lag | 0.00 | -0.00 | 0.00 | 0.00 | -0.00 |
| (early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| **Two-year lag rainfall variables** | | | | | |
| Positive deviation (dm) two-year lag | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 |
| (Early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| Absolute Negative deviation (dm) two-year lag | -0.02* | -0.02 | -0.03** | -0.03** | -0.02* |

| | | | | | |
|---|---|---|---|---|---|
| (Early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| **Lag rental participation dummies** | | | | | |
| Initial year (2010) rent-in dummy | | 0.10** | | | 0.05 |
| | | (0.05) | | | (0.03) |
| Lag rent-in dummy | | 0.07 | | | 0.10**** |
| (previous survey round) | | (0.05) | | | (0.03) |
| Initial year (2010) rent-in land (ha) | | 0.02 | | | -0.04 |
| | | (0.08) | | | (0.06) |
| Lag total rent-in land (ha) | | 0.08 | | | 0.12*** |
| (previous survey round) | | (0.06) | | | (0.04) |
| **Farm and Household Characteristics** | | | | | |
| **Observed control variables** | | | | | |
| Own farmland (ha) | | | -0.08** | | -0.05* |
| | | | (0.03) | | (0.03) |
| Own farmland to labour ratio | | | -0.00 | | 0.01 |
| (ha/adult equiv. labour unit) | | | (0.09) | | (0.07) |
| Share of male labour | | | -0.07 | | 0.01 |
| | | | (0.04) | | (0.04) |
| Sex of HH head (1=Female) | | | -0.08**** | | -0.08**** |
| | | | (0.02) | | (0.02) |
| Age of HH head (years) | | | -0.00 | | -0.00 |
| | | | (0.00) | | (0.00) |
| Education of HH head (years) | | | -0.00 | | -0.00 |
| | | | (0.00) | | (0.00) |
| Household size to labour ratio | | | 0.02 | | 0.04** |
| (No. of persons/adult equiv. labour unit) | | | (0.02) | | (0.02) |

| | | | |
|---|---|---|---|
| Total Livestock Units (TLU) to labour ratio | -0.00 | | -0.01 |
| | (0.01) | | (0.02) |
| One-year lag TLU to labour ratio | 0.00 | | 0.00 |
| (lag TLU No./ adult equiv. labour unit) | (0.01) | | (0.01) |
| Capital asset index to labour ratio | 0.04* | | 0.03 |
| | (0.02) | | (0.02) |
| Distance to the urban center (km) | 0.00*** | | 0.00*** |
| | (0.00) | | (0.00) |
| **Mean of observed control variables** | | | |
| Own farmland (ha) | | -0.08* | |
| | | (0.04) | |
| Own farmland to labour ratio | | -0.01 | |
| (ha/adult equiv. labour unit) | | (0.11) | |
| Share of male labour | | -0.19** | |
| | | (0.08) | |
| Sex of HH head (1=Female) | | -0.14**** | |
| | | (0.04) | |
| Age of HH head (years) | | -0.00 | |
| | | (0.00) | |
| Education of HH head (years) | | 0.00 | |
| | | (0.00) | |
| Household size to labour ratio | | -0.02 | |
| (No. of persons/adult equiv. labour unit) | | (0.03) | |
| Total Livestock Units (TLU) to labour ratio | | -0.01 | |
| | | (0.02) | |
| One-year lag TLU to labour ratio | | -0.00 | |

| | |
|---|---|
| (lag TLU No./ adult equiv. labour unit) | (0.02) |
| Capital asset index to labour ratio | 0.02 |
| | (0.04) |
| Distance to the urban center (km) | 0.00*** |
| | (0.00) |
| **Deviations from the mean** | |
| Own farmland (ha) | -0.09** |
| | (0.04) |
| Own farmland to labour ratio | 0.02 |
| (ha/adult equiv. labour unit) | (0.11) |
| Share of male labour | -0.02 |
| | (0.05) |
| Sex of HH head (1=Female) | -0.03 |
| | (0.03) |
| Age of HH head (years) | 0.00 |
| | (0.00) |
| Education of HH head (years) | -0.00 |
| | (0.00) |
| Household size to labour ratio | 0.02 |
| (No. of persons/adult equiv. labour unit) | (0.02) |
| Total Livestock Units (TLU) to labour ratio | 0.00 |
| | (0.02) |
| One-year lag TLU to labour ratio | 0.00 |
| (lag TLU No./ adult equiv. labour unit) | (0.01) |
| Capital asset index to labour ratio | 0.06 |
| | (0.04) |

| | | | | | |
|---|---|---|---|---|---|
| Distance to the urban center (km) | | | | -0.00 | |
| | | | | (0.00) | |
| **Year dummies** | | | | | |
| 2013.year | 0.06** | | 0.05** | 0.05** | |
| | (0.03) | | (0.03) | (0.03) | |
| 2016.year | 0.06** | 0.00 | 0.07*** | 0.06** | 0.00 |
| | (0.02) | (0.04) | (0.02) | (0.03) | (0.03) |
| N | 2085 | 1390 | 2085 | 2085 | 1390 |

Note: The table presents conditional margins for those participating in the market (y>0). The asterisks represent **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1. Normal standard errors in parenthesis.

## Table A8: Southern Region Random Effect Probit Models for Renting-in Land (Coefficients)

| | Parsimonious Random Effects (RE) models | | Random Effects (RE) models with controls variables | | |
|---|---|---|---|---|---|
| **VARIABLES** | **RE** | **Dynamic RE (DRE)** | **RE** | **Correlated Random Effects (CRE)** | **Dynamic RE (DRE)** |
| **One-year lag rainfall variables** | | | | | |
| Positive deviation (dm) one-year lag | -0.02 | -0.06 | -0.04 | -0.03 | -0.07 |
| (early plus mid-season) | (0.08) | (0.09) | (0.08) | (0.08) | (0.09) |
| Absolute Negative deviation (dm) one-year lag | -0.00 | -0.06 | -0.01 | -0.01 | -0.03 |
| (early plus mid-season) | (0.11) | (0.12) | (0.11) | (0.11) | (0.10) |
| **Two-year lag rainfall variables** | | | | | |
| Positive deviation (dm) two-year lag | -0.06 | -0.13 | -0.14 | -0.14 | -0.15 |
| (Early plus mid-season) | (0.11) | (0.13) | (0.12) | (0.12) | (0.14) |
| Absolute Negative deviation (dm) two-year lag | -0.30** | -0.21* | -0.43*** | -0.45*** | -0.26** |

| | | | | | |
|---|---|---|---|---|---|
| (Early plus mid-season) | (0.12) | (0.12) | (0.14) | (0.14) | (0.13) |
| **Lag rental participation dummies** | | | | | |
| Initial year (2010) rent-in dummy | | 1.87* | | | 1.09 |
| | | (1.03) | | | (1.00) |
| Lag rent-in dummy | | 0.69 | | | 1.19* |
| (previous survey round) | | (0.61) | | | (0.61) |
| **Farm and Household Characteristics** | | | | | |
| **Observed control variables** | | | | | |
| Own farmland (ha) | | | -1.24** | | -0.66 |
| | | | (0.54) | | (0.44) |
| Own farmland to labour ratio | | | 0.15 | | -0.12 |
| (ha/adult equiv. labour unit) | | | (1.58) | | (1.19) |
| Share of male labour | | | -0.61 | | 0.27 |
| | | | (0.57) | | (0.48) |
| Sex of HH head (1=Female) | | | -0.83*** | | -0.78*** |
| | | | (0.26) | | (0.29) |
| Age of HH head (years) | | | -0.00 | | -0.00 |
| | | | (0.01) | | (0.01) |
| Education of HH head (years) | | | -0.00 | | -0.01 |
| | | | (0.03) | | (0.02) |
| Household size to labour ratio | | | 0.27 | | 0.41* |
| (No. of persons/adult equiv. labour unit) | | | (0.23) | | (0.21) |
| Total Livestock Units (TLU) to labour ratio | | | -0.04 | | -0.07 |
| | | | (0.05) | | (0.08) |
| One-year lag TLU to labour ratio | | | 0.01 | | 0.01 |
| (lag TLU No./ adult equiv. labour unit) | | | (0.04) | | (0.03) |

| | | | |
|---|---|---|---|
| Capital asset index to labour ratio | 0.55* | | 0.38 |
| | (0.30) | | (0.26) |
| Distance to the urban center (km) | 0.02*** | | 0.01** |
| | (0.01) | | (0.01) |
| **Mean of observed control variables** | | | |
| Own farmland (ha) | | -1.11* | |
| | | (0.66) | |
| Own farmland to labour ratio | | -0.23 | |
| (ha/adult equiv. labour unit) | | (1.83) | |
| Share of male labour | | -2.50** | |
| | | (0.99) | |
| Sex of HH head (1=Female) | | -1.71**** | |
| | | (0.49) | |
| Age of HH head (years) | | -0.01 | |
| | | (0.01) | |
| Education of HH head (years) | | 0.01 | |
| | | (0.04) | |
| Household size to labour ratio | | -0.24 | |
| (No. of persons/adult equiv. labour unit) | | (0.44) | |
| Total Livestock Units (TLU) to labour ratio | | -0.09 | |
| | | (0.07) | |
| One-year lag TLU to labour ratio | | -0.06 | |
| (lag TLU No./ adult equiv. labour unit) | | (0.17) | |
| Capital asset index to labour ratio | | 0.30 | |
| | | (0.42) | |
| Distance to the urban center (km) | | 0.02*** | |

| | | | |
|---|---|---|---|
| | | | (0.01) |
| **Deviations from the mean** | | | |
| Own farmland (ha) | | | -1.47** |
| | | | (0.62) |
| Own farmland to labour ratio | | | 0.64 |
| (ha/adult equiv. labour unit) | | | (1.67) |
| Share of male labour | | | 0.19 |
| | | | (0.73) |
| Sex of HH head (1=Female) | | | -0.21 |
| | | | (0.37) |
| Age of HH head (years) | | | 0.01 |
| | | | (0.02) |
| Education of HH head (years) | | | -0.03 |
| | | | (0.03) |
| Household size to labour ratio | | | 0.36 |
| (No. of persons/adult equiv. labour unit) | | | (0.26) |
| Total Livestock Units (TLU) to labour ratio | | | -0.01 |
| | | | (0.09) |
| One-year lag TLU to labour ratio | | | 0.03 |
| (lag TLU No./ adult equiv. labour unit) | | | (0.04) |
| Capital asset index to labour ratio | | | 0.67 |
| | | | (0.47) |
| Distance to the urban center (km) | | | 0.01 |
| | | | (0.01) |
| **Year dummies** | | | |
| 2013.year | 0.80*** | 0.95*** | 0.98**** |

| | | | | | |
|---|---|---|---|---|---|
| | (0.27) | | (0.30) | (0.29) | |
| 2016.year | 0.73** | 0.04 | 0.92*** | 0.87*** | 0.06 |
| | (0.29) | (0.40) | (0.31) | (0.33) | (0.40) |
| Constant | -3.07**** | -1.80*** | -2.75*** | -0.91 | -1.87** |
| | (0.38) | (0.58) | (0.85) | (1.43) | (0.89) |
| lnsig2u | 1.01**** | -0.03 | 0.93**** | 0.96**** | -0.75 |
| | (0.25) | (1.01) | (0.26) | (0.26) | (1.70) |
| Observations | 2,085 | 1,390 | 2,085 | 2,085 | 1,390 |
| Number of y3_hhid | 695 | 695 | 695 | 695 | 695 |

Note: The asterisks represent **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1. Cluster robust standard errors in parenthesis.

## Table A9: Southern Region Random Effect Tobit Models for Renting-in Land (Coefficients)

| | **Parsimonious Random Effects (RE) models** | | **Random Effects (RE) models with controls variables** | | |
|---|---|---|---|---|---|
| **VARIABLES** | **RE** | **Dynamic RE (DRE)** | **RE** | **Correlated Random Effects (CRE)** | **Dynamic RE (DRE)** |
| **One-year lag rainfall variables** | | | | | |
| Positive deviation (dm) one-year lag | -0.04 | -0.05 | -0.05 | -0.04 | -0.05 |
| (early plus mid-season) | (0.05) | (0.06) | (0.05) | (0.05) | (0.06) |
| Absolute Negative deviation (dm) one-year lag | 0.01 | -0.03 | 0.01 | 0.01 | -0.00 |
| (early plus mid-season) | (0.06) | (0.07) | (0.06) | (0.06) | (0.07) |
| **Two-year lag rainfall variables** | | | | | |
| Positive deviation (dm) two-year lag | -0.05 | -0.08 | -0.10 | -0.10 | -0.09 |
| (Early plus mid-season) | (0.07) | (0.08) | (0.07) | (0.07) | (0.08) |
| Absolute Negative deviation (dm) two-year lag | -0.15* | -0.12 | -0.19** | -0.19** | -0.16* |

| | | | | | |
|---|---|---|---|---|---|
| (Early plus mid-season) | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) |
| **Lag rental participation dummies** | | | | | |
| Initial year (2010) rent-in dummy | | 0.73** | | | 0.40 |
| | | (0.35) | | | (0.25) |
| Lag rent-in dummy | | 0.48 | | | 0.81**** |
| (previous survey round) | | (0.34) | | | (0.23) |
| Initial year (2010) rent-in land (ha) | | 0.15 | | | -0.32 |
| | | (0.56) | | | (0.43) |
| Lag total rent-in land (ha) | | 0.58 | | | 0.89*** |
| (previous survey round) | | (0.45) | | | (0.34) |
| **Farm and Household Characteristics** | | | | | |
| **Observed control variables** | | | | | |
| Own farmland (ha) | | | -0.58** | | -0.39* |
| | | | (0.25) | | (0.22) |
| Own farmland to labour ratio | | | -0.03 | | 0.06 |
| (ha/adult equiv. labour unit) | | | (0.63) | | (0.57) |
| Share of male labour | | | -0.51 | | 0.05 |
| | | | (0.32) | | (0.31) |
| Sex of HH head (1=Female) | | | -0.55**** | | -0.59**** |
| | | | (0.16) | | (0.17) |
| Age of HH head (years) | | | -0.00 | | -0.00 |
| | | | (0.01) | | (0.00) |
| Education of HH head (years) | | | -0.00 | | -0.01 |
| | | | (0.01) | | (0.01) |
| Household size to labour ratio | | | 0.11 | | 0.29** |
| (No. of persons/adult equiv. labour unit) | | | (0.13) | | (0.14) |

| | | | |
|---|---|---|---|
| Total Livestock Units (TLU) to labour ratio | -0.02 | | -0.04 |
| | (0.08) | | (0.12) |
| One-year lag TLU to labour ratio | 0.01 | | 0.01 |
| (lag TLU No./ adult equiv. labour unit) | (0.06) | | (0.06) |
| Capital asset index to labour ratio | 0.30* | | 0.26 |
| | (0.17) | | (0.16) |
| Distance to the urban center (km) | 0.01*** | | 0.01*** |
| | (0.00) | | (0.00) |
| **Mean of observed control variables** | | | |
| Own farmland (ha) | | -0.57* | |
| | | (0.33) | |
| Own farmland to labour ratio | | -0.10 | |
| (ha/adult equiv. labour unit) | | (0.85) | |
| Share of male labour | | -1.44** | |
| | | (0.58) | |
| Sex of HH head (1=Female) | | -1.04**** | |
| | | (0.28) | |
| Age of HH head (years) | | -0.00 | |
| | | (0.01) | |
| Education of HH head (years) | | 0.01 | |
| | | (0.02) | |
| Household size to labour ratio | | -0.11 | |
| (No. of persons/adult equiv. labour unit) | | (0.25) | |
| Total Livestock Units (TLU) to labour ratio | | -0.06 | |
| | | (0.13) | |
| One-year lag TLU to labour ratio | | -0.01 | |

| | |
|---|---|
| (lag TLU No./ adult equiv. labour unit) | (0.18) |
| Capital asset index to labour ratio | 0.14 |
| | (0.28) |
| Distance to the urban center (km) | 0.01*** |
| | (0.00) |
| **Deviations of the mean** | |
| Own farmland (ha) | -0.66** |
| | (0.32) |
| Own farmland to labour ratio | 0.16 |
| (ha/adult equiv. labour unit) | (0.81) |
| Share of male labour | -0.12 |
| | (0.38) |
| Sex of HH head (1=Female) | -0.19 |
| | (0.22) |
| Age of HH head (years) | 0.01 |
| | (0.01) |
| Education of HH head (years) | -0.01 |
| | (0.02) |
| Household size to labour ratio | 0.13 |
| (No. of persons/adult equiv. labour unit) | (0.16) |
| Total Livestock Units (TLU) to labour ratio | 0.01 |
| | (0.15) |
| One-year lag TLU to labour ratio | 0.01 |
| (lag TLU No./ adult equiv. labour unit) | (0.08) |
| Capital asset index to labour ratio | 0.41 |
| | (0.28) |

| | | | | | |
|---|---|---|---|---|---|
| Distance to the urban center (km) | | | | -0.00 | |
| | | | | (0.01) | |
| **Year dummies** | | | | | |
| 2013.year | 0.40** | | 0.41** | 0.40** | |
| | (0.19) | | (0.19) | (0.19) | |
| 2016.year | 0.44*** | 0.02 | 0.49*** | 0.44** | 0.02 |
| | (0.17) | (0.26) | (0.17) | (0.19) | (0.25) |
| Constant | -1.88**** | -1.16**** | -1.47*** | -0.65 | -1.28** |
| | (0.25) | (0.23) | (0.51) | (0.82) | (0.52) |
| sigma_u | 1.02**** | 0.48** | 0.93**** | 0.94**** | 0.00**** |
| | (0.10) | (0.23) | (0.10) | (0.10) | (0.00) |
| sigma_e | 0.64**** | 0.76**** | 0.63**** | 0.62**** | 0.82**** |
| | (0.05) | (0.12) | (0.05) | (0.05) | (0.07) |
| Observations | 2,085 | 1,390 | 2,085 | 2,085 | 1,390 |
| Left Censored (_n) | 1,953 | 1,288 | 1,953 | 1,953 | 1,288 |
| Uncensored (_n) | 132 | 102 | 132 | 132 | 102 |
| Number of y3_hhid | 695 | 695 | 695 | 695 | 695 |

Note: The asterisks represent **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1. Normal standard errors in parenthesis.

# Paper Four

## The falling land to labour ratios and agricultural trade response strategies in Malawi

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**Abstract**

This study assesses how the growing land scarcity relative to family labour is influencing the household decision to trade in agricultural land and labour markets as their livelihood strategies. Using the farm household model, I analyse the decisions to rent-in land or hire out labour among smallholder farmers in Malawi. I use two rounds of a nationally representative household balanced panel data and apply a systems approach to jointly estimate the land rental and labour market decisions while controlling for simultaneity and unobserved heterogeneity. From the results, the falling owned land to labour endowment ratio can push households to participate in either land rental or seasonal agricultural labour markets. But, the probability of hiring out labour for casual work and short-term gains reduces if potential tenant households rent-in the land. Using asset wealth to labour endowment ratio, wealthier households are more likely to rent-in land while the poorer and majority of the farm households hire out labour. These results point towards higher friction in the land rental compared to agricultural labour markets and liquidity constraints that can support agricultural household operations and needs. Thus, agricultural policy in Malawi should aim at reducing frictions in the factor markets.

**Keywords:** Land scarcity; Factor markets; *Ganyu*; Conditional Mixed Process; Malawi.

**JEL Codes**: Q15; J22

## 1. Introduction

The general trend of agricultural land in Sub-Saharan Africa (SSA) has been from land abundance towards scarcity mainly from population growth (Holden, 2020; Lowder et al., 2014). Land scarcity is particularly a challenge for farm households that rely on agricultural land and labour factors of production for both income and food security in SSA (Chamberlin et al., 2014; Hazell, 2020). Literature indicates that the trend on farm households' owned land to labour endowment ratios has been falling, especially in areas with high population density in SSA (Headey & Jayne, 2014; Jayne et al., 2014). The falling land to labour ratios has resulted in farm households using more family labour relative to owned farmland considering the labour market imperfections and limited opportunities to use labour outside the agricultural sector (Jayne et al., 2014; Wineman & Jayne, 2020). Such use of labour is considered less profitable if households can trade in the labour and land factor markets (Wineman & Jayne, 2020). Therefore, understanding the farm household decisions to trade in the land and labour markets should be important for developing policies that can improve factor markets in SSA.

The literature on household decisions from both farm household models and the livelihood approach studies in SSA, shows that farm households have been responding to the land scarcity challenge by diversifying and intensifying the use of land and labour factors of production, mainly within the agricultural sector (Alobo Loison, 2015; Jayne et al., 2014). Despite the existing literature, empirical evidence on the extent to which the changing farm households' owned land to labour endowment ratio is influencing the decision to trade in either agricultural land or labour markets, as livelihood strategies remain limited in SSA. The empirical gap has been partly an issue of missing, absent or thin land markets despite non-missing but imperfect agricultural labour markets in most Sub-Saharan African countries (Jayne et al., 2014).

Nevertheless, land markets are now developing with more active and expanding land rental markets in SSA (Chamberlin et al., 2014; Holden et al., 2010). Thus, the objective of this paper is to understand how the changes in the owned land relative to family labour are influencing the trade of land and labour among smallholder farmers, amidst land scarcity challenges. Specifically, I consider the labour rich (more family labour) relative to farmland households, who are capable of renting-in the land or hiring out labour for casual work in seasonal agricultural labour markets. The focus on the relative labour rich farm households is because of the increase in farm household-level population pressure and landlessness that is leaving households with relatively more labour to owned farmland in most counties in SSA (Hazell, 2020; Holden, 2020). Furthermore, I analyse how the falling owned land to labour endowment ratio is affecting entry and extent of farm households' participation in either land rental or seasonal agricultural labour markets.

Considering that land rental markets develop to enhance the efficient allocation of land and non-land factors of production (Holden et al., 2010), I further assess the extent to which renting-in agricultural land is influencing the decision to hire out labour for seasonal agricultural casual work. I specifically assess the decision to hire out labour for casual work because the majority of the smallholder farm households in SSA use or trade their labour within the agricultural sector because of limited skills, capital and labour opportunities in the non-agricultural sectors (Davis et al., 2017; Van Hoyweghen et al., 2020). Additionally, trading labour for agricultural casual work within SSA is considered a short-term economic response to food consumption needs (Bezu et al., 2012; Orr et al., 2009; Pender & Fafchamps, 2006; Van Hoyweghen et al., 2020). Casual work is also considered a coping strategy to idiosyncratic shocks that might reallocate labour out of family farms, thereby worsening the poverty gap (Cole & Hoon, 2013; Fink et al., 2014; Orr et al., 2009; Whiteside, 2000). Thus, understanding how the land rental markets are influencing the labour trade decisions should be key for developing policy strategies that can sustain livelihoods and improve the use of labour for medium to long-term gains among smallholder farmers.

I use two rounds of balanced household panel data from Malawi, one of the countries in SSA with high population density. The balanced panel data is from the Malawi Living Standards Measurement Surveys (LSMS) conducted in 2013 and 2016. Malawi is appropriate for this study considering the increase in land pressure and demand for land for both food security and economic growth (Government of Malawi, 2019; Headey & Jayne, 2014). The reviewed literature from Malawi also shows a history of farm households responding to such land scarcity challenges by doing casual work in the localised seasonal agricultural labour markets, as a coping strategy to food consumption shocks (Ellis et al., 2003; Whiteside, 2000).

In addition, recent evidence shows that land rental markets are developing in Malawi with a positive impact on resource allocation, income and welfare (Chamberlin & Ricker-Gilbert, 2016; Ricker-Gilbert et al., 2019). However, from the reviewed literature, no study has focused on the joint decision to trade either agricultural land or labour as livelihood response strategies to the falling owned land to labour endowment ratios in Malawi. There is also limited evidence on how the developing rental markets are influencing the farm household decision to hire out labour for casual work among smallholder farmers in Malawi.

To achieve the objective of this paper, I use the bivariate and recursive bivariate models for entry into the land rental and seasonal agricultural labour markets, as a joint and sequential decision, respectively. On the extent of participation, I use a simultaneous system approach combining the Tobit model for renting-in the land and fractional probit model for hiring out labour. I apply the Conditional Mixed Process (CMP) estimation method that considers both the simultaneity and endogeneity issues even in a recursive system (Roodman, 2011). Overall, the paper adds new empirical evidence to the growing literature on diversification of livelihood strategies and efficient allocation of productive resources through market assisted strategies in SSA (Asfaw et al., 2019; Holden et al., 2010).

In what follows, section two gives a background of the land and seasonal agricultural labour markets in Malawi. Section three presents the household theoretical model and highlights the specific hypotheses proposed in this paper. Section four presents the data and estimation methods while section five gives the descriptive statistics. Section six presents and discusses the results with a conclusion in section seven.

## 2. Background

Malawi is an agricultural-based country where 84 percent of the population resides in rural areas while the agricultural sector employs 64 percent of the workforce (Government of Malawi, 2013; Government of Malawi, 2019). The country is among the areas with high population density in SSA, reported at 186 persons per square kilometre (Government of Malawi, 2019). Almost 67 percent of the total land is under customary tenure system and mainly cultivated by smallholder farmers in rural areas (Government of Malawi, 2002). The rural households and to some extent the urban dwellers mainly depend on this customary land and family labour for both income and food security (Ellis et al., 2003; Headey & Jayne, 2014). Tione and Holden (2020) showed that the demand for land and how farm households value their land has been increasing over time from both household-level population pressure and proximity to urban areas. Thus, land and labour remain the key factors for sustaining rural livelihoods in Malawi.

Literature shows that the smallholder farm households in Malawi have been responding to the land scarcity challenge by mainly hiring out family labour for casual work in seasonal agricultural labour markets, commonly known as *ganyu* (Ellis et al., 2003; Whiteside, 2000).

Ellis et al. (2003) indicated that farm households in Malawi mainly trade their labour for casual work (*ganyu*) to cope with the mismatch between land ownership and ability or wish to cultivate agricultural land, due to non-existing (absent) land rental markets. Considering that the land rental markets are now developing in Malawi (Ricker-Gilbert et al., 2019), assessing the farm household trade response strategies should be important for developing policies in Malawi and lessons relevant for other countries in SSA.

Following Whiteside (2000), the word *ganyu* broadly means any "off-own-farm work", calculated as piecework and usually agricultural-related, that individuals do on a casual basis, covering days or weeks with payment as cash or in-kind (for instance food). Overall, g*anyu* involves daily wage or short-term wage contracts. Such contracts are mostly localised within or neighbouring communities involving unskilled work like ploughing or weeding using a hand hoe and also harvesting or shelling of grains or legumes. *Ganyu* differs from skilled labour work and long-term agricultural labour contract mostly offered under estate farms commonly known as "tenant labour" in Malawi (Kerr, 2005).

Historically, smallholder farmers engage in *ganyu* activities as both a livelihood and a coping strategy during acute food shortage period (December to February) and when there is a high demand for agricultural labour, based on the unimodal rainfall pattern that starts from November to April in Malawi (Kerr, 2005; Peters, 1988; Whiteside, 2000). Scholarly papers have argued that households who engage in *ganyu* either neglect all or part of their farms, especially the female-headed households, while others have argued that households hire out male labour, leaving female members to attend to family farms, which are possible indicators of household vulnerability to shocks and a poverty trap (Bigsten & Tengstam, 2011; Dimowa et al., 2010; Fink et al., 2014; Orr et al., 2009; Takane, 2008; Whiteside, 2000). However, as indicated by Ellis et al. (2003), this could also have been an indicator of limited opportunities to trade farmland from non-existing or absent land rental markets, which are now developing in Malawi.

Recent literature shows that the land rental markets in Malawi are reallocating land-use from relatively land-rich and labour-poor households to land-poor and relatively labour-rich households. Evidence also indicates that farm households renting-in the land are relatively more productive and wealthier in non-land factors (capital and labour) compared to landlords (Chamberlin & Ricker-Gilbert, 2016; Lunduka et al., 2009; Ricker-Gilbert et al., 2019). This could be an indicator of stress renting out of the land by poor farm households who cannot sell land due to family ties or who are not willing to sell their land despite their labour endowment conditions (Ricker-Gilbert et al., 2019). Such evidence highlights the important role of capital wealth and labour endowment in facilitating household decision to trade agricultural land or labour. Thus, the study analyses the farm household decision to participate in the land rental and seasonal agricultural labour markets, as the trade response strategies to the falling owned land to labour endowment ratio and the changes in asset wealth (capital) relative to labour endowment. This is in addition to understanding the extent to which land rental markets are influencing the allocation of family labour for casual work (*ganyu*) among smallholder farmers in Malawi.

**3. Theoretical framework and hypotheses**

A farm household whose objective is to maximise income utility from land and labour endowment can either use all or part of their endowment on their own-farm or trade these resources across farms to achieve desired levels of resource use (Holden et al., 2010). The farm households with the potential to trade can either rent-in or rent out the land, hire-in or hire out their labour in short to medium term. For such a household, the income utility function can be given as $Max\, U = U[Y]$, where the utility is a twice differentiable quasi-concave function (Singh et al., 1986). The $[Y]$ is for the equivalent income from both crop production output and trading of resources. Thus, a farm household endowed with land $(\bar{A})$ and labour $(\bar{L})$ will have the intermediate own-farm resource use functions as $A = \bar{A} + A^i - A^o$ and $L = \bar{L} + L^i - L^o$. Where $A$ and $L$ is the level of land and labour use on own-farm, $A^i$ and $A^o$ is the amount of land rented-in or out, while $L^i$ and $L^o$ is the amount of labour hired-in or out, respectively. Following Singh et al. (1986) the labour endowment $(\bar{L})$ is the sum of labour time used for both work $(L_u)$ and for leisure $(L_e)$ given as $[\bar{L} = L_u + L_e]$. Thus, the total estimate of labour at household level is based on the total household adult equivalent labour, that farm households can use or trade while implicitly capturing leisure time.

Using the farm household decision model, equation (1) specifies the household income utility function.

$$\underset{A,A^i,A^o,L,L^i,L^o}{\text{Max}} \; U[Y] = U[P_q q(A,L,k) - \eta(A^i) + \theta(A^o) - \tau(L^i) + \varphi(L^o) - p_m M] \qquad (1)$$

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

From equation (1), the household choice variables reflect the land and labour use and/or trade. In the equation, the $(P_q)$ is for output prices and the $q(A, L, k)$ is the production function subject to own-farm use of land *(A)*, labour *(L)* and capital *(K)* factors of production. Considering the market imperfections that characterise markets in SSA, farm households mostly face non-linear transaction costs even with linear unit prices of goods, from either information asymmetry or transportation costs (Fafchamps, 2004; Holden et al., 2010). Thus, the parameters ($\eta$) and ($\theta$) for renting-in and renting out the land, and ($\tau$) and ($\varphi$) for hiring in or out labour are the overall non-linear prices in the equation. This assumes that market participants on the demand and supply sides encounter different transaction costs even if they may face a similar unit land rent (Sadoulet et al., 2002). The ($p_m M$) is the total cost of other marketed inputs used on the farm. For simplicity, the model assumes away liquidity constraints related to credit, and output market prices, considering the long gestation period of agriculture products and risk factors, that are associated with output prices and household preferences (Carter & Yao, 2002; Holden & Quiggin, 2017; Sadoulet et al., 2002).

Using the duality theory, the theoretical framework in this paper focuses on the income function, that is twice differentiable and quasi-convex. If prices of both output ($P_q$) and other marketed inputs ($p_m$) are normalised to one, the First Order Conditions (FOCs) from the income function are as specified in equations (2) to (6). The FOCs shows that household will only participate in the markets if the marginal revenue of trading the factors of production is greater than the marginal cost of using the resources on own-farm. Based on the FOCs, Table 1 summarises the optimal trade response strategies for farm households. I present the detailed optimal trade options that reflect the FOCs in each cell in Appendix A, Table A1.

*Net buyer of labour (hiring-in)*

$$\frac{\partial Y}{\partial L^i} = \frac{\partial q}{\partial L^i} - \frac{\partial \tau}{\partial L^i} \leq 0 \qquad \perp \quad L^i \geq 0 \qquad \textbf{i.e.} \ \frac{\partial q}{\partial L^i} \leq \frac{\partial \tau}{\partial L^i} \qquad \text{if } L^i \geq 0 \tag{2}$$

*Net seller of labour (hiring out)*

$$\frac{\partial Y}{\partial L^o} = -\frac{\partial q}{\partial L^o} - \frac{\partial \tau}{\partial L^o} \leq 0 \quad \perp \quad L^0 \geq 0 \qquad \textbf{i.e.} \ \frac{\partial q}{\partial L^o} \geq \frac{\partial \tau}{\partial L^o} \qquad \text{if } L^o \geq 0 \tag{3}$$

*Net buyer of land (renting-in)*

$$\frac{\partial Y}{\partial A^i} = \frac{\partial q}{\partial A^i} - \frac{\partial \eta}{\partial A^i} \leq 0 \qquad \perp \quad A^i \geq 0 \qquad \textbf{i.e.} \ \frac{\partial q}{\partial A^i} \leq \frac{\partial \eta}{\partial A^i} \qquad \text{if } A^i \geq 0 \tag{4}$$

*Net seller of land (renting out)*

$$\frac{\partial Y}{\partial A^i} = -\frac{\partial q}{\partial A^o} - \frac{\partial \eta}{\partial A^o} \leq 0 \quad \perp \quad A^o \geq 0 \qquad \textbf{i.e.} \ \frac{\partial q}{\partial A^o} \geq \frac{\partial \eta}{\partial A^o} \qquad \text{if } A^o \geq 0 \tag{5}$$

*Non-participant (shadow value)*

$$\frac{\partial \tau}{\partial L^o} > \frac{\partial q}{\partial L} < \frac{\partial \tau}{\partial L^i} \quad \text{and} \quad \frac{\partial \eta}{\partial A^o} > \frac{\partial q}{\partial A} < \frac{\partial \eta}{\partial A^i} \tag{6}$$

Table 1: Summary of potential optimal household trade response strategies

| | | Trade response strategies | | |
|---|---|---|---|---|
| | | Labour option (Equation 2) | | |
| | | **Hire-in** $(L^i > 0)$ | **Non-participant** $(L^i = 0 = L^0)$ | **Hire out** $(L^o > 0)$ |
| **Land option (Equation 1)** | **Rent-in** $(A^i > 0)$ | Hire-in labour or rent-in land (*Labour poor and land poor*) | Not trading labour but rent-in land (*Labour sufficient and land poor*) | Hire-out labour or rent in the land (*Labour rich and land poor*) |
| | **Non-participant** $\begin{pmatrix} A^0 = 0 \\ A^i = 0 \end{pmatrix}$ | Hire-in labour or not trading land (*Labour poor and land sufficient*) | Not trading both labour and land (*Labour and land sufficient*) | Hire out labour or not trading land (*Labour rich and land sufficient*) |
| | **Rent-out** $(A^o > 0)$ | Hire in labour or rent out the land (*Labour poor and land rich*) | Not trading labour but rent out the land (*Labour sufficient and land rich*) | Hire out labour or rent out the land (*Labour rich and land rich*) |

From Table 1, the farm household trade response strategies to land scarcity challenge can be to trade in the land or labour market only, participate in both markets or not participating in any market depending on owned land to labour endowment ratios and their ability to participate in the market. Based on the FOCs, the ability to participate in the markets is further a function of non-linear transaction costs that can raise the household shadow value on factors of production, hence rationing potential market participants into the non-participating group. Thus, assessing each or a combination of these optimal solutions, even among non-participating but potential market participants, should be important for understanding the farm household trade responses to the changing resource ratios in SSA.

With increasing land pressure and assuming more family labour relative to land for the majority of the farm households in Malawi, I hypothesize that;

H1. Falling owned land to labour endowment ratio increases entry and extent of (amount of land rented-in) farm household participation in land rental markets.

With land rental markets developing as efficiency-enhancing mechanisms to the non-land factor markets, the focus on this hypothesis is whether the change in owned land to labour endowment ratio is a push-factor among smallholder farmers in the land rental market. In line with Alobo Loison (2015), a push-factor is a negative factor that may force farm households to seek additional livelihood activities within or outside the farm.

H2. Entry into the land rental market is negatively associated with trading labour for casual work (*ganyu*) in seasonal agricultural labour markets.

From the theoretical framework, renting-in land increases operational farmland. By renting-in agricultural land, farm household should allocate more family labour for their farm work than hiring it out for short-term wage assuming imperfect and seasonal agricultural labour markets. Also, assuming that farm households make the land rental decisions at the start of the season while making the labour decisions throughout the season, I assess how entry into the land rental markets can influence entry into the labour markets using a recursive model.

H3. Increase in the household asset wealth to labour endowment ratio increases tenant household entry and extent of participation in the land rental markets.

H4: Increase in the household asset wealth to labour endowment ratio reduces entry and extent of hiring out labour for agricultural casual work (*ganyu*).

Using the asset wealth variable should be important for assessing household ability to finance agricultural activities, as opposed to using the available income at the farm household level. The use of available household income can be challenging considering the liquidity constraints that most farm household face when producing under a unimodal rainfall pattern and with high output price fluctuations across space and over time (Cornia et al., 2016). Thus, higher asset wealth to labour endowment ratio should be associated with the higher ability of a farm household to rent-in the land, while reducing the need to hire out labour for casual work.

**4. Data and estimation method**

The study uses data from two-panel rounds of the Malawi Living Standards Measurement Surveys (LSMS) collected in 2013 and 2016. In 2013, the sample size was 1,990 that I used to construct a balanced panel of 1,895 households, signifying a 4 percent attrition rate. Using the inverse mills ratio estimated from a probit model, I did not observe attrition bias hence the results that I present excludes the inverse mills ratio[1]. Since land and labour decisions in Malawi mainly follow rainfed production with a unimodal rainfall pattern, farm households are also vulnerable to production shocks across different agro-ecological zones (Katengeza et

[1] The results with inverse mills ratio are available upon request.

al., 2018). Thus, I use the monthly district-level rainfall data from Malawi that was shared upon request from the Department of Climate Change and Meteorological Services ([www.metmalawi.gov.mw](http://www.metmalawi.gov.mw)). The monthly district-level rainfall data is for 10 years (2007 to 2017) and covers the within-region rainfall variations across the three regions in Malawi (North, Central and South). I consider these variations to be important for prompting households to trade their land and labour resources aftershock, as a coping strategy amidst increasing climate shocks in Malawi (Katengeza et al., 2018).

To estimate the results, I jointly assess the participation in land rental and seasonal agricultural labour markets using the bivariate and recursive bivariate models for entry into the markets while using Tobit and fractional probit models for the extent of participation (Kassouf & Hoffmann, 2006; Roodman, 2011; Wooldridge, 2010). The Tobit model analyses the farmland area rented-in at the household level (measured in hectares) while the fractional probit analyses the share of adult equivalent household labour located for casual work in the seasonal agricultural labour markets. The additional use of a recursive bivariate model is to understand how entry into the land rental markets, a decision that households make early in the season, is likely to influence the labour decisions made throughout the production season. Furthermore, with limited dependent variables, I apply the Correlated Random Effects (CRE) model that uses the Mundlak (1978) and Chamberlain (1982) device, which is equivalent to using household fixed effects in a model with a continuous dependent variable. Overall, I use Roodman (2011) Conditional Mixed Process (CMP) that applies the full-information maximum likelihood estimation method, which allows estimating the equations jointly in line with the Zellner's Seemingly Unrelated Regression (SUR) model specification.

Based on the discussed theory, I jointly estimate the reduced functional form of household renting-in the land or hiring out labour over time. Equations (7), (8a) and (8b) specify the farm household decision to participate in the land rental (${A^i}_{jt}$) and seasonal agricultural labour (${L^o}_{jt}$) markets for household *j* and at time *t* as a joint decision. Equations (7) and (8a) are for bivariate entry and extent of participation in each market while (8b) is for the recursive bivariate land and labour market decisions. The parameters of interest in line with the hypotheses are $\beta$, $\sigma$, and $\delta$ for household land to labour ratio, asset wealth to labour ratio and renting-in the land under a recursive system, respectively.

$$ {A^i}_{jt} = \alpha + \beta \left(\frac{\bar{A}}{\bar{L}}\right)_{jt} + \sigma \left(\frac{K}{\bar{L}}\right)_{jt} + \gamma \check{X}_j + \pi \hat{X}_j + \check{Z}_j \beta + \hat{Z}_j \delta + \lambda N_{t-1}^{e+m} + \varrho H_{t-1}^{e+m} + \tau + \mu_j + \varepsilon_{jt} \quad (7) $$

$$L^{o}{}_{jt} = \alpha + \beta\left(\frac{\bar{A}}{\bar{L}}\right)_{jt} + \sigma\left(\frac{K}{\bar{L}}\right)_{jt} + \gamma\check{X}_j + \pi\hat{X}_j + \check{Z}_j\beta + \hat{Z}_j\delta + \lambda N_{t-1}^{e+m} + \varrho H_{t-1}^{e+m} + \tau + \mu_j + \varepsilon_{jt} \quad (8a)$$

$$L^{o}{}_{jt} = \alpha + \delta A^{i}{}_{jt} + \beta\left(\frac{\bar{A}}{\bar{L}}\right)_{jt} + \sigma\left(\frac{K}{\bar{L}}\right)_{jt} + \gamma\check{X}_j + \pi\hat{X}_j + \check{Z}_j\beta + \hat{Z}_j\delta + \lambda N_{t-1}^{e+m} + \varrho H_{t-1}^{e+m} + \tau + \mu_j + \varepsilon_{jt} \quad (8b)$$

Land endowment $(\bar{A})$ is defined as land acquired through customary inheritance systems, government distribution and purchases. Following Holden et al. (2013), I categorised households who use farmland from either borrowing, encroachment and farming under estate management as having only pre-rental farmland without secure land ownership. Thus, I categorise such households as landless in ownership sense, as they hold an endogenous tenure right while controlling for pre-rental land in the analysis. The pre-rental land captures farmland from all other sources operated by a household but excluding the rented-in land.

On asset wealth to labour ratio, I use the Factor Component Analysis (FCA) to estimate the asset wealth (*K*) index for each household depending on their endowment of durable goods and farm implements. The list of goods and farm implements included in the FCA is presented in Appendix A. For the labour endowment $(\bar{L})$, I estimated the total adult equivalent labour from all available household members in a year. Using the asset wealth to labour endowment ratio, I categorised the households into four quantiles ($25^{th}$ quartiles) that reflect their endowment and capacity to rent-in the land. Households in the $25^{th}$ quartile are in the lowest group hence considered poor compared to the above $75^{th}$ quartile with an ascending order in the intermediate groups.

In line with the CRE specification, the equations control for means and "deviations from the mean" of the community or household $(\check{Z}_j\ \hat{Z}_j)$ and farm $(\check{X}_j,\ \hat{X}_j\ )$ characteristics, respectively. Specifically, the analysis controls for sex, age and education of the household head; household size to labour ratio; livestock ownership based on Total Livestock Unit (TLU) in the current and one-year lag periods; pre-rental farmland; and distance to nearest city area zone for proximity to urban areas with high demand for land, and with a higher probability of labour opportunities in both agricultural and non-agricultural sectors.

Furthermore, the analysis controls for one-year lag upside and downside rainfall variations that happen early to mid-season at district-level and within the regions in Malawi. Such rainfall variations should reflect the spatial production shock effects that can facilitate the need to shift household land and labour resources through factor markets. The variables $N_{t-1}^{e+m}$ and $H_{t-1}^{e+m}$ are for one-year lag downside *(N)* and upside *(H)* deviations while *(e)* is for early and (*m*) is for mid-season periods in Malawi. With a unimodal rainfall pattern in Malawi, the early to mid-season variables capture the period from October to February of each production season, including October as a preparation month. I use the early to mid-season variations to reflect the production shock effects related to crop development and maturity while excluding the late-season period that coincides with harvesting time in Malawi (Government of Malawi, 2012).

The $\tau$ is for time dummy while $\mu_j + \varepsilon_{jt}$ is the additive error term with the time constant unobserved heterogeneity ($\mu_j$) and the idiosyncratic error ($\varepsilon_{jt}$) that is independent and identically distributed. Although with observational data it is challenging to fully estimate causal effects, I consider that the specified estimation methods have accounted for potential endogeneity and simultaneity concerns in this analysis. Thus, the interpretation of the results should be able to unveil policy issues that can be relevant for improving factor markets in Malawi.

**5. Descriptive statistics**

Recall that in this paper, a lower land to labour ratio implies more labour relative to farmland while a higher ratio implies less labour relative to farmland. The Lorenz curves in Figures 1(a) and 1(b) shows the distribution of the owned land and operational land to labour endowment ratios. In the figures, I broadly categorise the farm households into four groups, which reflect who participated in one or both markets and who did not participate in the factor markets. However, to assess the statistical differences in line with the hypotheses, the four categories in the Lorenz curves are re-organised into three main categories, which I present in Table 2.

The categories in Table 2 and their respective percentages in the sample are (i) renting-in or tenant households, 9 percent; (ii) hiring out or casual labour households, 52 percent; (iii) non-market participant households who are 43 percent of the sample. Focusing on the trade response strategies in this study, the ttest in Table 2 assesses the differences between households renting-in (tenants) and hiring out (casual labour), independent of the non-market participant households. To further understand the heterogeneity in asset endowment that can reflect potential market participants within the non-market participant group, I further sub-divided the households in this group into three other categories. These groups are (i) regular farmers defined as households that cultivated their land in both survey rounds, (ii) non-regular farmers defined as households that cultivated their land in either one of the survey rounds and (ii) non-agricultural households for those who did not engage in cultivation in any survey round.

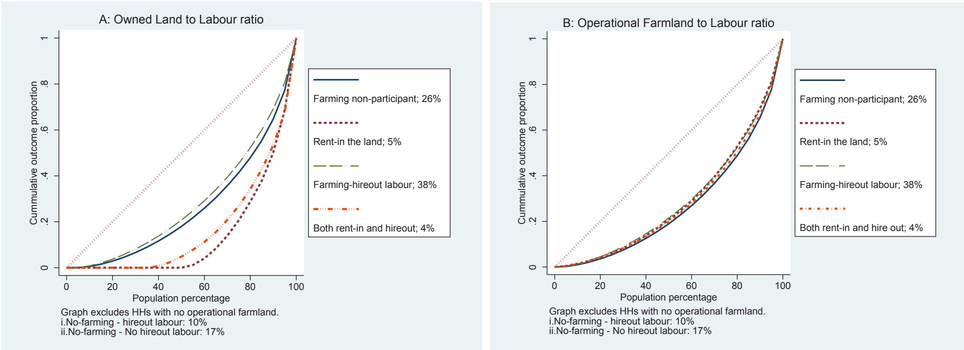


Figure 1: Lorenz curves, (a) owned land to labour endowment ratio (b) operational farmland to labour endowment ratio. Note: Owned land excludes rented, borrowed or encroached land. Operational or cultivated land includes land from all the reported sources at the farm household level.

From Figure 1(a), the Lorenz curves show that households hiring out labour have a relatively higher owned land to labour endowment ratio while households renting-in the land have relatively lower owned land to labour endowment ratio. This implies that households hiring out labour for casual work (*ganyu*) have less family labour relative to owned land, an indicator of hiring out of labour in distress. This concurs with Ellis et al. (2003) observation that households use *ganyu* as a coping strategy for short-term food consumption needs in Malawi. For tenant households, the Lorenz Curves in Figure 1(a) shows a lower ratio that implies more family labour relative to the owned land, which could be important for renting-in the land. The owned land to labour endowment ratios for farming non-participants are slightly lower than the casual labour households. Households that engaged in both markets have lower owned land to labour endowment ratios compared to casual labour households but these are slightly above the tenant households.

The differences in the intermediate groups reflect that households can easily shift in and out of either market depending on their endowment, needs and market-related transaction costs over time. The operational land to labour endowment ratios, therefore, should reflect such shifting of households as observed in Figure 1(b). From Figure 1(b), there are no visible differences in operational farmland to labour ratio among different groups of farm households compared to Figure 1(a). This could signify the importance of land and labour factor markets in reallocating land and labour among farm households.

**Table 2: Summary statistics**

| VARIABLES | Household categories and average values across years | | | | | |
|---|---|---|---|---|---|---|
| | Land and labour market participant | | | Non-market participant (Non-tenant and no casual labour households) | | |
| | **Tenant** (1) | **Casual labour** (2) | **ttest** (1 vs. 2) | **Regular farmer** (Farmed in both survey rounds) **(3)** | **Non-regular farmer** (Farmed in one survey round) **(4)** | **Non-agricultural household** (No farming in all rounds) **(5)** |
| **Land and labour participation variables** | | | | | | |
| Rent-in dummy | 9.2 | | | | | |
| Rent-in land (mean ha) | 0.49 (0.24) | | | | | |
| Casual labour dummy | | 51.9 | | | | |
| Share of hired out labour | | 27.5 | | | | |
| Non-participant dummy | | | | 26.3 | 3.6 | 13.3 |
| **Endowment variables** | | | | | | |
| Owned farmland (mean ha) | 0.37 (0.03) | 0.52 (0.01) | **** | 0.76 (0.02) | 0.0 | 0.0 |
| Operational farmland (mean ha) | 0.87 (0.04) | 0.58 (0.02) | **** | 0.78 (0.02) | 0.0 | 0.0 |
| No pre-rental land dummy | 41.4 | 21.5 | **** | 0.0 | 100 | 100 |
| Household labour (mean adult equiv.) | 3.38 (0.08) | 3.32 (0.03) | | 3.10 (0.05) | 3.01 (0.13) | 3.04 (0.06) |
| Own farmland to labour ratio (mean ha/adult equiv. labour unit) | 0.12 (0.01) | 0.17 (0.01) | **** | 0.28 (0.01) | 0.0 | 0.0 |
| Operational farmland to labour ratio (mean ha/adult equiv. labour unit) | 0.29 (0.02) | 0.19 (0.01) | **** | 0.30 (0.01) | 0.0 | 0.0 |
| Asset wealth index (mean value) | 0.05 (0.05) | -0.30 (0.01) | **** | -0.05 (0.03) | 0.59 (0.13) | 1.06 (0.06) |
| Quartiles of Asset wealth index to labour ratio | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Quartile 1 | 18.1 | 29.3 | **** | 26.9 | 24.6 | 8.9 |
| Quartile 2 | 24.3 | 32.4 | *** | 22.6 | 12.3 | 7.8 |
| Quartile 3 | 30.6 | 26.1 | * | 28.3 | 17.4 | 13.7 |
| Quartile 4 | 26.9 | 12.2 | **** | 22.2 | 45.7 | 69.6 |
| **Households variables** | | | | | | |
| Sex of HH head dummy (1=Female) | 13.7 | 25.8 | **** | 27.4 | 23.9 | 18.3 |
| Age of HH head (mean years) | 40.8 (0.68) | 42.8 (0.33) | ** | 47.3 (0.53) | 41.4 (1.38) | 40.3 (0.57) |
| Education of HH head (mean years) | 7.2 (0.25) | 5.4 (0.09) | **** | 5.8 (0.15) | 8.4 (0.39) | 10.6 (0.23) |
| Household size to labour ratio | 1.72 (0.03) | 1.69 (0.01) | | 1.64 (0.02) | 1.53 (0.03) | 1.58 (0.03) |
| Total Livestock Units (TLU) to labour ratio (mean) | 0.13 (0.02) | 0.08 (0.01) | *** | 0.19 (0.03) | 0.05 (0.01) | 0.06 (0.03) |
| One-year lag TLU to labour ratio (mean) | 0.09 (0.14) | 0.05 (0.00) | *** | 0.08 (0.01) | 0.05 (0.02) | 0.15 (0.07) |
| Distance to the nearest city zone (mean km) | 32.7 (0.91) | 30.2 (0.43) | ** | 31.3 (0.62) | 19.8 (1.57) | 11.7 (0.64) |
| Observations **(N)** | 350 | 1966 | | 998 | 138 | 503 |
| | | | | | | |
| **Rainfall variations (Early plus mid-season)** | **2013** | **2016** | **Total** | | | |
| One-year lag positive deviation (mean dm) | 0.63 (0.01) | 1.84 (0.45) | 1.23 (0.03) | | | |
| Absolute one-year lag negative deviation (mean dm) | 0.78 (0.02) | 1.23 (0.03) | 0.94 (0.01) | | | |

Note: Standard errors in parentheses. The asterisks indicate **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1.

To further assess the differences in owned land to labour endowment ratios, Table 2 shows that there are significant differences in the ratios between households renting-in the land and those hiring out labour for casual work. However, the table does not show significant differences in household adult equivalent labour, while showing significant differences in owned land amongst tenant and casual labour households. Thus, the differences in the owned land to labour endowment ratio should be reflecting the land scarcity challenges in Malawi.

On other household characteristics, Table 2 shows that tenant households own an average of 0.37 ha but rent-in an average of 0.49 ha which increases their operational farm size to an average of 0.87 ha. The share of labour allocated to casual work is on average 28 percent of total adult equivalent household labour. On average, casual labour households own and operate 0.5 ha, which is significantly lower than tenant households. The percent of households with no pre-rental farmland is higher among those renting-in the land compared to causal labour households when I exclude households in the non-market participant group. Furthermore, tenant households are significantly wealthier as indicated by higher asset wealth index value compared to casual labour households.

Comparing the distribution of the households across the asset wealth to labour endowment ratio quartiles, tenant households have a higher distribution in the upper quartiles while those hiring out labour have a higher distribution in the lower quartiles. However, observations from the non-market participant categories show that the tenant households are not the wealthiest in the sample. This suggests that renting-in the land could not be an issue of the rich exploiting the poor but more related to resource use on the farm. Among the non-market participants, regular farmers are indeed poor but slightly better off than casual labour households on average, which point to poor households using casual work as a livelihood coping strategy. The non-regular farmers and the non-agricultural households are wealthier than the tenant households, an indicator of less dependency on rented land and farming activities.

Table 2 further shows that the percent of female-headed households is higher among casual labour households and such households are headed by slightly older and less educated heads compared to tenant households. Casual labour households also own relatively lower livestock units than tenant households. There are no significant differences in the household size to labour ratio, thus pointing to both household categories aiming at producing for own consumption. At the community level, the distance to nearest city area zone shows that tenant households are on average farther away from the nearest city area zone or urban area compared to casual labour households in Table 2. At the district level, the rainfall shock variables show that the one-year lag downside rainfall deviations were on average higher than the upside deviations in 2013. On the contrary, in 2016 it was the upside one-year lag rainfall deviations that were higher than downside deviations on average. Such rainfall variations should be important in accounting for spatial and intertemporal production shock effects in Malawi.

## 6. Results and discussion

Tables 3 and 4 present the key results that can be used to test the hypotheses. Specifically, Table 3 presents the bivariate and recursive bivariate average marginal effects for entry into the land rental and seasonal agricultural labour markets, based on the Conditional Mixed Process (CMP) estimation method. Table 4 presents the CMP average marginal effects for the extent of participation in the land rental and casual labour markets, estimated using the Tobit and Fractional Probit models, respectively. In both tables, models 1 and 2 presents the joint random effects models while models 3 and 4 presents the joint Correlated Random Effects (CRE) models. The random effects models were a starting point in the analysis, which I used for robustness check on model specification before estimating the CRE. Nevertheless, the discussion of the results mainly focuses on the joint CRE models presented in Tables 3 and 4. The full analytical results expounding Tables 3 and 4 are in Appendix A, Table A2 to A5. In what follows, I present and discuss the results in line with the stated hypotheses.

In hypothesis one, the study proposed that the falling owned land to labour endowment ratio increases entry and extent of (amount of land rented-in) farm household participation in land rental markets. The results in Table 3 and 4 indicate that an increase in the ratio decreases participation in land rental markets from both the bivariate and recursive bivariate models. Assessing the other side of the coin, this implies that decreasing or falling owned land to labour endowment ratio increases participation in the land rental markets. From Table 3–models 3a and 4a, the results show that at 5 percent significance level, a decrease in the land per adult equivalent labour (ha/labour unit) increases entry into the land rental market by an average of 10 percentage points. From Table 4–model 3, the extent of land rental market participation also increases by an average of 0.08 hectares with a unit decrease in the land per adult equivalent labour, at 5 percent significance level. Overall, the results support hypothesis one, which implies that farm households with more family labour relative to owned land are more likely to be potential tenants.

**Table 3: Bivariate Probit model with Conditional Mixed Process (CMP) margins for land rental and casual labour (*ganyu*) market participation**

| | Bivariate probit Random Effects (CMP margins) | | Recursive bivariate probit Random Effects (CMP margins) | | Bivariate probit Correlated Random Effects (CMP margins) | | Recursive bivariate probit Correlated Random Effects (CMP margins) | |
|---|---|---|---|---|---|---|---|---|
| | 1a | 1b | 2a | 2b | 3a | 3b | 4a | 4b |
| VARIABLES | Rent in | Hire out | Rent in | Hire out | Rent in | Hire out | Rent in | Hire out |
| **Key variables** | | | | | | | | |
| Land rented-in (1= Yes) | | | | -0.379**** | | | | -0.375**** |
| | | | | (0.09) | | | | (0.09) |
| Own farmland to labour ratio | -0.095** | -0.202**** | -0.101*** | -0.222**** | -0.096** | -0.199**** | -0.102*** | -0.219**** |
| (ha/adult equiv. labour unit) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) |
| Asset wealth index to labour ratio | | | | | | | | |
| Base: Quartile 4 | | | | | | | | |
| Quartile 1 | -0.037** | 0.236**** | -0.045*** | 0.209**** | -0.038** | 0.213**** | -0.046*** | 0.188**** |
| | (0.02) | (0.02) | (0.02) | (0.03) | (0.02) | (0.03) | (0.02) | (0.03) |
| Quartile 2 | -0.005 | 0.275**** | -0.010 | 0.254**** | -0.007 | 0.253**** | -0.011 | 0.235**** |
| | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) |
| Quartile 3 | 0.021 | 0.196**** | 0.019 | 0.190**** | 0.021 | 0.178**** | 0.019 | 0.174**** |
| | (0.01) | (0.02) | (0.01) | (0.02) | (0.02) | (0.02) | (0.01) | (0.02) |
| No pre-rental land (1= yes) | 0.052**** | -0.138**** | 0.047*** | -0.106**** | 0.053**** | -0.132**** | 0.049**** | -0.100**** |
| | (0.01) | (0.02) | (0.01) | (0.02) | (0.02) | (0.02) | (0.01) | (0.02) |
| **Control variables** | | | | | | | | |
| One-year lag rainfall variations | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observed household control variables | Yes | Yes | Yes | Yes | No | No | No | No |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Mean of observed household variables | No | No | No | No | Yes | Yes | Yes | Yes |
| Deviations from the above mean | No | No | No | No | Yes | Yes | Yes | Yes |
| Regional dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 2016. year | -0.016* | 0.223**** | -0.012 | 0.202**** | -0.017* | 0.218**** | -0.015 | 0.198**** |
| | (0.01) | (0.02) | (0.01) | (0.02) | (0.01) | (0.02) | (0.01) | (0.02) |
| Constant | -1.633**** | 0.258 | -1.541**** | 0.281 | -1.808**** | 0.375* | -1.679**** | 0.369* |
| | (0.25) | (0.17) | (0.25) | (0.17) | (0.30) | (0.20) | (0.30) | (0.20) |
| atanhrho_12 | | -0.038 | | 0.625*** | | -0.038 | | 0.620*** |
| | | (0.04) | | (0.21) | | (0.04) | | (0.22) |
| N | 3790 | 3790 | 3790 | 3790 | 3790 | 3790 | 3790 | 3790 |

Note: Standard errors in parentheses, asterisks indicate **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1. Full model results are in Appendix A, Tables A2 and A3

**Table 4: Systems approach with Tobit for the land rental markets and Fractional Probit for the share of adult equivalent labour hired out for casual work (*ganyu*) with Conditional Mixed Process (CMP) margins.**

| | Random Effects (CMP margins) | | Correlated Random Effects (CMP margins) | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| VARIABLES | Tobit – Rent in | Fractional probit – Hire out | Tobit – Rent in | Fractional probit – Hire out |
| **Key variables** | | | | |
| Own farmland to labour ratio | -0.087** | -0.052** | -0.088** | -0.049* |
| (ha/adult equiv. labour unit) | (0.04) | (0.03) | (0.04) | (0.03) |
| Asset wealth index to labour ratio | | | | |
| Base: Quartile 4 | | | | |
| Quartile 1 | -0.047*** | 0.243**** | -0.047*** | 0.229**** |
| | (0.02) | (0.02) | (0.02) | (0.02) |
| Quartile 2 | -0.014 | 0.185**** | -0.014 | 0.173**** |
| | (0.02) | (0.02) | (0.02) | (0.02) |
| Quartile 3 | 0.017 | 0.105**** | 0.018 | 0.095**** |
| | (0.01) | (0.02) | (0.02) | (0.02) |
| No pre-rental land (1= yes) | 0.054**** | -0.070**** | 0.055**** | -0.067**** |
| | (0.01) | (0.01) | (0.01) | (0.01) |
| **Control variables** | | | | |
| One-year lag rainfall variations | Yes | Yes | Yes | Yes |
| Observed household control variables | Yes | Yes | No | No |
| Mean of observed household variables | No | No | Yes | Yes |
| Deviations from the above mean | No | No | Yes | Yes |
| Regional dummies | Yes | Yes | Yes | Yes |
| 2016. year | -0.011 | 0.108**** | -0.013 | 0.102**** |

| | | | | |
|---|---|---|---|---|
| | (0.01) | (0.01) | (0.01) | (0.01) |
| Constant | -1.614**** | -0.421*** | -1.802**** | -0.230 |
| | (0.25) | (0.13) | (0.31) | (0.16) |
| lnsig_1 | | -0.040 | | -0.043 |
| | | (0.06) | | (0.06) |
| atanhrho_12 | | -0.018 | | -0.018 |
| | | (0.03) | | (0.03) |
| N | 3790 | 3790 | 3790 | 3790 |

Note: Standard errors in parentheses. The asterisks indicate **** $p<0.001$, *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Full model results are in Appendix A, Table A4 and A5

**Control variables collapsed in Table 2 and 3:** (i) ***One-year lag rainfall variations***: Positive deviation (dm) one-year lag (early plus mid-season); Absolute Negative deviation (dm) one-year lag (early plus mid-season); (ii) ***household control variables***: Sex of HH head (1=Female); Age of HH head (years); Education of HH head (years); Household size to labour ratio; Total Livestock Units (TLU) to labour ratio; One-year lag TLU to labour ratio; and Distance to the nearest city area zones (km); (iii) ***Regional dummies***: Northern, Central and Southern Regions.

Although the analysis shows that farm households with more family labour relative to owned land are likely to be potential tenants, the results in Tables 3 and 4 also show that the fall in the owned land to labour endowment ratio is also positively associated with being a potential casual labour household. Both the bivariate and recursive bivariate models in Table 3 show that at one percent significance level, the decrease in the owned land to labour endowment ratio (ha/labour unit) is likely to increase hiring labour for casual work (*ganyu*) by an average of 20 percentage points. However, this effect is only significant at 10 percent in the fractional probit model on the extent of participation in Table 4. If the falling owned land to labour endowment ratio is a push factor in either land rental or agricultural labour factor markets, how are the land rental market decisions influencing hiring out of family labour for casual work? I focus on this question in hypothesis two.

Hypothesis two stated that entry into the land rental market is negatively associated with trading labour for casual work (*ganyu*) in seasonal agricultural labour markets. The recursive bivariate probit model results in Table 3–model 4b, shows that households that rent-in the land are less likely to trade their labour for casual work (*ganyu*). If a farm household rents in the land, the probability of hiring out labour for short-term casual work statistically reduces by 38 percentage points, at one percent significance level. Such a reduction shows how the land markets can improve labour use on own-farm for medium to long-term gains compared to the short-term gains associated with casual labour work within the agricultural sector (Dimowa et al., 2010; Headey & Jayne, 2014). On *Ganyu* as a livelihood coping strategy, Ellis et al. (2003) hinted that households hire out labour for casual work because of absent land rental markets that could facilitate the use of land and labour among smallholder farmers in Malawi. The results in this paper concur with this argument by indicating that land rental markets can reduce hiring out labour for casual work among potential tenant households.

The observed negative association of land rental market decisions on casual labour market decisions is further augmented by the observation that having no pre-rental land is likely to push farm households into renting-in land than hiring out labour. Table 3 shows that at one percent significance level, having no pre-rental land is positively associated with increasing land rentals by 5 percentage points while being negatively associated with hiring out of labour by 11 percentage points on average. These results could imply that households aim at allocating land and labour for own production to achieve self-sufficiency objectives compared to relying on short-term wages from labour markets. Thus, the results support hypothesis two, which calls for the need to consider land rental markets as an affordable means of accessing agricultural land, that can allow for more profitable use of farm household labour among smallholder farmers.

But then I ask, who is capable of renting-in land? Hypotheses three and four partly answer to this question, which I discuss jointly. Hypothesis three stated that an increase in the household asset wealth to labour endowment ratio increases tenant household entry and extent of participation in the land rental markets. Hypothesis four stated that the increase in the household asset wealth to labour endowment ratio reduces entry and extent of hiring out labour for agricultural casual work (*ganyu*). The analysis compares the statistically significant differences across asset wealth to labour endowment ratio quartiles with the highest quartile as the reference group.

From Table 3, the bivariate and recursive bivariate model results show that households in the bottom half of the asset wealth to labour endowment ratio are less likely to rent-in the land compared to the quartiles in the upper half, based on the negative sign in the result tables. However, the negative association is only significant between the lowest and the highest quartiles, which imply that the very poor households in asset wealth relative to labour endowment ratio are rationed out of land rental markets compared to the intermediate groups. In the seasonal agricultural labour markets, the observed association is slightly different. The results indicate that the households across all the lower quartiles compared to the highest quartile are more likely to hire out labour. Being in the $25^{th}$, $50^{th}$ and $75^{th}$ quartile increase the probability of hiring out labour compared to above $75^{th}$ quartile. This suggests that hiring out labour for casual work (*ganyu*) is not only for the very poor but the majority of the smallholder farmers in Malawi.

The results in Table 4 also show a similar effect of asset wealth to labour endowment ratio on the extent of participation in both markets. Overall, the results are consistent with literature that participation in the land rental markets increases with more capital (asset wealth) and labour endowment while the very poor are rationed out (Ricker-Gilbert et al., 2019). On the contrary, hiring out labour for *ganyu* in seasonal agricultural labour markets is generally higher among the poor and the majority of the smallholder farmers because of low capital relative to labour endowment (Fink et al., 2014). The results flag out the farm household capital or liquidity constraints that can affect agricultural activities like renting in the land and how farmers resort to short-term solutions like hiring out labour for casual work (*ganyu*) in Malawi.

## 7. Conclusion

As land scarcity challenges continue to increase in Sub-Saharan Africa (SSA) from both population pressure and increase in urbanisation rates, and as land markets continue to develop in most countries within SSA, the objective of this paper was two-fold. Firstly, I assessed the extent to which the falling owned land to labour endowment ratio and asset wealth relative to labour endowment ratio is affecting the farm household decisions to either rent-in agricultural land or hire out family labour, as the trade response strategies to the growing land scarcity challenges. Secondly, I assessed how the land rental markets are influencing the farm household decision to hire out family labour for short-term agricultural casual work. Using the Malawi Living Standards Measurement Survey data collected in 2013 and 2016, I constructed a balanced household panel data which I combined with district-level rainfall data to control for spatial rainfall related production shocks. I used the system approaches to jointly analyse the decisions to rent-in land or hire out labour while controlling for possible endogeneity, simultaneity and unobserved heterogeneity.

The results indicate that the falling owned land to labour endowment ratio is a push factor for farm households to participate in either the land rental or seasonal agricultural labour markets. However, renting-in agricultural land can reduce entry into the labour markets to engage in casual work and earn short-term wage returns. Using asset wealth to labour endowment ratio, it is the wealthier farm households who are more likely to rent-in the land. The poor in asset wealth relative to labour endowment and the majority of the smallholder farm households are more likely to hire out labour for casual work in Malawi. A higher probability of smallholder farmers hiring out labour for casual work could be a sign of household liquidity constraints related to agricultural operational and other household needs, or higher friction or transaction costs in the land rental markets compared to the labour markets.

To ensure that factor markets efficiently allocate land and labour, agricultural and land-use policies can focus on easing the liquidity burden amongst potential tenant households through programs like input subsidies or cash transfers at the start of the season. On market friction, policy strategies like land campaigns, access to land market information at the community level and even establishing a land bank that can facilitates access to capital for land rental transactions can help farm households to achieve food self-sufficiency and sustain their livelihoods. However, future research is needed on how decisions of both potential tenants and landlords are influencing the agricultural labour market decisions over time.

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## Appendix A

**Table A1: Summary of potential optimal household trade response strategies from the First Order Conditions (FOCs)**

| | | Trade response strategies | | |
|---|---|---|---|---|
| | | Labour (Equation 2) | | |
| | | **Buyer/hiring in** $(L^i > 0)$ | **Non-participant** $(L^i = 0 = L^0)$ | **Seller/hiring out** $(L^o > 0)$ |
| **Land (Equation 1)** | **Buyer/ renting out** $(A^i > 0)$ | ***Hire-in labour or rent-in land***<br>Labour poor<br>**1.** $MR_{L^i} = MC_{L^i}$<br>Land poor<br>**2.** $MR_{A^i} = MC_{A^i}$ | ***Not trading labour but rent-in land***<br>Labour sufficient<br>**1.**$MC_{L^o} < MR_A < MC_{L^i}$<br>Land poor<br>**2.**$MR_{A^i} = MC_{A^i}$ | ***Hire-out labour or rent out the land***<br>Labour rich<br>**1.** $MR_{L^o} = MC_{L^o}$<br>Land poor<br>**2.** $MR_{A^i} = MC_{A^i}$ |
| | **Non-participant** $\begin{pmatrix} A^0 = 0 \\ A^i = 0 \end{pmatrix}$ | ***Hire-in labour and not trading land***<br>Labour poor<br>**1.** $MR_{L^i} = MC_{L^i}$<br>Land sufficient<br>**2.** $MR_{A^o} < MR_A < MC_{A^i}$ | ***Not trading both labour and land***<br>Labour sufficient<br>**1.** $MC_{L^o} < MR_{\bar{L}} < MC_{L^i}$<br>Land sufficient<br>**2.** $MR_{A^o} < MR_{\bar{A}} < MC_{A^i}$ | ***Hire out labour and not trading land***<br>Labour rich<br>**1.** $MR_{L^o} = MC_{L^o}$<br>Land sufficient<br>**2.** $MR_{A^o} < MR_{\bar{A}} < MC_{A^i}$ |

| | ***Hire in labour or rent out the land*** | ***Not trading labour but rent out the land*** | ***Hire out labour or rent out the land*** |
|---|---|---|---|
| **Seller/ renting out** $(\boldsymbol{A^o > 0})$ | Labour poor<br>**1.** $MR_{L^i} = MC_{L^i}$<br>Land rich<br>**2.** $MR_{A^o} = MC_{A^o}$ | Labour sufficient<br>**1.** $MC_{L^o} < MR_{\bar{L}} < MC_{L^i}$<br>Land rich<br>**2.** $MR_{A^o} = MC_{A^o}$ | Labour rich<br>**1.** $MR_{L^o} = MC_{L^o}$<br>Land rich<br>**2.** $MR_{A^o} = MC_{A^o}$ |

Note: MR is marginal revenue and MC is marginal cost with respect to land $(A)$ and labour $(L)$.

**Factor Component Analysis variables for Capital Asset index:**

**(i) Durable assets**

(1) Mortar/pestle (Mtondo); (2) Bed; (3) Table; (4) Chair; (5) Fan; (6) Air conditioner; (7) Radio ('wireless'); (8) Tape or CD/DVD player or HiFi; (9) Television; (10) VCR; (11) Sewing machine; (12) Kerosene/paraffin stove; (13) Electric or gas stove; (14) hot plate; (15) Refrigerator; (16) Washing machine; (17) Bicycle; (18) Motorcycle/scooter; (19) Car; (20) Mini-bus; (21) Lorry; (22) Beer-brewing drum; (23) Upholstered chair; (24) sofa set; (25) Coffee table (for the sitting room); (26) Cupboard; (27) drawers; (28) bureau; (29) Lantern (paraffin); (30) Desk; (31) Clock; (32) Iron (for pressing clothes); (33) Computer equipment & accessories; (34) Satellite dish; (35) Solar panel; (36) Generator; (37) Radio with flash drive/micro CD.

**(1) Farm implements**

(1) Hand Hoe; (2) Slasher; (3) Axe; (4) Sprayer; (5) Panga Knife; (6) Sickle; (7) Treadle Pump; (8) Watering Can; (9) Ox Cart; (10) Ox Plough; (11) Tractor; (12) Tractor Plough; (13) Ridger; (14) Cultivator; (15) Motorised Pump; (16) Grain Mill (17) Chicken House; (18) Livestock Kraal, (19) Poultry Kraal; (20) Storage House; (21) Granary; (22) Pig Sty.

**Table A2: Bivariate Probit model with Conditional Mixed Process (CMP) margins for land rental and casual labour (*ganyu*) market participation**

| | Bivariate probit Random Effects (CMP margins) | | Recursive bivariate probit Random Effects (CMP margins) | | Bivariate probit Correlated Random Effects (CMP margins) | | Recursive bivariate probit Correlated Random Effects (CMP margins) | |
|---|---|---|---|---|---|---|---|---|
| | **1a** | **1b** | **2a** | **2b** | **3a** | **3b** | **4a** | **4b** |
| **VARIABLES** | **Rent in** | **Hire out** | **Rent in** | **Hire out** | **Rent in** | **Hire out** | **Rent in** | **Hire out** |
| **Key variables** | | | | | | | | |
| Land rented-in (1= Yes) | | | | -0.379**** | | | | -0.375**** |
| | | | | (0.09) | | | | (0.09) |
| Own farmland to labour ratio | -0.095** | -0.202**** | -0.101*** | -0.222**** | -0.096** | -0.199**** | -0.102*** | -0.219**** |
| (ha/adult equiv. labour unit) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) |
| Asset wealth index to labour ratio | | | | | | | | |
| Base: Quartile 4 | | | | | | | | |
| Quartile 1 | -0.037** | 0.236**** | -0.045*** | 0.209**** | -0.038** | 0.213**** | -0.046*** | 0.188**** |
| | (0.02) | (0.02) | (0.02) | (0.03) | (0.02) | (0.03) | (0.02) | (0.03) |
| Quartile 2 | -0.005 | 0.275**** | -0.010 | 0.254**** | -0.007 | 0.253**** | -0.011 | 0.235**** |
| | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) |
| Quartile 3 | 0.021 | 0.196**** | 0.019 | 0.190**** | 0.021 | 0.178**** | 0.019 | 0.174**** |
| | (0.01) | (0.02) | (0.01) | (0.02) | (0.02) | (0.02) | (0.01) | (0.02) |
| No pre-rental land (1= yes) | 0.052**** | -0.138**** | 0.047*** | -0.106**** | 0.053**** | -0.132**** | 0.049**** | -0.100**** |
| | (0.01) | (0.02) | (0.01) | (0.02) | (0.02) | (0.02) | (0.01) | (0.02) |
| **Rainfall variations** | | | | | | | | |
| **Positive** deviation (dm) **one-year lag** | 0.001 | -0.007 | -0.000 | -0.006 | 0.001 | -0.006 | -0.000 | -0.006 |
| (Early plus mid-season) | (0.00) | (0.01) | (0.00) | (0.01) | (0.00) | (0.01) | (0.00) | (0.01) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Absolute Negative** deviation (dm) **one-year lag** | 0.020*** | -0.028*** | 0.020*** | -0.018* | 0.020*** | -0.027** | 0.020*** | -0.017 |
| (Early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| **Farm and Household Characteristics** | | | | | | | | |
| **Observed control variables** | | | | | | | | |
| Sex of HH head (1=Female) | -0.040*** | -0.042** | -0.039*** | -0.050*** | | | | |
| | (0.01) | (0.02) | (0.01) | (0.02) | | | | |
| Age of HH head (years) | -0.001* | -0.004**** | -0.001** | -0.004**** | | | | |
| | (0.00) | (0.00) | (0.00) | (0.00) | | | | |
| Education of HH head (years) | 0.001 | -0.014**** | 0.001 | -0.013**** | | | | |
| | (0.00) | (0.00) | (0.00) | (0.00) | | | | |
| Household size to labour ratio | 0.024** | -0.003 | 0.025*** | 0.008 | | | | |
| (No. of persons/adult equiv. labour unit) | (0.01) | (0.02) | (0.01) | (0.02) | | | | |
| Total Livestock Units (TLU) to labour ratio | 0.007 | -0.016 | 0.006 | -0.011 | | | | |
| | (0.01) | (0.02) | (0.00) | (0.02) | | | | |
| One-year lag TLU to labour ratio | 0.004 | -0.054 | 0.003 | -0.046 | | | | |
| | (0.00) | (0.03) | (0.00) | (0.03) | | | | |
| Distance to the nearest city zone (km) | 0.002**** | 0.001 | 0.002**** | 0.001*** | | | | |
| | (0.00) | (0.00) | (0.00) | (0.00) | | | | |
| **Mean of observed control variables** | | | | | | | | |
| Sex of HH head (1=Female) | | | | | -0.040*** | -0.032 | -0.038*** | -0.041** |
| | | | | | (0.01) | (0.02) | (0.01) | (0.02) |
| Age of HH head (years) | | | | | -0.001 | -0.004**** | -0.001* | -0.004**** |
| | | | | | (0.00) | (0.00) | (0.00) | (0.00) |
| Education of HH head (years) | | | | | 0.001 | -0.018**** | 0.001 | -0.016**** |
| | | | | | (0.00) | (0.00) | (0.00) | (0.00) |
| Household size to labour ratio | | | | | 0.035** | 0.009 | 0.033** | 0.021 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (No. of persons/adult equiv. labour unit) | | | | | (0.01) | (0.02) | (0.01) | (0.02) |
| Total Livestock Units (TLU) to labour ratio | | | | | 0.009 | -0.016 | 0.007 | -0.010 |
| | | | | | (0.01) | (0.02) | (0.01) | (0.02) |
| One-year lag TLU to labour ratio | | | | | 0.004 | -0.066 | 0.004 | -0.055 |
| | | | | | (0.01) | (0.04) | (0.01) | (0.04) |
| Distance to the nearest city zone (km) | | | | | 0.002**** | 0.001 | 0.002**** | 0.001*** |
| | | | | | (0.00) | (0.00) | (0.00) | (0.00) |
| **Deviations from the mean** | | | | | | | | |
| Sex of HH head (1=Female) | | | | | -0.037 | -0.083* | -0.031 | -0.088* |
| | | | | | (0.02) | (0.05) | (0.02) | (0.05) |
| Age of HH head (years) | | | | | -0.000 | -0.001 | -0.000 | -0.001 |
| | | | | | (0.00) | (0.00) | (0.00) | (0.00) |
| Education of HH head (years) | | | | | -0.001 | 0.009** | -0.000 | 0.009** |
| | | | | | (0.00) | (0.00) | (0.00) | (0.00) |
| Household size to labour ratio | | | | | 0.009 | -0.030 | 0.011 | -0.023 |
| (No. of persons/ adult equiv. labour) | | | | | (0.01) | (0.02) | (0.01) | (0.02) |
| Total Livestock Units (TLU) to labour ratio | | | | | -0.000 | -0.044 | -0.000 | -0.040 |
| | | | | | (0.01) | (0.04) | (0.01) | (0.04) |
| One-year lag TLU to labour ratio | | | | | 0.004 | -0.019 | 0.003 | -0.017 |
| | | | | | (0.00) | (0.05) | (0.00) | (0.04) |
| Distance to the nearest city zone (km) | | | | | 0.001 | 0.000 | 0.001 | 0.001 |
| | | | | | (0.00) | (0.00) | (0.00) | (0.00) |
| **Regional dummy (1= Central)** | | | | | | | | |
| 2. Northern region | -0.127**** | 0.015 | -0.125**** | -0.036 | -0.128**** | 0.017 | -0.127**** | -0.034 |
| | (0.01) | (0.03) | (0.01) | (0.03) | (0.01) | (0.03) | (0.01) | (0.03) |
| 3. Southern region | -0.073**** | 0.001 | -0.072**** | -0.023 | -0.074**** | -0.003 | -0.073**** | -0.027 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (0.01) | (0.02) | (0.01) | (0.02) | (0.01) | (0.02) | (0.01) | (0.02) |
| 2016.year | -0.016* | 0.223**** | -0.012 | 0.202**** | -0.017* | 0.218**** | -0.015 | 0.198**** |
| | (0.01) | (0.02) | (0.01) | (0.02) | (0.01) | (0.02) | (0.01) | (0.02) |
| N | 3790 | 3790 | 3790 | 3790 | 3790 | 3790 | 3790 | 3790 |

Note: Standard errors in parentheses. The asterisk indicate **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1.

**Table A3: Coefficients of the Bivariate Probit model with Conditional Mixed Process (CMP) for land rental and casual labour market participation**

| | **Bivariate probit Random Effects (CMP coefficients)** | | **Recursive bivariate probit Random Effects (CMP coefficients)** | | **Bivariate probit Correlated Random Effects (CMP coefficients)** | | **Recursive bivariate probit Correlated Random Effects (CMP coefficients)** | |
|---|---|---|---|---|---|---|---|---|
| | **1a** | **1b** | **2a** | **2b** | **3a** | **3b** | **4a** | **4b** |
| **VARIABLES** | **Rent in** | **Hire out** | **Rent in** | **Hire out** | **Rent in** | **Hire out** | **Rent in** | **Hire out** |
| **Key variables** | | | | | | | | |
| Land rented-in (1= Yes) | | | | -1.140**** | | | | -1.134**** |
| | | | | (0.28) | | | | (0.29) |
| Own farmland to labour ratio | -0.633** | -0.594**** | -0.674*** | -0.667**** | -0.638** | -0.589**** | -0.680*** | -0.664**** |
| (ha/adult equiv. labour unit) | (0.27) | (0.12) | (0.23) | (0.13) | (0.27) | (0.12) | (0.24) | (0.13) |
| Asset wealth index to labour ratio | | | | | | | | |
| Base: Quartile 4 | | | | | | | | |
| Quartile 1 | -0.247** | 0.696**** | -0.300*** | 0.630**** | -0.251** | 0.632**** | -0.306*** | 0.571**** |
| | (0.11) | (0.08) | (0.11) | (0.08) | (0.12) | (0.08) | (0.12) | (0.08) |
| Quartile 2 | -0.035 | 0.809**** | -0.064 | 0.766**** | -0.044 | 0.752**** | -0.072 | 0.712**** |
| | (0.11) | (0.07) | (0.10) | (0.08) | (0.11) | (0.07) | (0.11) | (0.08) |
| Quartile 3 | 0.142 | 0.577**** | 0.126 | 0.573**** | 0.140 | 0.529**** | 0.124 | 0.527**** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (0.10) | (0.07) | (0.09) | (0.07) | (0.10) | (0.07) | (0.10) | (0.07) |
| No pre-rental land (1= yes) | 0.347**** | -0.406**** | 0.316*** | -0.318**** | 0.353**** | -0.390**** | 0.324*** | -0.304**** |
| | (0.10) | (0.06) | (0.10) | (0.07) | (0.10) | (0.06) | (0.10) | (0.07) |
| **Rainfall variations** | | | | | | | | |
| **Positive** deviation (dm) **one-year lag** | 0.004 | -0.020 | -0.003 | -0.019 | 0.003 | -0.018 | -0.003 | -0.017 |
| (Early plus mid-season) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) |
| **Absolute Negative** deviation (dm) **one-year lag** | 0.132*** | -0.084*** | 0.131*** | -0.054* | 0.133*** | -0.082** | 0.131*** | -0.052 |
| (Early plus mid-season) | (0.04) | (0.03) | (0.04) | (0.03) | (0.04) | (0.03) | (0.04) | (0.03) |
| **Farm and Household Characteristics** | | | | | | | | |
| **Observed control variables** | | | | | | | | |
| Sex of HH head (1=Female) | -0.268*** | -0.123** | -0.257*** | -0.150*** | | | | |
| | (0.09) | (0.06) | (0.09) | (0.06) | | | | |
| Age of HH head (years) | -0.005* | -0.011**** | -0.006** | -0.011**** | | | | |
| | (0.00) | (0.00) | (0.00) | (0.00) | | | | |
| Education of HH head (years) | 0.004 | -0.041**** | 0.004 | -0.038**** | | | | |
| | (0.01) | (0.01) | (0.01) | (0.01) | | | | |
| Household size to labour ratio | 0.163** | -0.008 | 0.165*** | 0.023 | | | | |
| (No. of persons/adult equiv. labour unit) | (0.06) | (0.05) | (0.06) | (0.05) | | | | |
| Total Livestock Units (TLU) to labour ratio | 0.046 | -0.047 | 0.042 | -0.034 | | | | |
| | (0.04) | (0.07) | (0.03) | (0.05) | | | | |
| One-year lag TLU to labour ratio | 0.027 | -0.159 | 0.023 | -0.140 | | | | |
| | (0.03) | (0.10) | (0.03) | (0.09) | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Distance to the nearest city zone (km) | 0.015**** | 0.002 | 0.015**** | 0.004*** | | | | |
| | (0.00) | (0.00) | (0.00) | (0.00) | | | | |
| **Mean of observed control variables** | | | | | | | | |
| Sex of HH head (1=Female) | | | | | -0.268*** | -0.095 | -0.256*** | -0.123** |
| | | | | | (0.10) | (0.06) | (0.10) | (0.06) |
| Age of HH head (years) | | | | | -0.004 | -0.012**** | -0.006* | -0.012**** |
| | | | | | (0.00) | (0.00) | (0.00) | (0.00) |
| Education of HH head (years) | | | | | 0.005 | -0.053**** | 0.006 | -0.050**** |
| | | | | | (0.01) | (0.01) | (0.01) | (0.01) |
| Household size to labour ratio | | | | | 0.233** | 0.026 | 0.223** | 0.064 |
| (No. of persons/adult equiv. labour unit) | | | | | (0.09) | (0.06) | (0.09) | (0.06) |
| Total Livestock Units (TLU) to labour ratio | | | | | 0.057 | -0.047 | 0.050 | -0.031 |
| | | | | | (0.05) | (0.07) | (0.04) | (0.05) |
| One-year lag TLU to labour ratio | | | | | 0.030 | -0.197 | 0.025 | -0.167 |
| | | | | | (0.05) | (0.12) | (0.05) | (0.11) |
| Distance to the nearest city zone (km) | | | | | 0.015**** | 0.002 | 0.015**** | 0.004*** |
| | | | | | (0.00) | (0.00) | (0.00) | (0.00) |
| **Deviations from the mean** | | | | | | | | |
| Sex of HH head (1=Female) | | | | | -0.250 | -0.247* | -0.210 | -0.267* |
| | | | | | (0.16) | (0.15) | (0.15) | (0.15) |
| Age of HH head (years) | | | | | -0.003 | -0.002 | -0.001 | -0.003 |
| | | | | | (0.01) | (0.01) | (0.01) | (0.01) |
| Education of HH head (years) | | | | | -0.003 | 0.028** | -0.002 | 0.026** |
| | | | | | (0.02) | (0.01) | (0.02) | (0.01) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Household size to labour ratio | | | | | 0.063 | -0.089 | 0.073 | -0.071 |
| (No. of persons/adult equiv. labour unit) | | | | | (0.05) | (0.07) | (0.05) | (0.07) |
| Total Livestock Units (TLU) to labour ratio | | | | | -0.002 | -0.129 | -0.001 | -0.121 |
| | | | | | (0.03) | (0.13) | (0.04) | (0.12) |
| One-year lag TLU to labour ratio | | | | | 0.024 | -0.056 | 0.021 | -0.051 |
| | | | | | (0.02) | (0.15) | (0.02) | (0.13) |
| Distance to the nearest city zone (km) | | | | | 0.005 | 0.001 | 0.003 | 0.002 |
| | | | | | (0.00) | (0.00) | (0.00) | (0.00) |
| **Regional dummy (1= Central)** | | | | | | | | |
| 2. Northern region | -1.168**** | 0.045 | -1.143**** | -0.109 | -1.181**** | 0.050 | -1.155**** | -0.103 |
| | (0.15) | (0.08) | (0.14) | (0.09) | (0.15) | (0.08) | (0.14) | (0.09) |
| 3. Southern region | -0.441**** | 0.004 | -0.436**** | -0.069 | -0.448**** | -0.008 | -0.445**** | -0.081 |
| | (0.09) | (0.06) | (0.09) | (0.06) | (0.09) | (0.06) | (0.09) | (0.06) |
| 2016.year | -0.106* | 0.645**** | -0.081 | 0.600**** | -0.116* | 0.634**** | -0.103 | 0.590**** |
| | (0.06) | (0.05) | (0.06) | (0.05) | (0.06) | (0.05) | (0.07) | (0.05) |
| Constant | -1.633**** | 0.258 | -1.541**** | 0.281 | -1.808**** | 0.375* | -1.679**** | 0.369* |
| | (0.25) | (0.17) | (0.25) | (0.17) | (0.30) | (0.20) | (0.30) | (0.20) |
| atanhrho_12 | | -0.038 | | 0.625*** | | -0.038 | | 0.620*** |
| | | (0.04) | | (0.21) | | (0.04) | | (0.22) |
| Log pseudolikelihood | | -3308.3 | | -3304.3 | | -3289.7 | | -3285.8 |
| Observations | 3,790 | 3,790 | 3,790 | 3,790 | 3,790 | 3,790 | 3,790 | 3,790 |

Note: Standard errors in parentheses. The asterisk indicate **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1.

**Table A4: Systems approach with Tobit for the land rental markets and Fractional Probit for the share of adult equivalent labour hired out for casual work (*ganyu*) with Conditional Mixed Process (CMP) margins.**

| | Random Effects (CMP margins) | | Correlated Random Effects (CMP margins) | |
|---|---|---|---|---|
| **VARIABLES** | **Tobit – Rent in** | **Fractional probit –Hire out** | **Tobit – Rent in** | **Fractional probit – Hire out** |
| **Key variables** | | | | |
| Own farmland to labour ratio | -0.087** | -0.052** | -0.088** | -0.049* |
| (ha/adult equiv. labour unit) | (0.04) | (0.03) | (0.04) | (0.03) |
| Asset wealth index to labour ratio. | | | | |
| Base: Quartile 4 | | | | |
| Quartile 1 | -0.047*** | 0.243**** | -0.047*** | 0.229**** |
| | (0.02) | (0.02) | (0.02) | (0.02) |
| Quartile 2 | -0.014 | 0.185**** | -0.014 | 0.173**** |
| | (0.02) | (0.02) | (0.02) | (0.02) |
| Quartile 3 | 0.017 | 0.105**** | 0.018 | 0.095**** |
| | (0.01) | (0.02) | (0.02) | (0.02) |
| No pre-rental land (1= yes) | 0.054**** | -0.070**** | 0.055**** | -0.067**** |
| | (0.01) | (0.01) | (0.01) | (0.01) |
| **Rainfall variations** | | | | |
| **Positive** deviation (dm) **one-year lag** | -0.001 | -0.001 | -0.001 | -0.000 |
| (Early plus mid-season) | (0.00) | (0.00) | (0.00) | (0.00) |
| **Absolute Negative** deviation (dm) **one-year lag** | 0.018*** | -0.013* | 0.018*** | -0.013* |
| (Early plus mid-season) | (0.01) | (0.01) | (0.01) | (0.01) |
| **Farm and Household Characteristics** | | | | |
| **Observed control variables** | | | | |
| Sex of HH head (1=Female) | -0.045**** | -0.030** | | |

| | | | | |
|---|---|---|---|---|
| | (0.01) | (0.01) | | |
| Age of HH head (years) | -0.001 | -0.003**** | | |
| | (0.00) | (0.00) | | |
| Education of HH head (years) | 0.001 | -0.010**** | | |
| | (0.00) | (0.00) | | |
| Household size to labour ratio | 0.026*** | -0.011 | | |
| (No. of persons/adult equiv. labour unit) | (0.01) | (0.01) | | |
| Total Livestock Units (TLU) to labour ratio | 0.007 | -0.026 | | |
| | (0.01) | (0.03) | | |
| One-year lag TLU to labour ratio | 0.005 | -0.022 | | |
| | (0.00) | (0.02) | | |
| Distance to the nearest city zone (km) | 0.002**** | 0.001** | | |
| | (0.00) | (0.00) | | |
| **Mean of observed control variables** | | | | |
| Sex of HH head (1=Female) | | | -0.044*** | -0.018 |
| | | | (0.01) | (0.01) |
| Age of HH head (years) | | | -0.000 | -0.004**** |
| | | | (0.00) | (0.00) |
| Education of HH head (years) | | | 0.001 | -0.012**** |
| | | | (0.00) | (0.00) |
| Household size to labour ratio | | | 0.037*** | -0.017 |
| (No. of persons/adult equiv. labour unit) | | | (0.01) | (0.02) |
| Total Livestock Units (TLU) to labour ratio | | | 0.009 | -0.024 |
| | | | (0.01) | (0.03) |
| One-year lag TLU to labour ratio | | | 0.005 | -0.041 |
| | | | (0.01) | (0.03) |

| | | | | |
|---|---|---|---|---|
| Distance to the nearest city zone (km) | | | 0.002**** | 0.001** |
| | | | (0.00) | (0.00) |
| **Deviations from the mean** | | | | |
| Sex of HH head (1=Female) | | | -0.044* | -0.080** |
| | | | (0.02) | (0.03) |
| Age of HH head (years) | | | -0.000 | 0.000 |
| | | | (0.00) | (0.00) |
| Education of HH head (years) | | | -0.002 | 0.004 |
| | | | (0.00) | (0.00) |
| Household size to labour ratio | | | 0.009 | -0.005 |
| (No. of persons/adult equiv. labour unit) | | | (0.01) | (0.02) |
| Total Livestock Units (TLU) to labour ratio | | | -0.001 | -0.038 |
| | | | (0.01) | (0.04) |
| One-year lag TLU to labour ratio | | | 0.004 | 0.011 |
| | | | (0.00) | (0.03) |
| Distance to the nearest city zone (km) | | | 0.001 | 0.001 |
| | | | (0.00) | (0.00) |
| **Regional dummy (1= Central)** | | | | |
| 2. Northern region | -0.129**** | -0.004 | -0.131**** | -0.001 |
| | (0.01) | (0.02) | (0.01) | (0.02) |
| 3. Southern region | -0.066**** | -0.007 | -0.068**** | -0.010 |
| | (0.01) | (0.01) | (0.01) | (0.01) |
| 2016.year | -0.011 | 0.108**** | -0.013 | 0.102**** |
| | (0.01) | (0.01) | (0.01) | (0.01) |
| N | 3790 | 3790 | 3790 | 3790 |

Note: Standard errors in parentheses. The asterisks indicate **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1.

**Table A5: Systems approach with Tobit for the land rental markets and Fractional Probit for the share of adult equivalent labour hired out for casual work (*ganyu*) with Conditional Mixed Process (CMP) coefficients.**

| | Random Effects (CMP margins) | | Correlated Random Effects (CMP margins) | |
|---|---|---|---|---|
| **VARIABLES** | **Tobit – Rent in** | **Fractional probit – Hire out** | **Tobit – Rent in** | **Fractional probit – Hire out** |
| **Key variables** | | | | |
| Own farmland to labour ratio | -0.549** | -0.172** | -0.552** | -0.164* |
| (ha/adult equiv. labour unit) | (0.23) | (0.09) | (0.23) | (0.09) |
| Asset wealth index to labour ratio Base: Quartile 4 | | | | |
| Quartile 1 | -0.299*** | 0.806**** | -0.297*** | 0.764**** |
| | (0.11) | (0.06) | (0.11) | (0.06) |
| Quartile 2 | -0.087 | 0.613**** | -0.091 | 0.575**** |
| | (0.10) | (0.06) | (0.10) | (0.06) |
| Quartile 3 | 0.109 | 0.347**** | 0.112 | 0.316**** |
| | (0.09) | (0.06) | (0.10) | (0.06) |
| No pre-rental land (1= yes) | 0.342**** | -0.232**** | 0.346**** | -0.222**** |
| | (0.09) | (0.05) | (0.09) | (0.05) |
| **Rainfall variations** | | | | |
| **Positive** deviation (dm) **one-year lag** | -0.007 | -0.002 | -0.007 | -0.001 |
| (Early plus mid-season) | (0.02) | (0.01) | (0.02) | (0.01) |
| **Absolute Negative** deviation (dm) **one-year lag** | 0.111*** | -0.043* | 0.110*** | -0.043* |
| (Early plus mid-season) | (0.04) | (0.02) | (0.04) | (0.02) |
| **Farm and Household Characteristics** | | | | |
| **Observed control variables** | -0.281**** | -0.100** | | |
| Sex of HH head (1=Female) | (0.08) | (0.04) | | |
| | -0.004 | -0.011**** | | |

| | | | | |
|---|---|---|---|---|
| Age of HH head (years) | (0.00) | (0.00) | | |
| | 0.004 | -0.032**** | | |
| Education of HH head (years) | (0.01) | (0.00) | | |
| | 0.162*** | -0.035 | | |
| Household size to labour ratio | (0.06) | (0.04) | | |
| (No. of persons/adult equiv. labour unit) | 0.044 | -0.087 | | |
| Total Livestock Units (TLU) to labour ratio | (0.04) | (0.10) | | |
| | 0.029 | -0.072 | | |
| One-year lag TLU to labour ratio | (0.03) | (0.08) | | |
| | 0.015**** | 0.002** | | |
| Distance to the nearest city zone (km) | (0.00) | (0.00) | | |
| **Mean of observed control variables** | | | | |
| Sex of HH head (1=Female) | | | -0.277*** | -0.061 |
| | | | (0.09) | (0.04) |
| Age of HH head (years) | | | -0.003 | -0.013**** |
| | | | (0.00) | (0.00) |
| Education of HH head (years) | | | 0.007 | -0.040**** |
| | | | (0.01) | (0.01) |
| Household size to labour ratio | | | 0.234*** | -0.056 |
| (No. of persons/adult equiv. labour unit) | | | (0.09) | (0.05) |
| Total Livestock Units (TLU) to labour ratio | | | 0.056 | -0.079 |
| | | | (0.05) | (0.09) |
| One-year lag TLU to labour ratio | | | 0.032 | -0.136 |
| | | | (0.05) | (0.10) |
| Distance to the nearest city zone (km) | | | 0.016**** | 0.002** |
| | | | (0.00) | (0.00) |

| | | | | |
|---|---|---|---|---|
| **Deviations from the mean** | | | | |
| Sex of HH head (1=Female) | | | -0.275* | -0.265** |
| | | | (0.15) | (0.10) |
| Age of HH head (years) | | | -0.001 | 0.000 |
| | | | (0.01) | (0.00) |
| Education of HH head (years) | | | -0.010 | 0.013 |
| | | | (0.02) | (0.01) |
| Household size to labour ratio | | | 0.058 | -0.016 |
| (No. of persons/adult equiv. labour unit) | | | (0.04) | (0.06) |
| Total Livestock Units (TLU) to labour ratio | | | -0.006 | -0.128 |
| | | | (0.04) | (0.12) |
| One-year lag TLU to labour ratio | | | 0.025 | 0.036 |
| | | | (0.02) | (0.10) |
| Distance to the nearest city zone (km) | | | 0.005 | 0.002 |
| | | | (0.00) | (0.00) |
| **Regional dummy (1= Central)** | | | | |
| 2. Northern region | -1.145**** | -0.014 | -1.156**** | -0.005 |
| | (0.16) | (0.06) | (0.16) | (0.06) |
| 3. Southern region | -0.380**** | -0.024 | -0.387**** | -0.032 |
| | (0.08) | (0.04) | (0.08) | (0.04) |
| 2016.year | -0.072 | 0.358**** | -0.084 | 0.338**** |
| | (0.06) | (0.03) | (0.06) | (0.04) |
| Constant | -1.614**** | -0.421*** | -1.802**** | -0.230 |
| | (0.25) | (0.13) | (0.31) | (0.16) |
| lnsig_1 | | -0.040 | | -0.043 |
| | | (0.06) | | (0.06) |

| | | | | |
|---|---|---|---|---|
| atanhrho_12 | | -0.018 | | -0.018 |
| | | (0.03) | | (0.03) |
| Log pseudolikelihood | | -3160.5 | | -3160.5 |
| Observations | 3,790 | 3,790 | 3,790 | 3,790 |

Note: Standard errors in parentheses. The asterisks indicate **** p<0.001, *** p<0.01, ** p<0.05, * p<0.1.

# Errata

Norwegian University
of Life Sciences

# FORM 4.7 Errata
## Application for permission to correct formal errors in the thesis

Errata is a list of corrections made in a thesis after it has been approved, but before it is printed.

The PhD candidate may apply for permission to correct formal errors in the thesis (cf. the PhD regulations, section15.3-2). The application must include a complete list of the errors that the PhD candidate wishes to correct. The application must be e-mailed to the faculty PhD contact person at the latest 4 weeks before the planned disputation date.

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| | |
|---|---|
| Name of PhD candidate: | Sarah Ephrida Tione |
| Thesis title: | Land markets and agricultural household decisions nexus in Malawi |

The application is to be signed by the PhD candidate and the main supervisor and sent to the faculty for approval.

**Signatures and dates:**

| | | | |
|---|---|---|---|
| PhD candidate: | | Date: | 22/12/2020 |

| | | | |
|---|---|---|---|
| Main supervisor: | Stein T Holden | Date: | 21/12-2020 |

Errata approved by the faculty: Yes ☑ No ☐

| | | | |
|---|---|---|---|
| For the faculty: | Frode Alfnes | Date: | 04.01.2021 |

# Errata list

PhD candidate: Sarah Ephrida Tione
Thesis: Land markets and agricultural household decisions nexus in Malawi
Date: 22nd December, 2020

| Page | Line | Original text | Corrected text |
|---|---|---|---|
| 3 | 20 | sections | section |
| 3 | 27 | 7 | 6 |
| 3 | 27 | between | above |
| 3 | 28 | and | or |
| 11 | 13 | unit | constant |
| 52 | 12 | The | the |
| 60 | 5 | 6 | 5 |
| 60 | 19 | 7 | 6 |
| 61 | 14 | 0.55 | 0.53 |
| 61 | 16 | 0.55 | 0.52 |
| 62 | 38 | 0.52 | 0.53 |
| 68 | 8 | 30 | 32 |
| 69 | 27 | they | it |
| 110 | 10 | purcahes | purchases |
| 154 | 22 | agricultural | deleted text |
| 166 | 7 | households | household |
| 173 | 15 | quartile which | quartile, which |
| 171 | 12 | share of male labour | deleted text |
| 174 | 17 | earning | earn |

# Sarah Ephrida Tione

Sarah Tione was born on 18th June 1985 and grew up in Lilongwe, Malawi. She holds a BSc. Degree in Agriculture (Agricultural Economics) obtained in 2007 and MSc. Degree in Agricultural and Applied Economics obtained in 2011. She obtained both degrees from the University of Malawi, Bunda College, now called Lilongwe University of Agriculture and Natural Resources (LUANAR). Sarah currently works as an Economist in the Planning Department of the Ministry of Agriculture in Malawi.

This thesis assesses the changing trends in land transactions, opportunities and constraints in land rental markets that facilitate transfers and distribution of agricultural land among smallholder farm households in Malawi. Four independent but related empirical research papers in this thesis mainly apply the farm household decision theoretical framework and uses three rounds of the Living Standards Measurement Surveys and rainfall data from Malawi.

From the research work, this thesis recommends the need for land policy discussions to focus on improving farm household-level access to agricultural land amidst land scarcity challenges in Malawi. Development policies on agricultural and land-use should promote land campaigns that can improve low-cost access to land market information at the local or community level.

Overall, the policy interventions should aim at reducing frictions and easing the capital burden in factor markets, particularly amongst smallholder farm households with the potential of accessing land through land rental markets. Such interventions in the land markets can sustain livelihoods and contribute to the transformation of both rural and urban areas, as land scarcity challenges continue in Malawi and across countries in Sub-Saharan Africa.

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