LAND RENTAL MARKETS, INVESTMENT AND PRODUCTIVITY UNDER CUSTOMARY LAND TENURE SYSTEMS IN MALAWI

Jordleiemarked, investeringer og produktivitet under tradisjonelt jordeiendomsregime i Malawi

Philosophiae Doctor (PhD) Thesis

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DEDICATION

To my Dad, **Witman Joseph Lunduka,** who taught me
“Aim high, get low, is not a failure.......”

To my brother **Brighton Witman Lunduka** who encouraged me to aim high**.**

Guys know that am still aiming high.

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ABSTRACT

As customary land tenure remains the predominant model of landholding in rural Africa and land the cornerstone of rural livelihood security, improving land tenure security is often equated with integration of customary land law into the modern statutory law of the state. The integration has been aimed at being adaptive to the market and supportive of existing socio-cultural institutions. However, existing socio-cultural institutions do not all the time provide secure tenure to all members of the rural community. Formalization of land following the existing social cultural institutions can lead to putting certain groups of people in the rural community at risk of losing their land.

In Malawi, there are both matrilineal and patrilineal land inheritance systems. Under these systems, a household can reside in either a patrilocal (man's village of origin), a matrilocal (woman's village of origin), or a neolocal (neutral village) locations. Households in the patrilocal location of residence are more tenure secure than households in matrilocal and neolocal location of residence. It is therefore important to understand how the customary tenure system affects land management and investment decisions under the different tenure security regimes. This thesis investigates the customary land tenure systems in Malawi and how the tenure security they provide affect households' decisions on land rental market participation, investments on land and maize production efficiency.

The first paper investigates how tenure security affects land rental participation. Evidence that emerging land rental markets in Malawi have redistributed land from land-rich to land-poor households was significant. However, households residing on a woman's village of origin participate less in land rental market than households residing in man's village of origin. The second paper investigates the probability and intensity of investing in trees under secure and insecure land tenure systems. The probability of investing in trees is high in patrilocal and neolocal residence households, but low in matrilocal residence households. Although neolocal residence households are insecure, they increase their tenure security by investment, while matrilocal resident households do not have the ability to change their security. The third paper examines how farmers' resource endowment affects how much they invest in short term inputs of organic manure

and inorganic fertilizers. Results show that input use are constrained by the resource endowment of the farmer, mainly livestock, labour and liquidity assets. Therefore, if a household is secure and able to accumulate resources it is able to invest more in short run. The fourth and last paper investigates differences in maize production efficiency in secure and insecure households. The results show that insecure households have lower production efficiency than secure households.

Evidence from the study suggests that the current customary tenure system does not provide enough tenure security to households living in woman's village of origin. Land reforms that do not take into account these insecurities may marginalize these insecure households.

SAMMENDRAG

Tradisjonelle former for eiendomsrett til land er de mest vanlige i rurale områder av Afrika, og rettigheter til land er avgjørende for levekårene til de som bor på landsbygda. Det settes ofte likhetstegn mellom sikre landretter og integrering av tradisjonelle rettighetssystemer i moderne formelle, kodifiserte, landretter. Det har vært lagt vekt på at denne integrasjonen skal være tilpasset landmarkedene og i samsvar med eksisterende sosiokulturelle institusjoner. Men eksisterende sosiokulturelle institusjoner sikrer ikke alltid rettigheter til land for alle medlemmer av landsbysamfunnet. Formalisering av rettigheter i samsvar med de eksisterende sosiokulturelle institusjoner kan føre til at enkelte grupper av mennesker settes i fare for å miste sine retter til land.

I Malawi fines både matrilineære og patrilineære arvesystemer. Under begge disse systemene kan et hushold enten bo patrilokalt (i mannens landsby), matrilokalt (i konas landsby), eller neolokalt (i en nøytral landsby). Hushold som bor patrilokalt har sikrere rettigheter til land enn matrilokale eller neolokale hushold. Det er derfor viktig å forstå hvordan tradisjonelle rettighetssystemer påvirker bruken av land og bøndenes investeringsbeslutninger. I denne avhandlingen undersøkes hvordan tradisjonelle rettighetssystemer i Malawi virker, og hvordan forskjeller i sikkerhet for rettigheter påvirker husholdenes beslutninger om deltakelse i leiemarkeder for land, investeringer i jordbruket, og effektivitet i maisproduksjonen.

Avhandlingen består av fire artikler. Den første artikkelen undersøker hvordan forskjeller i sikkerhet for landrettigheter påvirker deltakelse i leiemarkeder for land. Leiemarkedene som er undersøkt bidrar til å omfordele land fra landrike hushold til landfattige hushold. Matrilokale hushold deltar mindre i leiemarkeder enn patrilokale hushold.

Artikkel to undersøker sannsynligheten for, og omfanget av, investering i treplanting under sikre og mindre sikre retter til land. Sannsynligheten for treplanting er høy for patrilokale og neolokale hushold, men lav for matrilokale hushold. Selv om neolokale hushold har mindre sikre landrettigheter, kan de øke sikkerheten sin ved å plante trær på det landområdet de bruker, mens for matrilokale hushold er det ikke mulig å øke sikkerheten på denne måten.

Artikkel tre undersøker hvordan forskjeller i bøndenes formue påvirker hvor mye de investerer i kortsiktige innsatsvarer som kunstgjødsel og organisk gjødsel. Vi finner at bruken av disse innsatsvarene er begrenset av bøndenes tilgang til ressurser, ikke minst tilgangen til husdyr (storfe og småfe), arbeidskraft og likvide eiendeler. Dersom et hushold har sikre landretter og er i stand til å akkumulere ressurser, er det også i stand til å gjøre kortsiktige investeringer.

Artikkel fire undersøker forskjeller i husholdenes produksjonseffektivitet i maisdyrking, avhengig av hvorvidt de har sikre eller mindre sikre rettigheter til land. Vi finner at hushold med usikre rettigheter har lavere effektivitet i produksjonen enn de som har sikrere rettigheter.

Funnene i disse studiene indikerer at de nåværende tradisjonelle rettighetssystemene for land i Malawi ikke gir tilstrekkelig sikkerhet for rettighetene til matrilokale hushold, hushold som bor i konas landsby. Landreformer som ikke tar hensyn til denne usikkerheten kan komme i skade for å marginalisere disse usikre husholdene.

1.0 INTRODUCTION

Customary land rights offer access to land and security of tenure to many poor households in sub-Saharan Africa (SSA). These rights differ according to cultural and matrimonial residence practices, providing different property rights and land ownership. The ways in which access to land is regulated, property rights are defined and land ownership conflicts are resolved have broader implications beyond agricultural production (Deininger and Binswanger 2001). However, under the influence of market forces, customary land rights are capable of autonomous evolution in an efficiency-enhancing direction (Platteau, 1996). The nexus between customary land tenure and market forces on one hand and regulation and policy on the other is crucial because it affects agricultural production and livelihoods in many poor households.

In Malawi, about 84% of the arable land is under the customary tenure system (Government of Malawi, 2002). This customary tenure system is complex, diverse and elusive, creating different constraints for agricultural production through insecurity of tenure (Place and Ostuka 2001). The government acknowledges that the failure to push through reform and secure the tenure rights of smallholder farmers has long been a primary cause of under-investment and reliance on primitive technology and is the fundamental reason for low wages in rural areas (Government of Malawi 2002). Efforts to reform the customary land system date back to the late 60s and early 70s, when the government of Malawi implemented the Lilongwe Land Development Programme (LLDP), supported by the World Bank. The overall aim of the main programme was increased agricultural productivity. Customary land reform and development was a means to that end, aiming to "re-organize land tenure systems from usufruct to consolidated holdings under a registered deed of freehold title, thus making land preservation and improvement worthwhile to the individual" (Mbalanje, 1986). A review of the Lilongwe Land Development Programme found that even though "privatisation through tenure conversion has been carried out … very little has changed (PCILPR 1998:48). The review further claims, "None of the benefits predicted by policy planners, such as greater 'security' of ownership, negotiability of title, and a robust land market, have materialised," (op.cit.). The form of privatisation of customary land carried out under the LLDP has tended to "erode customary social values and institutions especially in matrilineal societies" (PCILPR 1998:50). Therefore, there is a need to study the customary land tenure institution and learn how it operates in proving tenure security. At this time, the government has reviewed the national land policy, but the legislation for providing a framework for the policy is pending in the National Assembly due to disagreements between the government and traditional leaders. Clearly, further studies on the land tenure system will provide insight into how to implement the land reform.

In 1994, Malawi changed its political system from a one-party to a multi-party democracy. The change in democratic politics was followed by a rise in the encroachment on tea and tobacco private estates, government forest reserves and national parks by local people who wanted to get back the land that was taken from them by the government to give to private investors or to become forest reserves or national parks. These developments were associated with sometimes-violent conflicts when encroachers were removed from the private or public land. The immediate response of the government was to review the land policy based on an empirical assessment. The revision of the policy was based on several studies (Green 1996; Bosworth 1997; Gossage 1997; Chanthunya 1998; Liuma 1998; Msisha 1998) that mainly focus on a broader review of the land problems in the country. The customary land was viewed as being under siege from external influences—e.g., government powers—seeking to dispose of it. Therefore, most of the studies have viewed the land issue as one between the customary land on one hand and the private-owned or public land on the other hand. None of the studies has critically looked at the current customary land tenure system to evaluate its shortfalls and identify ways of improving its management via the new land policy.

The revised land policy recommends titling all customary land but does not specify whose name the title to the land will state. Assuming that the title will list a household name or will jointly list a man and a woman presumes that the kinsmen of the resident spouse will allow a person they consider a "stranger" to become a title-holder on land that they consider part of their heritage. In the case of death or divorce, can the surviving spouse be allowed to marry and bring a new partner into the village in which he is regarded as a stranger? (Kishindo, 2004). Besley (1995) points out that granting "legal rights" to land in the customary tenure system should not be viewed as a panacea for problems of low growth and investment before understanding the evolution of the rights themselves within the system. Active state interventions in 'kick starting' markets in 20th century green revolutions suggest that another major difficulty may be current policies which emphasize the benefits of liberalization and state withdrawal but fail to address critical institutional constraints to market and economic development in poor rural areas Dorward et al.(2004). It is indeed important to understand how the traditional customary system has evolved to cope with land scarcity and how that evolution is affecting management and investment decisions. This thesis looks at customary land tenure systems in Malawi and how they affect tenure security and decisions regarding land rental market participation, investments and land productivity.

This task is approached in four independent papers whose titles are as follows:

Paper I: Land rental market participation and tenure security in Malawi

Paper II: Land tenure security and investments in tree-planting

Paper III: Soil fertility and input use in maize production under the customary land tenure system in Malawi

Paper IV: Does customary tenure security affect Technical efficiency in maize production*?(A two stage bootstrap efficiency estimation procedure)*

2.0 LAND RIGHTS AND LAND TENURE SECURITY

2.1 Land rights

Until recently, customary land rights in sub-Saharan Africa were thought of as being ambiguous and communal with no sufficient protection in legislation. This was argued to be the main cause of inefficiencies in resource allocation (Sjaastad and Bromley, 1997). However, we now understand that the customary rights are neither ambiguous nor communal; they are flexible enough to cope with increasing land scarcity, and state intervention is often more harmful than beneficial if they are not well understood (Sjaastad and Bromley 1997). Considerable flexibility in customary land tenure arrangements has been observed due to, among other things, an increase in population and market penetration. These have given rise to gradual but meaningful changes in land practices in the direction of enhanced individualisation of tenure, the development of land markets and a shift from matrilineal to patrilineal inheritance patterns (Platteau 2000). The deepening individualisation takes place along two main dimensions: the range of rights and extent of autonomy afforded by the landholder in exercising these rights (Platteau 1996). In this thesis, a “land right” is referred to as a claim to a benefit stream that is protected through the assignment of duty to others who may covet or somehow interfere with the benefit stream (Bromley 1991). Bromley suggests that protection is by the state, but it can also be provided by another authority in society. Therefore, customary land rights may or may not be protected by the state, but they are seen here as involved in a triadic social relation including a benefit stream, rights-holders, and duty bearers (the authority in the society) (figure 1).

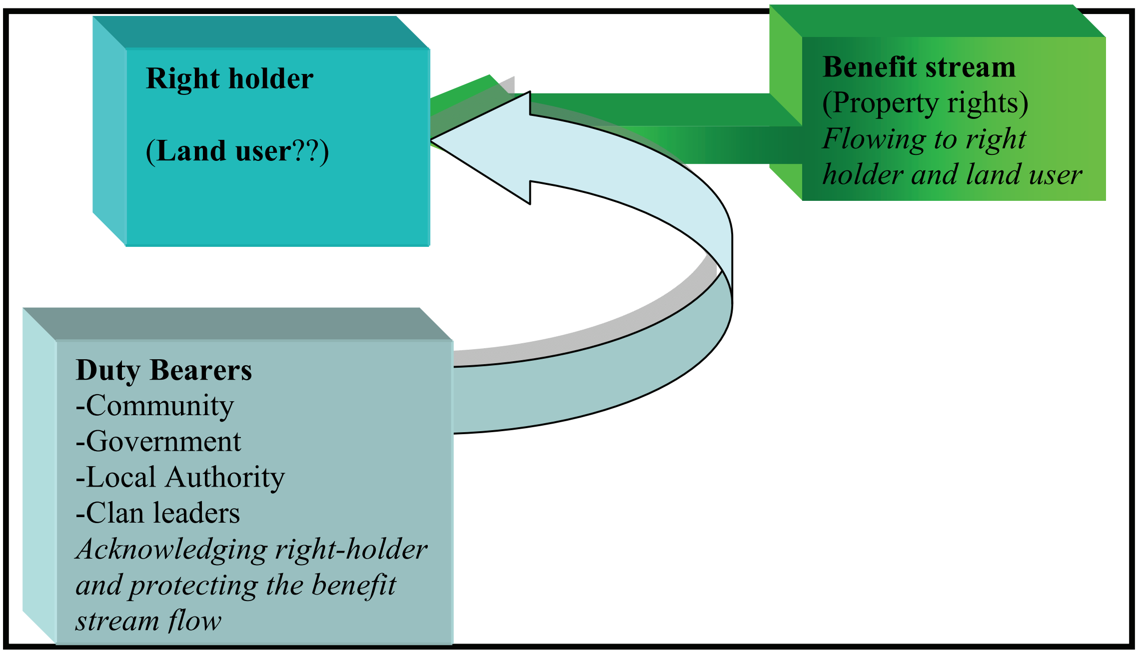

Figure 1: Triadic social relationship of benefits stream, rights-holders and duty bearers

Land tenure is therefore the social relation that determines who can use which land and how (Lastarria-Cornhiel 2001). This gives certain rights to the benefit stream. It is empirically useful to distinguish between access rights to land and ownership rights for land. Access rights to land simply mean that a person is able to make use of the land and enjoy its benefits in the meantime, while ownership rights entail the perpetual enjoyment of the stream of benefits from the land (Bruce and Migot-Adholla 1994). The customary tenure system may not grant all rights to the user of the land, and the society may hold some rights that hinder the user of the land to make some decisions—e.g., investments or renting out land. These arrangements are studied here to provide insights into how government intervention can be arranged—e.g., who holds the rights to land and how that affects land use.

2.2 Land security

Place and Swallow (2000) define security as having three components: a) breadth (i.e., type of rights held—e.g., right to sell or rent out, which Brasselle *et al.* (2002) call the realisation effect); b) duration (how long the land is held under the given rights); and c) assurance. Place and Swallow's (2000) categorisation is similar to that of Brasselle *et al.*(2002) in that they both include the breadth of rights, the duration and assurance. However, Brasselle *et al.* (2002) combine breadth and duration into assurance. Therefore, the main dilemma a farmer faces is what situation he/she will face after time *t*. Hence, Sjaastad and Bromley (1997) define tenure security as the perceived probability of losing ownership of the land. Barrow and Roth (1989) define tenure security more broadly as the perception of the likelihood of losing a specific right to a given parcel of land.

Secure land tenure has been argued to increase investment incentives for three main reasons. The first is the assurance effect, which is when a farmer feels more secure in maintaining the long-term use of the land and in the returns on long-term land improvements Brasselle *et al.* (2002). The second is the realisation effect, or tradability, which is the ability to convert land into liquid assets through land sales or land rentals. This makes land available to more efficient users. The third is collateralisation effects, which is the ability to use land as collateral to access credit. Many studies have looked at the empirical evidence of the former but have found inconsistent results. Studies on the second effect have been hampered mostly by the lack of land markets in most customary land tenure systems. However, evidence is surfacing of emerging land markets in Africa and particularly in Malawi (Holden *et al.* 2006; Holden *et al.,* 2009).

This study adds to the existing literature by providing additional evidence regarding emerging land markets in Malawi. These are, however, constrained by insecure tenure rights. I therefore assess households' participation in land rental markets (the realisation effect), which is determined by (among other things) the probability of maintaining or losing rights to transacted land. The study also adds to the discussion of the linkage between investments and tenure security by providing some explanation for the inconsistencies in past studies. This is done by investigating the ability to invest in the long term (agro-forestry and non-agro-forestry trees) and short term (i.e., the assurance effect: the right to recover returns on investment in the short and long term) of secure and insecure households. The study finally looks at the effect of tenure security on land productivity.

3.0 CONCEPTUAL FRAMEWORK

This section develops a theoretical conceptual framework that is used in this thesis (see figure 2). The framework is based on property rights theory and how the customary land tenure system and government policy affects land productivity and equity through investments and land markets. Platteau (1996) summarises the property rights theory, applying it to land rights in sub-Saharan Africa, and calls it "the evolutionary theory of land rights" (ETLR). The basic contention of the ETLR is that as land scarcity increases, the value of land increases more than the transaction cost of privatisation and hence, people demand more land tenure security. As a result of this demand, private property rights for land tend to emerge and, once established, to evolve towards greater measures of individualisation and formalisation. One major right is the right to benefits from investment. This then increases investments and creates land markets where land can be transferred to more efficient users. Therefore, land productivity is increased through the investments and the land market. At an advanced stage in the individualisation process, land transactions become increasingly supported by written documents, in which the involvement of the government can be called for to legally protect the land titles.

On the other hand, the supply of these rights is influenced by individuals with experiences and high roles in the community. These people are also called innovators (Lin and Nugent, 1995). The expected benefits associated with gaining individual property rights to land depend on these individuals. The traditional inheritance rules—e.g., patrilineal systems under which use rights are bequeathed from farmers to sons—can easily evolve into individual right systems favouring men, whereas a matrilineal system in which members of a large extended family have partial rights to land tends to preserve extended family ownership system (Otsuka and Place 2001). This makes land in the matrilineal inheritance system insecure so that it does not follow the ETLR.

Based on the proposed ETLR, Sjaastad and Bromley (1997) summarise the problems related to indigenous tenure security, noting three factors that affect efficiency and equity: lack of legal title to land, the absence of land markets and high transaction cost associated with establishing ownership. These three arguments have also been used in favour of property rights (Deininger and Binswanger 2001). This thesis is developed based on these problems (mainly the last two) and shows the relationship between land market and the high transaction cost with the customary tenure system. The first problem associated with the indigenous or customary tenure system is the lack of a legal title to land, which reduces its value as collateral. As a result, indigenous land cannot be used to obtain credit to purchase resources for investment in agricultural land, thereby increasing land productivity. Even if the customary tenure system provided enough tenure security, the lack of a formal title makes it impossible to enter into the formal credit market, which demands legal documentation for collateral, for which reason access to credit is possible only after obtaining formal land titles. In this thesis, access to credit is not investigated because none of the customary land (except for Lilongwe) had legal land titles associated with it. Additionally, there are other constraints on obtaining credit, which implies that even if titles were available for loan collateral, credit would not be extended.

The second problem associated with the indigenous/customary tenure system is the absence of land markets, which makes it impossible for farmers to convert fixed land assets into other asset forms. Due to a lack of written records, the transferability of land is not easy; there is asymmetric information available about land ownership and quality. However, as land becomes scarce in Malawi, its economic value is increasing, and land transactions (mainly fixed land rentals) are becoming common (Holden et al. 2006). The common land transactions in Malawi are informal land rental markets. Due to imperfections in other non-land factor markets like the labour market, the tenancy market is used as an alternative adjustment mechanism. This market transfers land to more productive farmers, thus minimising efficiency losses (Tikabo and Holden 2003). However, participation in this market is based upon acquiring ownership rights to land and insurance that the land will revert back to the owner after tenancy period. The first paper in this thesis studies the development of land rental markets under the customary tenure system, examining who is able to participate in the market given the tenure rights provided by the system.

The last problem is that the high transaction cost of establishing ownership reduces the value of an investment. Tenure security is expected to have an impact on long-term investment because it affects the expected future benefits. Important examples are semi-fixed investments in trees. The benefits range from increased output and tree resources to increased tenure security. Sjaastad and Bromley (1997) develop an alternative view of the evolution of land rights that says that investment is necessary to obtain security of tenure. Therefore, even an insecure household can invest in land if it is sure of recovering benefits from the investment and that land security will be high. Papers 2 and 3 review how investments are made under the customary tenure system in the short and long term. Paper 2 specifically presents under what circumstances this kind of long-term investment is possible.

Public policy intervention is aimed at harmonising the customary tenure system and legalising land tenure ownership to increase efficiency and equity. However, based on differences in the systems like matrilineal and patrilineal inheritance practices, the security of tenure differs and provides different opportunities to farmers. These differences are mainly differences in tenure security, which affects access to credit, land rental market participation, and long- and short-term investment. All of these elements affect land productivity. Paper 4 looks at the two major land tenure inheritance systems in Malawi and how they affect land productivity.

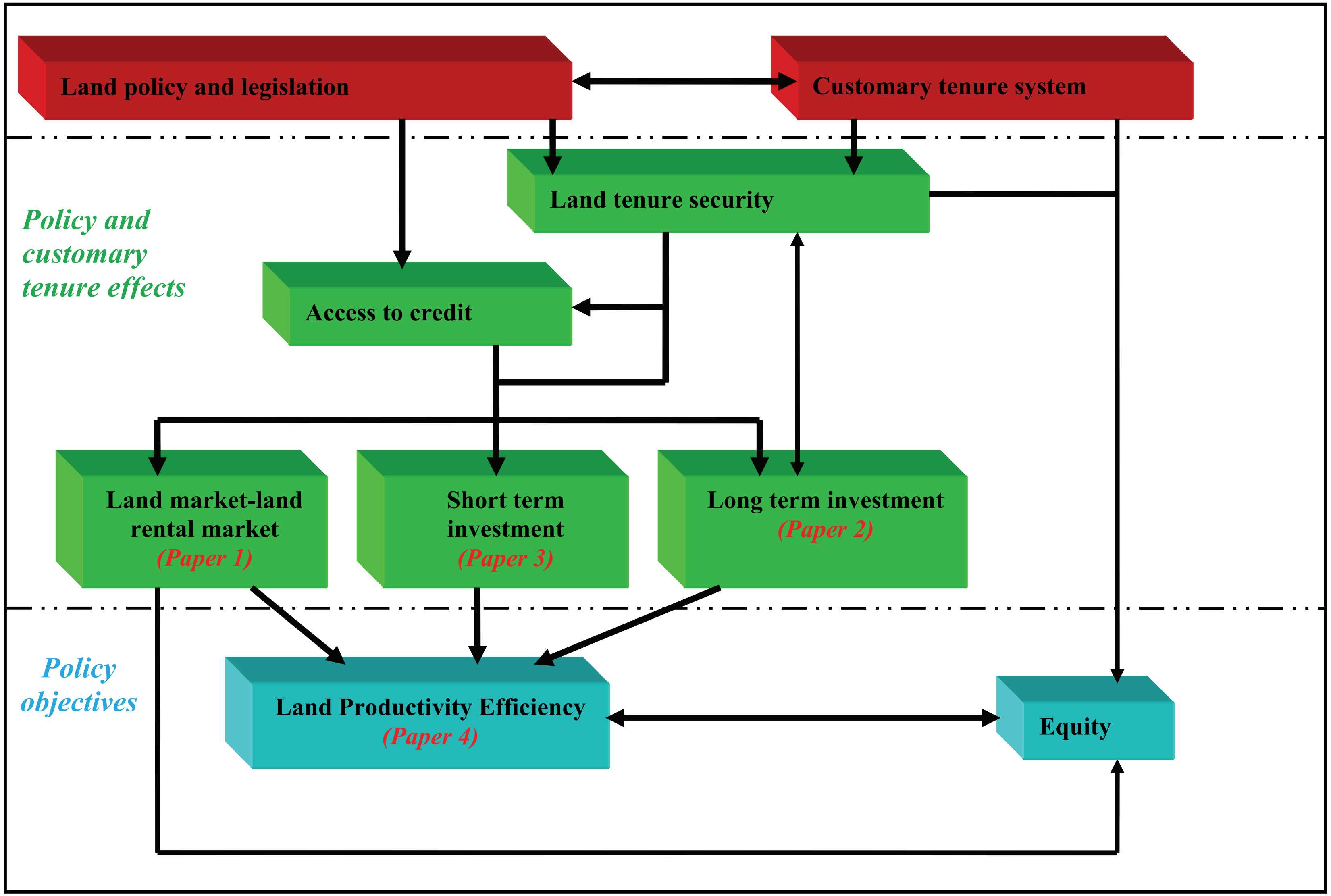

Figure 2: Conceptual framework for the relationship between customary land tenure and policy on land productivity and equity

4.0 THE CUSTOMARY TENURE SYSTEM IN MALAWI

The Land Act of 1965[1] and its amendments provided for the operation of three legally recognised tenure regimes in Malawi: the public tenure system[2], the private tenure system[3] and the customary tenure system[4]. The customary tenure system is by far the largest in terms of land area and the number of people working. The Government of Malawi (2002) estimates that a total of 6.5 million hectares (84%) of arable land is available to smallholder farmers, much of which is under the customary tenure system. The Act vests in the President of Malawi the right to public and customary land through the ministry responsible for land in perpetuity. However, the minister responsible for land delegates the control and administration of customary land to chiefs. Chiefs are empowered to authorise the use and occupation of any customary land within their areas in accordance with customary laws (Kishindo 2004).

4.1 Customary law and land inheritance

Under the customary laws*,* land is managed according to matrilineal and patrilineal principles, norms and practices. These norms and practices have to do with what anthropologists have traditionally identified and studied as "kinship systems", or more specifically, systems of kinship and descent. When individuals are related as kin through a female line, this is called matrilineal descent, while individuals related through a male line form an instance of patrilineal descent (Holden et al, 2006). In terms of land inheritance, we can note that in the matrilineal system, land is passed on to dependants through the mother's kinsmen—i.e., the mother herself, her brother, her parent or even her grandparent. This land is given mostly to female dependants but can also be given to a male dependant. In the patrilineal system, land is passed on through the male side—i.e., the father, his brothers, or his parents. Here, land is mainly given to male dependants but can also be given to female dependants.

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[1] Recently, the new land bill proposed a distinction between government, public and private land, the latter of which will include customary estates (the current customary land when registered).

[2] Public land is defined as that which is occupied, used or acquired by the government and any other land that is not customary or private; this includes settlement schemes, national parks, forest reserves and lapsed leaseholds.

[3] Private land is defined as that which is held or owned under a freehold or leasehold title or a Certificate of Claim; it also includes land registered under the Registered Land Act

[4] Customary land is that which is held or used under customary law.

4.2 Residential location

Matrilineal or patrilineal descent and the inheritance of land rights do not mean that a married couple necessarily settles down with the woman's or man's relatives. A newly married couple can settle in the woman's (matrilocal), the man's (patrilocal), or a neutral (neo-local) village depending on what they agree upon, which in most cases is determined by the availability of land and resources to buy land or of the man to pay a bride price. Taking this into account, the descent or inheritance systems can be distinguished from the residence location after marriage. Figure 3 below shows a distinction between the inheritance system and the location residence.

The first residence location where a married couple settles in the woman's village is called the matrilocal/uxorilocal residence. The woman inherits land from her parents, and the husband moves from his village to settle in the wife's village. He is first given the user rights to the land. He cannot have ownership rights and hence, in the case of divorce or of the death of the spouse, is expected to go back to his original village. It should be noted that even though the land is given to the wife by her parent, she may not have all rights to the land because some rights may be held by the family clan head. A man of in the matrilineal context, as brother or uncle to the women of the clan, has the role of "guardian" or "responsible relative", *nkhoswe* in Chichewa (Butler 1976). As a senior male member of the matrilineage, the man (as brother or uncle) could also have authority as *mwini-mbumba* (literally, owner of the matrilineal group) (Holden et al. 2006). This convention was developed to protect the women from men's marrying into the area and taking over ownership of the land from the women. The *mwini-mbumba* most often has the right to bequeath, subdivide or even sell the land. This has implications for the household that uses the land because there is uncertainty regarding the long-term availability of the land as the *mwini-mbumba* can sell or assign someone to take over the use of the land.

The second residence location is patrilocal/virilocal. In this residence system, the man's village is the matrimonial home, and the man pays *lobola (Chitengwa)* or a bride price to the wife's parents to establish his right to take his wife and children to his own village. Land is inherited from the man's parents. In most cases, the man is given full ownership rights. Therefore, he passes on the land to his own children (male or female) and hence can invest more in the future of the family.

The third and last residential location is neolocal. In this case, marriages are negotiated on neutral ground and tend to disadvantage women because the man in most cases assumes ownership of the land. Both man and woman leave their homes and settle in a neutral village where the land is either bought or given to the couple by the resident chief. Land ownership is mostly awarded to the head of the household, the man.

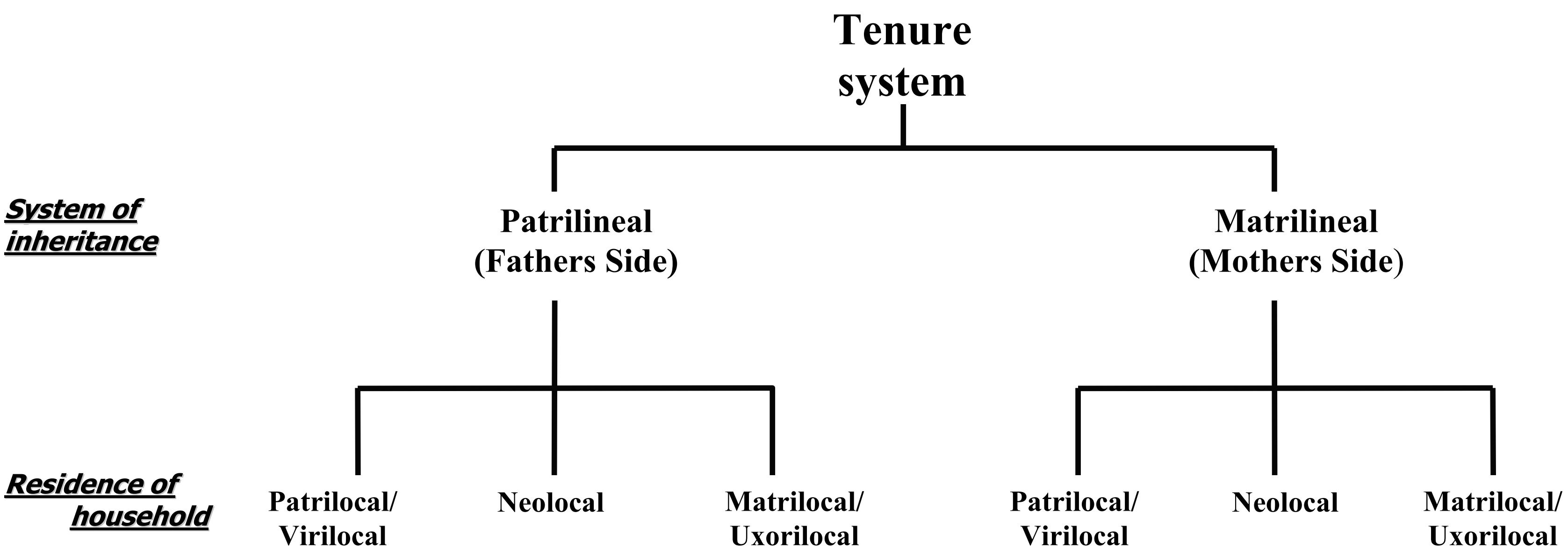


Figure 3: Land inheritance system and residence location

4.3 Sources of tenure insecurity

In the policy and land regulation setup, insecurity of tenure for customary land comes from the unfettered exercise of the ministerial power to dispose of customary land. Within the customary system itself, the instability of marriages, spousal death and the status of the right-holders in the community also affect tenure security (Kishindo, 2004). Due to the fundamental characteristics of land as a resource that is immobile in physical terms (Holden, et al. 2009), insecurity is common for men in matrilocal marriages and for women in patrilocal marriages because they move to join their spouses in forming households. While members of the local kinship group enjoy lifetime use of the land allocated to them, non-indigenous people do not enjoy such security, particularly in the early years of settlement (Kishindo 2004). Their situation upon the death of the wife/husband or upon a divorce is insecure, and they may have to leave the land and their children. For the men, it seems that this may have a negative effect on their willingness to invest in the land. Place and Otsuka (2001a) have found some evidence of this with regard to investment in tree planting in Malawi. Women in matrilineal and virilocal marriages similarly are very tenure insecure.

Failure on the part of immigrants to attend funerals or to participate in community projects may justify the revocation of land rights and eviction from a village. This insecurity can deter immigrants from making long-term investments in land (Kishindo 2004). Another weak group that may have insecure property rights is orphans (Mbaya 2002). Children who become orphans and thus depend on grandparents or other relatives for their survival and their rights to the land of their parents may also be insecure. Relatives may take the land without compensation.

Another source of insecurity is that by vesting the right to customary land in the president through the minister responsible for land, and by vesting the powers of control and administration in the chiefs, the Land Act effectively transferred the legal title to customary land from communities to the government machinery (Kishindo 2004). The government can therefore make decisions regarding customary land without being answerable to the communities. Most of the tobacco estates were established from customary land (Gossage 1997). The Act in its present form is a source of insecurity because powers given to the president, minister or chief, allow them to get customary land for any purpose anytime. Therefore, land can be taken away from local communities by these authorities anytime.

In this study, we use the first and second sources of insecurity to demonstrate the effect of insecurity on the customary land tenure system because it is the most common of the three. Since the introduction of multiparty politics in Malawi in 1994, government policies and actions have always been careful in order to gain popularity during voting; hence, there have been fewer or no cases of customary land being taken by the government.

5.0 DATA SOURCE FOR THE STUDY

The data used in this report are from the six districts of Thyolo, Chiradzulu, Zomba, Machinga in the southern region and Lilongwe and Kasungu in the central region. These districts were purposefully selected to capture pressing and varying land issues in Malawi. Thyolo and Chiradzulu were selected because they are the most populated districts in Malawi. They have the highest rural population density figures: 343 and 379 people per square kilometre, respectively. The average population density for the southern region is 185 people per square kilometre (National Statistical Office, 2008). Zomba and Machinga are in the south but are not as populated and thus were selected to represent a medium level of density. These four districts all feature matrilineal land inheritance. The central region districts of Lilongwe and Kasungu practice patrilineal inheritance system and were selected because of their close proximity to the city in the case of Lilongwe which has strong market influence. Kasungu was selected due to large land sizes and tobacco estate influence. These are also relatively low-density compared to the southern region districts.

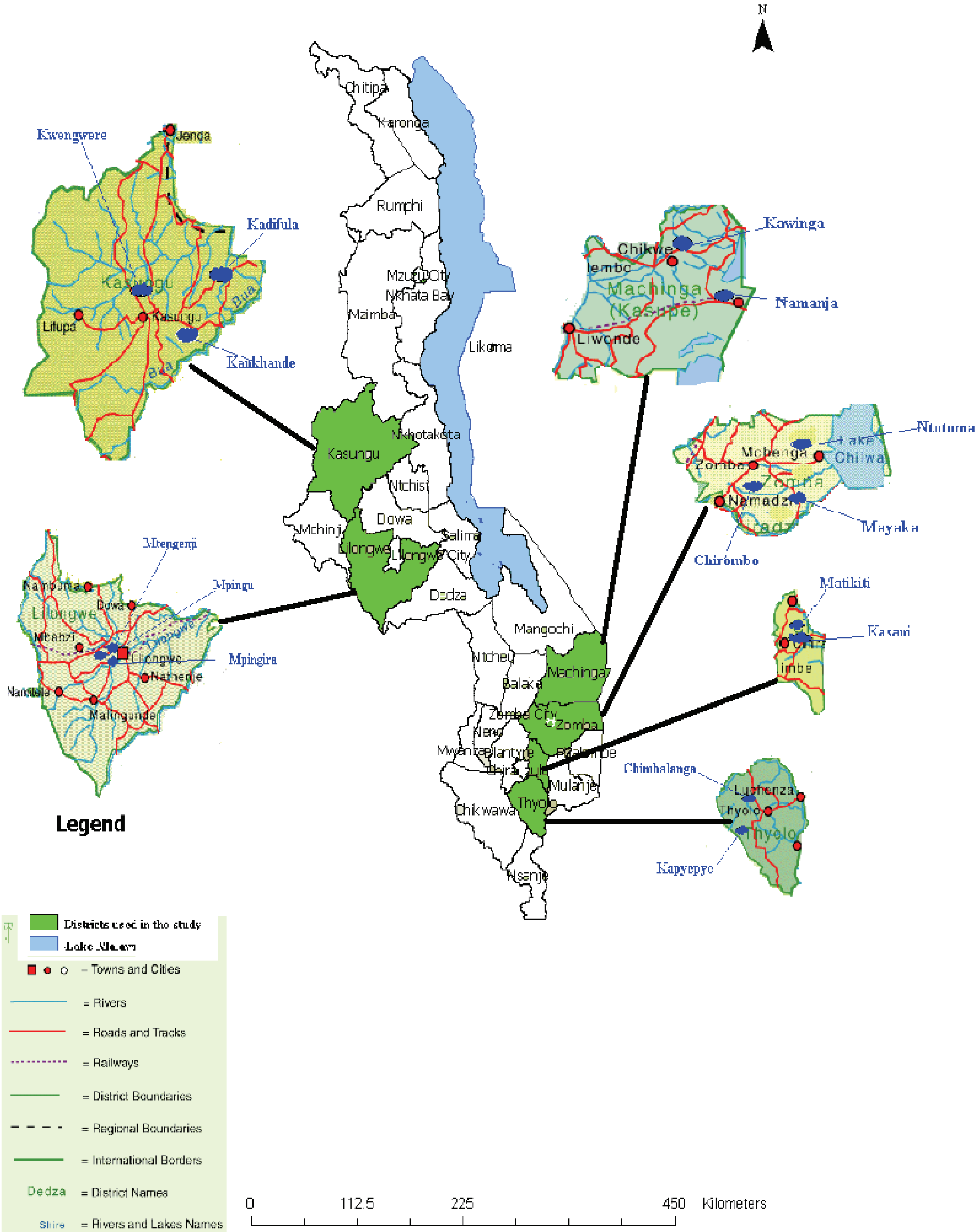
The primary sampling units (PSU) were the Enumeration areas (EAs) following the integrated household survey of 2004 by the National Statistical Office, Malawi. The household population figures used for the EAs are those from the 1998 Population census. In the Thyolo, Chiradzulu and Machinga districts, two EAs were randomly selected, and in the Zomba, Kasungu and Lilongwe districts, three EAs were randomly selected. In each EA, 30 households were randomly selected, yielding a total of 450 households. Figure 4 and Table 1 below show the districts and the main villages in the EAs selected for the study.

In 2006 and 2007, growing-season household surveys were conducted in the six districts. They were done at the end of the agricultural season in June, with the same households visited during both years. Two data collection methods were used. First, focus group discussions were conducted with randomly selected groups in each of the enumeration areas. This helped to illuminate key community issues mainly dealing with the customary land tenure practice in terms of the transfer of land rights, tenure security and marriage practices. The second method was the administration of a detailed questionnaire to the 450 households; the questionnaire had to do with household and plot information. A plot was defined based on major crop grown. The physical measurements of plot size were conducted using Geographical Positioning System (GPS) equipment. Although the data were collected for two different years in the same households, they were not used as a panel because there was not enough time to observe significant changes in time-variant variables. Therefore, the data were used separately for each year. Paper 1 used the 2006 data, and the other three papers used the 2007 data.

Table 1: Districts, main villages in enumeration area and number of households sampled

Region	*District*	*No of Enumeration areas*	*Main Village in enumeration area*	*No of households*
Southern	**Thyolo**	2	Chimbalanga	30
			Kapyepye	30
	Chiradzulu	2	Kasani	30
			Matikiti	30
	Zomba	3	Mtutuma	30
			Mayaka	30
			Chirombo	30
	Machinga	2	Kawinga	30
			Namanja	30
Central	**Lilongwe**	3	Mpingu	30
			Mtengenji	30
			Mpingira	30
	Kasungu	3	Kadifula	30
			Kankhande	30
			Kwengwere	30
Total				450

Figure 4: Map of Malawi showing districts and sites sampled for this study



6.0 ANALYTICAL APPROACH

The analysis in all 4 papers in this thesis is done on the primary data collected in Malawi in 2006 and 2007. Econometric analysis is mainly conducted using non-linear models. The dependent variables in all 4 papers are either categorical or censored. Therefore, probit and tobit models have been the "workhorses" in the analysis. The data collected and model specification posed some estimation problems that would have made the estimates inconsistent.

First, data was collected from central and southern regions of the country where the communities follow different land inheritance systems, patrilineal and matrilineal respectively. The geographical difference in these two regions also affects agricultural production and practices. The central region districts of Lilongwe and Kasungu are in the high agricultural production areas of the country. Combining the households in patrilineal and matrilineal households in the analysis can confound the results of effect of tenure security with geographical differences. Therefore, analysis on the effects of tenure security on land rental market, investment and technical efficiency are done separately for the patrilineal (central region) and matrilineal (southern region).

The second problem is measurement error. Papers 1, 2 and 4 study the impact of tenure security on land markets, investment and production efficiency, respectively. Major problems in estimating the impacts of tenure security have arisen in measuring tenure rights themselves and addressing the endogeneity of tenure rights. Several approaches have been used to address measurement error, ranging from the simple counting of rights, or dichotomous variables, to the use of a categorical variable based on an internally consistent hierarchy of rights (Brasselle et al., 2002). However, for all of these methods, there is a need to accurately measure the rights and security of the household. Using the rights and security position of the household head in the survey can lead to measurement errors due to a) overlapping rights, such that the exact level of security may not be estimated; b) self-reporting of the rights; and c) the difficulty of capturing the wide range of rights. Therefore, estimates of tenure security based on sets of rights can be inconsistent (Wooldridge, 2002).

Indicator variables are used to solve the measurement error problem (Wooldridge, 2002). It is assumed that tenure rights are determined by the tenure security systems—i.e., matrilineal or patrilineal systems—and furthermore by the household residential location—i.e., matrilocal, patrilocal, or neolocal. It is also assumed that a patrilocal residence gives more security to the man, the presumed household head; therefore, in a household in a patrilocal residence, the household head has full control of the land. Matrilocal residence provides less security to the household head; therefore, a household residing in a matrilocal location does not enjoy full control of the land. Replacing tenure security rights with the location of residence puts the measurement error into the error term. The location of residence is an indicator variable. This is different from classical error in variables (CEV) in that using the indicator variable assumes that the measurement error has zero covariance with the location of residence; therefore, the composite error is independent of the explanatory variables.

$$y = L\delta + x\beta + \left(e\theta \ + u\right)$$

where y is the dependent variable—e.g., land rented or tree planted or production efficiency—L is the location of residence, x are other explanatory variables and $e\theta$ is the measurement error estimate. The composite error term now has a mean of zero and is uncorrelated with the explanatory variables; however, the efficiency of the standard error is lost, and the variance of the error term is now the sum of the variance of the error term plus the variance of measurement error.

$$Var\left(u - e\gamma\right) = \sigma^2 + \gamma^2\sigma^2$$

The model estimates are now consistent (Wooldridge, 2002 p. 74).

The third problem with the analysis was endogenous explanatory variables. Several methods were used to solve this problem, but the main solution was the use of instrumental variables. The models that have been used are instrumental tobit for censored data (papers 1, 2 and 3) and instrumental probit (papers 1, 2and 3). In paper 2, a two-stage maximum likelihood analysis has been used to solve the endogenous explanatory variable problem, with the first stage involving a multi-normial logistic model before a tobit model applied to the dependent variable for investments. In paper 3, in addition to the instrumental tobit models, a two- step censored systems analysis was used to allow for the correlation of the error terms for the inorganic fertiliser and organic manure models.

Lastly, paper 4 used a Data Envelop Analysis (DEA) to calculate the technical efficiency score and analysed the determinants of technical efficiency using a truncated model. The major problem with DEA is that it does not take into account random error. Because the form of analysis cannot take into account such statistical noise, the efficiency estimates may be biased if the production process is largely characterised by stochastic elements, a phenomenon common in smallholder agriculture. Plot- and household-specific characteristics can have a significant influence on technical efficiency. To address this, propensity matching methods using the nearest neighbour were used on the DEA scores to compare patrilocal and matrilocal household plots. In principle, this involved matching plots and households with similar characteristics and evaluating whether they had different DEA scores. This at least controlled for plot-specific characteristics like fertility, texture and slope.

7.0 SUMMARY OF MAIN FINDINGS

<u>Paper I</u>: Lunduka, R., Holden, S. T. and Øygard, R. (2009). *Land Rental Market Participation and Tenure Security in Malawi*. In Holden, S. T., Otsuka, K. and Place, F. (Eds.). *The Emergence of Land Markets in Africa: Impacts on Poverty and Efficiency*. 2009 Resources for the Future Press, Washington D.C.

The main objective of this paper was to determine the effects of tenure security on individuals' decisions to participate in the land rental market as landlords or as tenants and on the degree of participation. In this paper, we refer to the Bliss and Stern (1982) model that argues that participation in the land market is an attempt to make up for the difference between the desired cultivated area and the land owned and that this difference is the net land leased-in. The household can either adjust non-land endowments (e.g., labour) if the markets for these work perfectly or, in cases in which these markets do not work (common in SSA), adjust land size in the market. However, making the decision to participate in the land rental market demands having certain rights to land. We therefore hypothesised that households that are secure have more land rights including the right to rent in or rent out land, hence being able to participate in the land rental market.

To isolate the effects of tenure security on land rental participation, we used random effects instrumental probit models to consider the probability of individuals' participating in the land rental market as landlords or as tenants and employed instrumental tobit models to assess the degree of participation. We found that households in patrilineal areas were more likely to rent out and that they rented out significantly more land than in matrilineal areas. Patrilocal households rented in significantly more land than did matrilocal households, both overall and separately, in matrilineal and patrilineal areas. Evidence that emerging land rental markets in Malawi have redistributed land from land-rich to land-poor households was significant. Due to the dual land tenure system, land security and the bundle of rights that one acquires vary and affect decisions regarding land rental market participation.

<u>Paper II</u>: Land tenure security and investments in tree planting

The objective was to assess in what context of insecurity of tenure a household decides to invest. Several studies linking tenure security and investment have found inconsistent results. The major inconsistency was that some insecure households were found to invest in their land. I therefore estimated the probability of investing under secure and insecure household settings. Insecure households were further separated into two groups, ones that can change their level of security and others that cannot change their level of security.

I used an instrumental variable probit model (IVP) to predict the probability of investing in tree planting and employed a two-stage conditional maximum likelihood (2SCML) and an instrumental truncated model to predict the intensity of tree planting at plot-level. The results show that investments in tree planting were high for the secure households and for insecure households that could increase their security. Households that are secure now and will be so in future were able to invest both in non-agro-forestry and in agro-forestry (productive) trees. Insecure households that could increase their security were able to invest more in non-agro-forestry trees. Insecure households that would not change their level of security had a lesser probability of investing in tree planting. Therefore, I concluded that some of the inconsistencies observed in the studies that found insecure households investing were due to poor definition of the context of insecurity.

Paper III: Soil fertility and input use in maize production under customary tenure system in Malawi

Soil fertility depletion from soil erosion and nutrient mining is a major problem affecting agriculture in Malawi. To address the problem, the government of Malawi has been promoting the integrated use of organic manure and inorganic fertiliser. Soil scientists have established that these technologies perform different functions in the soil and that hence, to improve soil fertility, they have to be used complementarily. However, empirical research into social economics has found that farmers use organic manure and inorganic fertilisers as substitutes for one another. Due to lack of markets for organic manure and inefficient markets for inorganic fertilisers, the use of these inputs depends on farmers' resource endowments, and surprisingly, most of the social economic studies have not controlled for the resource endowments of the farmers. Using data from smallholder farmers in Malawi, the resource endowments of the farmers are controlled for. The paper made use of three empirical estimation models: a) an instrumental tobit model to assess the determinants of using inorganic and organic fertiliser, b) a two-tier model for evaluating factors affecting how much inputs to use on a plot; and c) a two-step censored systems analysis intended to allow the correlation of the error terms for the two inputs. This was done because it is assumed that these inputs are used as compliments or substitutes; hence use of one affects the use and amount of use of the other. The study found that smallholder farmers use inorganic fertiliser and organic manure as complements at lower amounts. However, large amounts of input use are constrained by the amounts of resources at the farmer's disposal: mainly livestock, labour and liquidity assets. Hence, there is a negative relationship that has been taken as substitution when resource endowments are not fully controlled for.

<u>Paper IV</u>: Does customary tenure security affect technical efficiency in maize production *(A two stage bootstrap efficiency estimation procedure)*

After finding evidence of more tenure secure households' participating in land rental markets to adjust their land according to their resources endowments and that same households invest more in productive trees, I evaluated whether such activities lead to greater technical efficiency in maize production. I estimated the differences in the technical efficiency of the main staple food, maize, between tenure-secure (patrilocal) and -insecure (matrilocal) households.

The paper used non-parametric and parametric techniques. Efficiency scores were calculated using the computer programme Frontier Efficiency Analysis with R (FEAR), and their standard errors were corrected using the bootstrap procedure. These were then regressed against environmental factors that affect efficiency, including tenure security, using a truncated model. The propensity-matching method using the nearest neighbour to control for plot- and household-specific characteristics was employed to compare DEA scores in matrilocal and patrilocal households. The study found that patrilocal residence location households are more efficient than are matrilocal residence location households. This difference was attributed to the difference in land sizes and in the ability to invest in land through long-term technologies: e.g., contour bunds and vetiver grass.

8.0 CONCLUSION AND POLICY IMPLICATIONS

Customary tenure systems are complex and often poorly understood by policymakers. The current systems used in Malawi provide tenure security to only some households. This affects households' decisions regarding land management and land productivity. The above studies show that apart from tenure security's affecting land rental market participation, it also affects investment decisions and land productivity. A residence location in the man's village (patrilocal) provides more security to the man and hence gives him the ability to participate in land rental markets and encourages him to invest more in both productive agro-forestry tree and non-agro-forestry trees. However, immigrants, who are supposedly insecure due to a lack of hereditary roots in the new area, invest more in security-enhancing tree planting. This indicates that the customary system allows for new settlers to own land, which provides the opportunity for settlement programmes to be successful.

Tenure security is centred on the household head, who is most often the man. Therefore, increasing the security of the household means increasing the security of the man. However, this has equity consequences in that women will be marginalised. Addressing efficiency and equity issues at the same time will be a challenge. However, the source of insecurity for women is not just within the household but also within their kinship group. Women need to be empowered to own land and not depend on kin for some decisions—e.g., renting out. The planned land reform entails a closer integration of the traditional system and statutory law and government. Care needs to be taken to ensure equity because the current customary land tenure practice is inadequate for ensuring an equal distribution of rights to land to men and women. Place and Ostuka (2001a) find that the tenure system in Malawi is evolving towards a patrilocal residence arrangement without government intervention. The gender-neutral approach is contrary to current practice and my cause resentment among those who benefit from the status quo or enforce biases towards the current beneficiaries (men).

The two main customary systems in Malawi impose additional challenges to a land policy reform that should identify reform solutions for both parties under a unified law. The discriminatory rules that the new reforms aim to eliminate may not be effective due to the local land right inheritance system and marriage arrangements: e.g., gaining ownership rights to land, for a man moving into a new village where he marries, may create a source of conflict between the man and the wife's kinsmen. With emphasis on the promotion of investment, for which men are more responsible, there is an efficiency and growth argument for giving men greater tenure security and more rights in the matrilocal residence context, while a similar argument may not be presented with the same strength for giving women equal tenure rights in the patrilocal residence context. However, there is strong international pressure encouraging land reforms that aim to strengthen women's land rights. This is based on a human rights perspective aiming for equal rights for men and women. Therefore, deliberate and radical policy interventions can be justified to ensure equity between men and women.

This thesis has demonstrated that the land tenure system in Malawi introduces insecurity based on gender through the residence location of household as shown by participation in land markets, investments and effects on land productivity. These conditions may also affect how the new reforms should be implemented, interpreted and used by the various local stakeholders, including men and women within family networks.

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Paper I

Chapter 6

Land Rental Market Participation and Tenure Security in Malawi

RODNEY LUNDUKA, STEIN HOLDEN ,
AND RAGNAR ØYGARD

Security of property rights for agricultural land has been argued to have important effects on investments, access to credit, and the functioning of land sales and rental markets (Feder and Feeny 1991; Besley 1995; de Soto 2000). In many parts of sub-Saharan Africa, the system of communal property rights on cultivated agricultural fields has moved in direction of more individualized rights (Bruce and Migot-Adholla 1993; Otsuka and Place 2001). Under individualized property rights and immobility of land, when partners move together to make a household, the moving partner gains only limited rights to that land, and may be less tenure secure than the partner. For example, in patrilocal societies women often obtain usufruct rights to family land, but do not possess inheritance rights (Lastarria-Cornhiel 2001). When, or if, the marriage is terminated through death or divorce, the partner who brings land into the family may have more secure rights to the land than the other partner (see Chapter 9). Other sources of insecurity recognized in literature are land conflict, unclarified land rights, and attempts by tenants to squat in rented land (Deininger 2003; Chapter 13).

Several studies have assessed the impact of tenure security on investments (Deininger and Jin 2006; Amsalu and de Graaff 2006; Place and Hazell 1993; Place and Otsuka 2002; Braselle et al. 2002; Feder and Feeny 1991; Platteau 1996) and have found diverging results. Few studies have looked at tenure security and land rental market participation in Africa (see Chapters 3, 4, 5, and 7 for details). In examining the challenges facing land rental markets in the Europe and Central Asia Region, Vranken and Swinnen (2006) indicated that security of ownership is a condition for the efficient operation of land rental markets. Where land rights are insecure, landlords are reluctant to rent out for longer periods, are less likely to use formal contracts, and restrict renting to farms from the same ethnic or social group. Macours et al. (2004) found that in the Dominican Republic insecure property rights not only reduce the level of activity on land rentals but they also induce segmentation. Landlords who have reasons to fear losing their land will restrict renting to narrow local circles of confidence. Despite tenure security being a very highly debated issue in Africa, few studies have examined the relationship between emerging land markets and tenure security. In this chapter we focus on the link between tenure security and participation in the emerging land rental markets in Malawi.

Holden et al. (2006) provided evidence of emerging land rental markets in Malawi through which land-poor households are able to access land through the markets. However, the inheritance system provides differing tenure security to individuals in the household depending on the amount of land they bring into marriage and their residential area. The amount of land brought into marriage may affect the household decision either to rent in more land or rent out excess land. The bargaining power of the individuals plays an important role in the final decision on use of land. Quisumbing and Maluccio (2003) found that land brought into marriage by either spouse influenced decisions regarding the use of household resources.

This chapter uses random effects instrumental probit and tobit models to analyze how intrahousehold land rights and tenure security affect decisions to participate in the land rental market as landlords or as tenants, and by how much to participate. We propose that individuals who reside in the home area of their spouse tend to be more insecure and they have weaker rights to make decisions on the land—and therefore are less able to participate in land rental markets. Based on the assumption that insecure individual rights to land at the beginning of marriage reduces the bargaining position of an individual in a household, this study tests whether the inheritance system (matrilineal or patrilineal) and residence (patrilocal or matrilocal) affect land renting decisions. It is hypothesized that men are more active in the land rental market if they possess stronger land rights.

Land Tenure System in Malawi

There are three legally recognized tenure regimes operating in Malawi: the public tenure system[1], the private tenure system[2], and the customary tenure system[3]. The customary tenure system is by far the largest in terms of land area and the number of people working. Customary tenure systems in the late 1970s operated on about 80% of the total arable land, and by 1997 less than 10% had been converted to leasehold.

Within the customary tenure sector, the methods of land transfer differ principally according to descent practices—namely, matrilineal or patrilineal—and to residency practices—namely, patrilocal (wife residing in the husband's village) or matrilocal or uxorilocal (husband residing in wife's village) (Place and Otsuka 2001a). In the matrilineal system, as Peters (2002) reports, descent, succession, and inheritance run through the matriline. Marriage is overwhelmingly uxorilocal, so that men marry into a village and use the land belonging to their wives' families. Land is passed matrilineally, but almost all passes go to daughters and not to sons. This is because sons leave; that is, they get married and are then expected to use land belonging to their wives (Peters2002). Therefore, in such a system women have more secure land rights than men. Men married under an uxorilocal system may experience insecurity, as their continued enjoyment of land rights in the matrimonial village depends on the longevity of the marriage (Place and Otsuka 2001a). A divorced man or one who has been predeceased by his wife is expected to return to his own village. The children remain in their mother's village because they are deemed to belong to their mother's matrilineage. Young men still living at home or who return for periods between divorce and remarriage (which is common) maybe given a field to use by their mothers or sisters. However, it is very rare for a married man to have full rights to a field belonging to his matrilineage. In some cases married sons who have received fields are in families where there is no daughter who can inherit, or who have large amounts of land—more than sufficient for the claims of daughters.

The other system, common in the northern part of the country, is both patrilineal (receiving land through the father's side) and patrilocal (the couple living in the husband's village) (Place and Otsuka 2001a). Land is passed from the father's side to sons, or in some very few cases (e.g., if there are no sons or if there is abundant land) to daughters. The son continues to reside in the father's village, normally bringing in a wife from another village. In patrilineal systems a divorced woman is expected to return to her own village and relinquish all rights she had to her husband's land. A widow would normally remain in her deceased husband's village and continue to enjoy cultivation rights, provided a bride price was paid for her; but she may be forced out if her deceased husband's kin believe that she somehow contributed to her husband's death, or the marriage produced no offspring, or she refused to be inherited by a kinsman of the dead as required by custom, or she is otherwise considered to be of bad character.

Divorce or death of a spouse under both residential arrangements, effectively renders the non local partner landless. When such persons return to their own villages, allocations of land made to them are understood to be temporary, as those entitled to the land under customary rules may claim it at any time. To avoid losing land rights in the circumstances discussed, men in matrilineal social systems may opt for neolocal residence[4], which would give them more control of the land rights, as opposed to their wives. Therefore insecurity of land tenure to an individual is reduced if he or she moves away from his or her original home. Figure 6-1 shows that the residence of the household determines the individual's land tenure security.

As indicated earlier, the matrilocal system is slowly being replaced by the patrilocal system. Men now prefer to take their wives to their village in order

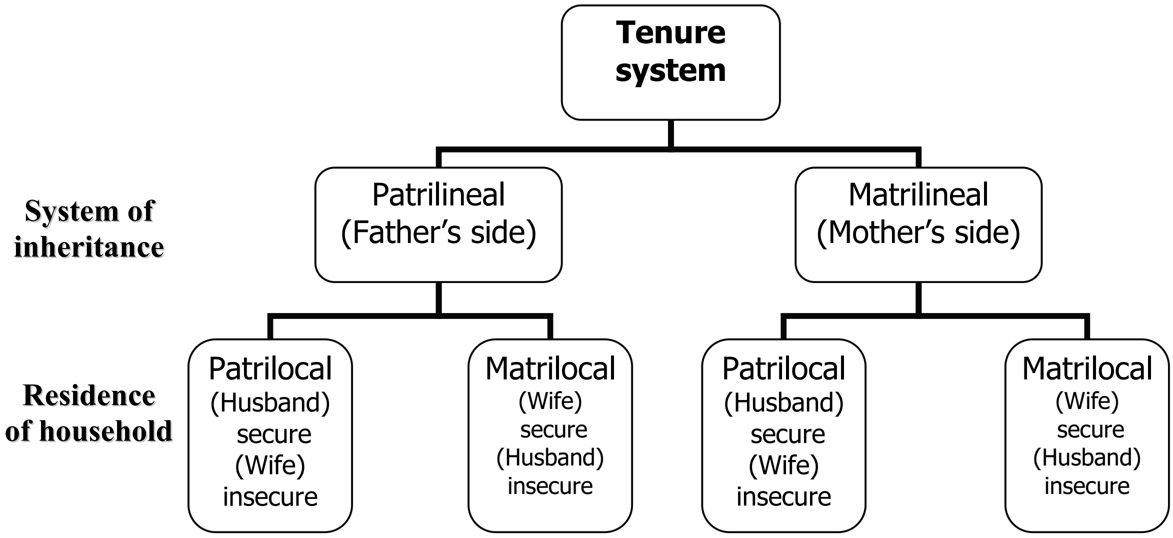

Figure 6-1 Source of individual land insecurity

to increase their tenure security, as they there have full rights over the land resources. However, this requires payment of a bride price that in itself is determined by the resource endowments the man has before getting marriage. If the man has more resources, he is able to pay the bride price, but if he has less endowments, he is forced to move to the wife's village. Therefore, better-off men would prefer to increase their security by paying the bride price.

Theoretical Framework

Rural peasant farm households typically face a number of imperfections in markets for factors of production (Sadoulet and de Janvry 1995; Eswaran and Kotwal 1985; Bell and Sussangkarn 1988; Bliss and Stern 1982; Feder 1985; Chapters 2, 3, 4, and 5). High transaction costs in factor services such as labor lead to market imperfections. Thus, households having, for example, surplus labor in relation to their landholdings lease in land, whereas households with excess land in relation to their factor endowments lease out land. In light of this, we postulate that participation in the land rental market in Malawi is a result of imperfections in the markets for labor (including management) and credit.

Households' Decisions to Participate in Land Markets

A household with endowments of land, labor, and initial wealth can derive income from agricultural production on its own farm and from off-farm wage employment. Agricultural production is based on the operational land used by the household, family labor is the effective labor input on the farm, and the initial wealth is used to purchase inputs (seeds and fertilizer) and pay rent, if the household rents in land. In Malawi, fixed rent contracts are dominant (Holden et al. 2006), and hence our theoretical framework is developed on the assumption that farmers have only fixed rent contracts.

We refer to the Bliss and Stern (1982) model as presented in Chapter 2. Bliss and Stern argued that participation in the land market is an attempt to make up the difference between desired cultivated area (*DCA*) and owned land (*L*) and this difference is the net land leased in (L_j). The household can either adjust nonland endowments (e.g., labor), the land rented in or out, or other inputs. In our case, however, where rights and tenure security may be different for the husband and wife depending on inheritance system and residence location, they may also each have a different "desired cultivated area" that will depend on their relative bargaining power and control over resources. Still, if we deviate from the unitary household model and replace it with a bargaining model, also such households face similar fixed and variable transaction costs in the land rental market, and the basic hypotheses that are derived from the model are still relevant to test.

We will therefore test the basic hypotheses derived from the Bliss and Stern model, assuming that the labor endowment is the most important non-land resource endowment in Malawi:

> H1: Land-rich households will rent out land, whereas land-poor households will rent in land.
> H2: Households with less labor endowments will rent out land, whereas households with more labor endowment will rent in land.

The extent of non-participation in the land rental market may be an indicator of the fixed and variable transaction costs in that market. Non-participants may include households that are completely rationed out of the market (Bell and Sussangkarn 1988; Skoufias 1995), and rationing may be explained by other factors than those explaining the degree of market participation.

If we relax the assumptions of the unitary household model, it is possible that intra-household characteristics related to inheritance rights and location of residence may affect land rental market participation. Inheritance rights and location of residence may matter for the degree of control and relative bargaining power of husband and wife. Rights to land are normally held primarily by the partner who actually brought the land into marriage and this also typically determines location of residence, R ($R \in$ (*patrilocal*, *matrilocal*)). Residential location is also influenced by the inheritance system, I (i.e., $I \in$ (*patrilineal*, *matrilineal*)) which also affects the rights of individuals within the household.

With these complications we resort to estimating a reduced form model where we assess whether net land leased in is affected by inheritance system and residential location in addition to the nonland resources and inherited land.

$$L_j = f(N_h, L^i, I, R(L^i, Z_h)) \qquad (6.1)$$

L_j= *Net land leased in*

L^i=Inherited land by husband or wife

R =Residence R∈{1=matrilocal, 0=patrilocal}
I= inheritance system, I∈ (1=matrilineal, 0=patrilineal)
N= Non-land factors of production
Z_h= *Household characteristics*
$j \in \{s = landlord, b = tenant * = nonparticipant\}$
i∈{husband, wife}

Land is immobile, and this has important consequences. For example, if a husband moves to live in the wife's village, he cannot move with his land. This may imply that he loses his rights to land in his village. He can only gain usufructory rights to land in the wife's village. He does not have rights to sell, subdivide, or even rent out the land. A similar situation arises for a wife moving to her husband's village. Therefore, the decision to rent out will depend more on the spouse with such rights or the bargained rights to land gained in the marriage. However, the husband living in his wife's village may have a stronger influence on the decision to rent in land, since the man is typically the head of household. For this reason, the wife living in the village of her husband would have a weak influence on the decision to rent in land. The stronger position of the husband as the household head may imply that the matrilineal and patrilineal systems do not represent "mirror images," as the husband's position in matrilineal communities in relation to household decision making over land is likely to be stronger than the wife's position in patrilineal communities.

The total effect of a change in land transacted in the rental markets may be decomposed into a land endowment effect, $\partial L/\partial L^i$ (households with more inherited land will rent in less land and rent out more, and households with less inherited land will rent in more land and rent out less) and a shift in the rights or security effect, $\partial f/\partial R * \partial R/\partial L^i$, resulting from a change in the residence which is itself affected by the landowner and inheritance system (patrilineal or matrilineal). That is:

$$\partial L_j/\partial L^i = -\partial L_j/\partial L^i|_{R,} + \partial f/\partial h * \partial h/\partial R * R/\partial L^i \qquad (6.2)$$

We may hypothesize that an increase in security of tenure of (potential) landlord households increases rental market participation. Thus, hypothesis HA1 must be qualified to the extent that the residence affects the tenure security. The decisions on participation in land markets may follow the rights on the inherited land. This means that if we assume symmetry in rights to land by the husband and wife in the household, then residential location should not matter for land renting decisions. However, Peters (2002) and Place and Otsuka (2001a) reported that under the matrilocal system, where men bring less or no land into marriage, it is still primarily men who make the major farm management decisions, including decisions to invest in land improvement. This may also imply that they dominate land rental decisions when it comes to renting in decisions, while they may have less influence over renting out decisions. We therefore hypothesize:

HA3: Men in matrilineal-dominated society have less security and control over land and will hence rent in more and rent out less land than households in predominantly patrilineal societies.

Residential location may be determined by the inheritance system and the assets, including land that the spouses potentially have control over. The chosen location is likely to be where the married couple gains better access to resources. The consequence of the choice of residential location may, however, also affect the relative bargaining power of husband and wife in terms of controlling the resources they brought into the marriage. We assume that only user rights are given to the spouse but rights to sell and rights to subdivide remain with the person who inherited the land. It is very rare for a married man to have full rights to a field belonging to his matrilineage (Peters, 2002). These rights are exogenous and can be used to determine residential area. Land rights are treated separately from security of tenure, which is defined as the probability or likelihood of losing land as used by Holden and Yohannes (2002), Sjaastad and Bromley (1997), and Alemu (1999). We asked the households the probability of losing the user rights to the land due to any other external factors such as death of the spouse, divorce, or land being grabbed away by other people. We perceived this to indicate their security on the land. The security of tenure is exogenously treated in our analysis and we assume that it is determined by culture and traditions (e.g. the risk of being evicted after divorce or death of spouse).

Data and Econometric Estimation

Sampling, Data, and Descriptive Statistics

The data used in this study is from six districts (Thyolo, Chiradzulu, Zomba, Machinga, Kasungu, and Lilongwe) with a total of 462 households. Table 6-1 shows that 58% of the households were in matrilineal societies and of those, 47% lived in the wife's village and 15% lived in the husband's village. Of the 42% that were in a patrilineal society, 12% lived in the wife's village and 26% lived in the husband's village. The average landholding size was highest for patrilocal-patrilineal households and lowest for matrilineal-matrilocal households. This could be because the majority of the matrilineal households are in the south, which generally has a higher population density and smaller landholding size than the patrilineal-dominated area of central Malawi. However, there is a systematic pattern such that patrilocal households both in matrilineal and patrilineal societies have larger land sizes as compared to their counterparts in matrilocal societies (see Table 6-1).

Table 6-1 Number of households by inheritance system, residential area, and rental market participation in 2005/06 cropping season and household land endowment

Inheritance system and Residential area	*Number of households*	*Percentage of households*	*% renting in*	*% renting out*	*Average land endowments (Ha)*
Matrilineal					
matrilocal	199	47	21	6	0.784
patrilocal	64	15	14	14	0.8
Patrilineal					
matrilocal	53	12	23	4	1.21
patrilocal	109	26	26	13	1.476
Total	425	100	20.3	7.56	1.038

Table 6-2 Description, mean and standard deviation of the variables used in the regression

Variable	*Mean*	*Standard Deviation*	*Gini Coefficient*	*N*
Renting in Dummy *(1= yes 0= no)*	0.207	0.406		425
Amount of land rented in (ha)	0.439	0.266		95
Amount of land rented out (ha)	0.423	0.240		36
Total land inherited (ha)	1.038	2.153	0.4613	425
Total Operated land (ha)	1.106		0.4342	425
Age household head	41.426	16.202		425
Education of household head *(Years in school)*	6.998	3.916		
Per capita labour supply of household per year*(hours)*	767.935	838.226		425
Value of assets (MK)	5830	18160		425

Of the 462 households, 28% participated in the land rental market in the 2005–2006 growing season. Participation in land rental markets was observed in all four types of societies. Renting-in land was more common among patrilineal-patrilocal households (26% of the households) and less common among matrilineal-patrilocal households. Renting out was more common among patrilocal households in both patrilineal and matrilineal societies.

Table 6-2 shows that the average amounts of land rented in and out per household were 0.439 hectare and 0.423 hectare, respectively. Average total operational land per household in 2005–2006 growing season was 1.106 hectares. The Gini-coefficients for inherited land and operated land were 0.46 and 0.43, respectively. This indicates that the land rental markets contributed to

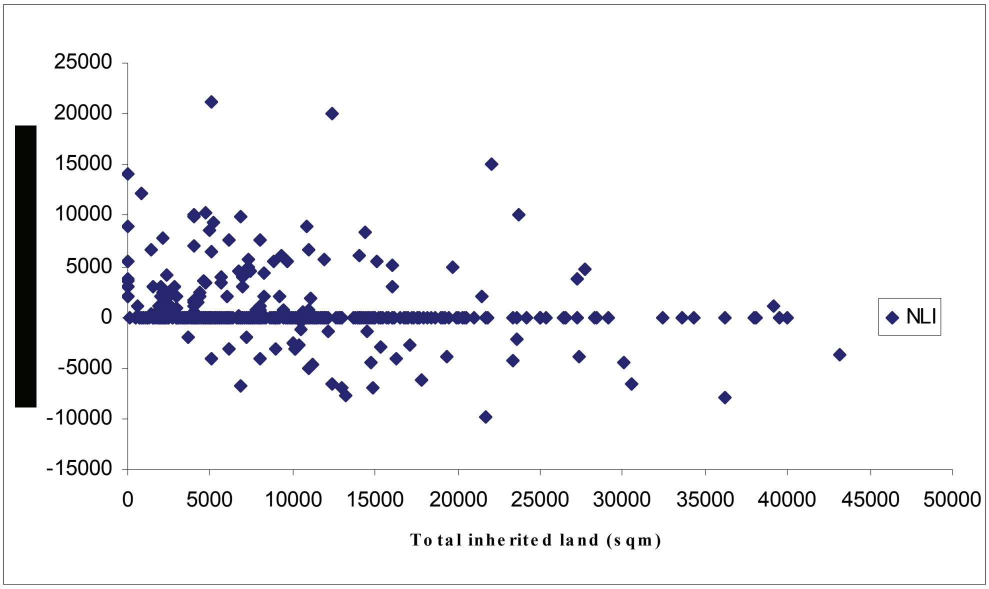

Figure 6-2 Net leased land vs total inherited land (sqm

equalizing the land distribution. This is further illustrated in Figure 6-2, relating own farm size to net land leased in or out. One can see that land-poor households and even landless households can access land through the land rental market. The land rental market to some extent reallocates land from land-rich to landpoor households, leading to a more egalitarian land distribution.

Note from Table 6-3 that tenants were land-poor households with the lowest average inherited land of 0.69 hectare and landlords were relatively landrich with average land size of 1.56 hectares. This was similar in matrilineal and patrilineal areas, but patrilineal areas have larger land sizes for both tenant and landlord households. Tenants had higher asset values than landlords in all districts, but when breaking up in patrilineal and matrilineal areas, we see that this was due to the large difference in patrilineal areas, while this was not the case in matrilineal areas. In matrilineal areas, landlords had higher asset values than tenants, and nonparticipants were the poorest in terms of assets. Tenants also tended to have higher labor endowments and household sizes than landlords. Tenants (heads of households) were also on average younger than landlords and nonparticipating households.

In Figure 6-3 households are ordered by the size of net land leased in, illustrating the relative size of the three categories of households relative to the land sizes rented in or out. Relatively few households rented out land, and the maximum land rented out is about 1 hectare. It was also more common to rent in very small pieces of land than to rent out small pieces of land. This may indicate something about the nature of the transaction costs in the market. The willingness to rent in small pieces of land may indicate that there are no economies of scale and entry barriers due to lumpiness of some inputs. This may be due to hoe-based cultivation, unlike in Ethiopia where oxen are used for plowing (see Chapter 4). The land rental market may therefore be a pathway for land-poor and landless households to access land. The graph may also

Table 6-3 Description, mean of the variables used in the regression

Variable	All districts			Matrilineal			Patrilineal		
	Tenants	Non-participants	Landlords	Tenants	Non-participants	Landlords	Tenants	Non-participants	Landlords
Average inherited land (ha)	0.69*ab*	0.97*ac*	1.56 *bc*	0.53*ab*	0.82*ac*	1.3*bc*	0.92*ab*	1.2*ac*	1.7*bc*
Land rented in	0.460	0	0	0.34	0	0	0.581	0	0
Land rented out	0	0	0.413	0	0	0.382	0	0	0.445
Assets value (MK,000)	10.42a	5.22a	6.22	7.7a	3.9ac	8.9c	14.2ab	7a	4.4b
Total labour	0.94ab	0.8a	0.7b	0.92a	0.75a	0.79	0.95b	0.869	0.70b
Male labour	0.34ab	0.27a	0.25b	0.33a	0.25a	0.30	0.35b	0.31	0.22b
Female labour	0.31ab	0.27a	0.25b	0.31b	0.26	0.24b	0.30	0.29	0.26
Household size	5.4	5.3	4.6	5.3b	5.1	4.2b	5.6	5.6	4.9
Age	37.5ab	43.3a	44.3b	37.5ab	44a	43.1b	37.6ab	42.4a	45.1b
CWratio	1.36	1.4	1.28	1.2	1.47	1.3	1.5	1.3	1.2
Education	7.6ab	6.8a	6.5b	8.3a	6.7a	6.1	6.7	6.9	6.8
Rights									
Sale land	0.46a	0.35a	0.37	0.34a	0.24a	0.14	0.64ab	0.53a	0.52b
Sub divide	0.57ab	0.39a	0.37b	0.52a	0.3a	0.21	0.64a	0.52a	0.57
Security									
Probability not to stop cultivate	0.22ab	0.73a	0.74b	0.25ab	0.73a	0.85b	0.17ab	0.07a	0.66b
conflict	0.1ab	0.051a	0.085b	0.02ab	0.07a	0.07b	0b	0.02	0.09b
Number of observation	96	331	35	55	200	14	41	132	21

Note:c are significant levels at 10% a= tenants different from non participant, b= tenant different from landlords and c= landlord different from nonparticipant

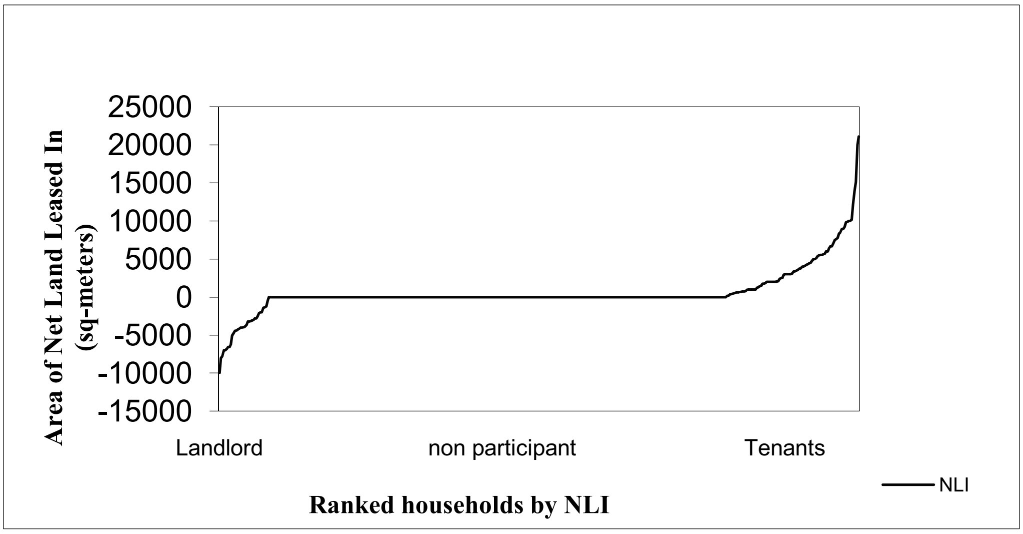

Figure 6-3 Net leased land vs total inherited land (sqm)

imply a need for assessing the two sides of the markets separately, as different factors may be at play on the two sides. Tenure insecurity, customary rules, and poverty may also be at play and restrict adjustment on the landlord side, as focus group discussions revealed that the land rental market may serve as insurance during times of emergency (distress rentals), such as for cash to pay hospital bills, buy food, or even buy inputs.

The high share of nonparticipating households (the flat part in Figure 6-3) may indicate that there are significant transaction costs in the market. This may also be due to its recent occurrence (Fafchamps 2004) as market participation may grow gradually with expansion of trust and experience with such transactions.

Econometric Estimation

A simple linear specification of the reduced form model was chosen. This can be written in its econometric form as:

$$L_j = \alpha_j + \beta_j N + \beta_j I + \delta_j R - \xi_j L^i + \mu_j \qquad (6.3)$$

This equation can be estimated econometrically to study the leasing behaviour of households participating in the land rental market, although estimation is not straightforward. Leasing behaviour involves two decisions: the decision to participate and how much to participate, given participation on each side of the tenancy market (Tikabo et al. 2008). To investigate the decision to participate, we used an ordered probit model by categorizing households into tenants, nonparticipants, and landlords. We let the categories of farmers be the latent variable $J \in (b, *, s)$.

$$J = \beta_j N + \beta_{jL} I + \delta_j \hat{R} - \xi_j L^i + e_j \qquad e|\ h, L, R, Z \sim Normal\ (0,1) \quad (6.4)$$

The error term e is assumed normally distributed and the cumulative density function is Φ. We let α_1 and α_2 and be cut-off points and we define: $J = -1$ if $L_j \le \alpha_1$ $J = 0$ if $\alpha_1 < L_j \le \alpha_2$ $J = 1$ if $L_j > \alpha_2$.

To investigate how much to participate and the effects of security on participation, we use an instrumental tobit model on area rented in or out:

$$L_j = max(0, \alpha_j + \beta_j N + \beta_j I + \xi_j L^i + \delta j(\beta_{jh} L^i + \beta_{jI} I + \theta Z_j + v) + \mu_j \qquad (6.5)$$
$$u|N,L, Z \sim normal\ (0, \sigma^2 + \delta^2 \tau^2)$$

$$R = \gamma_j + \beta_{jh} L^i + \beta_{jL} I - \xi_j Z + v \qquad v|N, L, Z \sim Normal(0, \tau^2) \qquad (6.6)$$

Using probit to predict $\hat{R}$ and get the predicted error term $\hat{v}$ and using the R and the predicted error term in a tobit model of the net leased in land on household and plot variables gives consistent estimators (Wooldridge, 2002). We therefore estimated the following model with robust standard errors:

$$L_j = Max(\ 0, \alpha_j + \beta_j N + \beta_j I - \xi_j L^i + \delta_j R\ \ \theta\hat{v} + e_j) \qquad (6.7)$$

Using the ordered probit model, we tested the hypothesis that participation in land markets is a result of households adjusting available cultivable land to the labor endowments (i.e., households with more labor relative to land will rent in land, whereas households with less labor relative to land endowment will rent out land. Using the instrumental probit model, we further investigated if the security and residential location influence the decision for the households to be either a landlord or tenant. We estimated the determinants of renting by including the residential location variable, which is a proxy for tenure security. However, residential location is endogenous as it is a function of other variables that also affect renting in for inherited land rights. As a remedy for the endogeneity, residential area was instrumented by rights to sell land, rights to subdivide land, and initial inherited land. These are assumed to be exogenous as they come before the residential decision. A wife or husband will have acquired the rights to land even before getting married. These instruments are used in the instrumental tobit model.

Findings

Participation in Land Markets

As indicated earlier, 28% of the farmers interviewed participated in land renting either as landlords or tenants. Using an ordered probit model for the households that participated in rental markets by either renting in or renting out and those that did not participate, we found that having more inherited land had a negative effect on the rented-in land for all the districts and separately for matrilineal-dominated and patrilineal-dominated areas. Table 6-4 provides the results, which indicate that farmers were using the land market to adjust for imperfections in other factor markets like labor. Tikabo and Holden (2003) demonstrated the importance of the land rental market for adjustment to nontradable or semi-tradable nonland household endowments in Eritrea. Ghebru and Holden (Chapter 4) demonstrate the same in Ethiopia.

Labor is another factor that is important for households to be able to get into the land market. Households with less labor were unable to increase their operational holding, hence both male and female labor were positively correlated with leasing in land. Male-headed households preferred to rent in land when in matrilineal societies, as indicated by a significant positive coefficient

Table 6-4 Parameter estimates for Ordered Probit Regression on decision to participate in land markets

	All districts b/se	*Matrilineal Dominant* b/se	*Patrilineal Dominant* b/se
Inherited land	-0.405**	-0.495**	-0.354
	(0.17)	(0.25)	(0.24)
Sex of hhh	0.107	0.394*	-0.119****
	(0.17)	(0.23)	(0.02)
Male labour	0.290	-0.450	1.024**
	(0.50)	(0.39)	(0.41)
Female labour	0.786***	1.202**	0.393****
	(0.27)	(0.58)	(0.08)
cwratio	0.040	0.122**	-0.018
	(0.05)	(0.05)	(0.06)
Educ of hhh	0.005	0.037	-0.014
	(0.03)	(0.03)	(0.02)
Asset value	0.013	0.004	0.012
	(0.01)	(0.03)	(0.01)
Age of hhh	-0.006	-0.006	-0.005
	(0.01)	(0.01)	(0.01)
Security	-0.905****	-1.063****	-0.811****
	(0.15)	(0.20)	(0.20)
cut1_cons	-2.220****	-2.175**	-2.240***
	(0.50)	(0.85)	(0.72)
cut2_cons	0.311	0.676	0.086
	(0.45)	(0.67)	(0.60)
Prob > chi2	0.000	0.000	0.012
Number of obs.	394	225	169

Robust standard errors. The superscripts ****, ***, ** and * indicate the 1%, 5%, and 10% levels of confidence, respectively.

of sex of household head in matrilineal districts. As they could not bargain for more inherited land from the wife's relatives, the land rental market becomes an option to access more land. This could encourage men to prefer rented-in land while in an insecure situation. Female-headed households, on the other hand, preferred to rent out in patrilineal-dominated societies. This may be an indication of resource poverty and distress, as land rentals in Malawi are used as a safety net in times of emergency. Evidence in other countries in Africa suggests that landlords are poor and often female-headed households with insufficient labor to operate land themselves. They therefore rent it out to less poor tenants who have the necessary resources (Tikabo and Holden 2003; Holden and Ghebre 2006; Kassie and Holden 2006; Chapters 3, 4, 8, 9, 10).

Separating the landlords and tenants and assessing the location of residence (by instrumenting for it) in an instrumental probit model, we found that patrilocal households participate more in land markets as tenants than matrilocal households do in both patrilineal and matrilineal societies (see Table 6-5). Land-poor and labor-rich (female labor) households have a high probability of participating in land markets as tenants in both matrilineal and patrilineal societies.

There was a significant difference between patrilocal and matrilocal households when it came to the renting-out decision (for all districts and in matrilineal societies separately), as can be seen from Table 6-6. Households with more land endowment rented out significantly more land in the total sample model and in both matrilineal and patrilineal areas. Similarly, households with less land endowment were more likely to rent in land in the total sample model and in matrilineal and the patrilineal areas (Table 6-5). This indicates that land-poor and even landless households (Figure 6-2) access land through the land rental market, thereby leading to a more egalitarian distribution of land.

How Much to Participate

The results from instrumental variable tobit models are presented in Table 6-7 for area rented in and in Table 6-8 for area rented out. Notice in Table 6-7 that area rented in was significantly higher for land-poor households in the total sample and in matrilineal and patrilineal areas separately. It appears, therefore, that the land rental market is "pro-poor" in both patrilineal and matrilineal areas. Patrilocal residence was associated with significantly larger areas rented in the total sample and in the matrilineal areas. Land-rich households tended to rent out land, whereas households poor in land tended to rent in land. Households with more assets were more able to rent in land in the overall sample and patrilineal society. Households with access to more capital may be able to rent in land and intensify land use by using higher levels of purchased inputs such as labor and fertilizer (Holden et al. 2006), which is indicated by their level of assets. Holden et al. (2006) also observed that, in central and southern Malawi,

Table 6-5 Instrumental variable probit models for land rented in.

	All districts b/se	*Matrilineal Dominant* b/se	*Patrilineal Dominant* b/se
Patrilocal	1.295****	1.240**	2.013****
	(0.37)	(0.52)	(0.55)
Inherited land	-0.470***	-0.589**	-0.426***
	(0.14)	(0.26)	(0.16)
Asset value	0.019	0.006	0.036*
	(0.01)	(0.01)	(0.02)
Sex of hhh	0.226	0.910*	-0.561
	(0.33)	(0.53)	(0.57)
Male labour	0.068	-0.214	0.125
	(0.40)	(0.51)	(0.72)
Female labour	1.129**	1.262*	1.352*
	(0.45)	(0.67)	(0.73)
Cwratio	0.021	0.064	-0.026
	(0.09)	(0.12)	(0.10)
Age	-0.001	-0.010	0.013
	(0.01)	(0.01)	(0.01)
Educ. Of hhh	0.013	0.065*	-0.005
	(0.02)	(0.04)	(0.01)
Security	-1.164****	-1.149****	-0.922*
	(0.20)	(0.25)	(0.48)
Patrilineal	-0.541**		
	(0.23)		
Constant	-0.761	-1.321*	-1.614**
	(0.49)	(0.80)	(0.66)
Prob > chi2	0.000	0.000	0.000
Number of obs.	337	205	132

Robust standard errors. The superscripts ****, ***, **, and * indicate the 0.1%, 1%, 5%, and 10% levels of confidence, respectively

land-scarce households with sufficient cash and nonland factors of production rented in land, whereas land-rich and cash- and labor-poor households were more likely to rent out their land. Female labor was positively correlated with the area rented in (Table 6-5) and negatively correlated with area rented out at 10% significance level (Table 6-6).

Effects of Security on Land Market Participation

By incorporating the security variable, we relaxed the assumption that all households have secure tenure and take into account the rights on the land

Table 6-6 Instrumental variable probit models for land rented out, with household random effects

	All districts	*Matrilineal Dominant*	*Patrilineal Dominant*
	b/se	*b/se*	*b/se*
Patrilocal	-1.115**	-1.278*	-0.883
	(0.51)	(0.73)	(0.69)
Inherited land	0.461****	0.461*	0.474***
	(0.13)	(0.25)	(0.15)
Asset value	0.004	0.034***	-0.012
	(0.00)	(0.01)	(0.03)
Sex of hhh	0.371	0.270	0.938*
	(0.33)	(0.56)	(0.49)
Male labour	0.272	1.004	-1.362*
	(0.49)	(0.66)	(0.81)
Female labour	-1.031*	-1.147	-0.735
	(0.54)	(1.01)	(0.77)
Cwratio	-0.082	-0.323*	0.017
	(0.08)	(0.18)	(0.09)
Age	0.002	-0.004	0.007
	(0.01)	(0.01)	(0.01)
Educ. Of hhh	-0.027	-0.062	-0.014
	(0.03)	(0.04)	(0.03)
Security	0.221	0.486*	0.115
	(0.20)	(0.28)	(0.29)
Patrilineal	0.701***		
	(0.26)		
constant	-1.622***	-1.145	-1.629*
	(0.53)	(0.84)	(0.86)
Prob > chi2	0.001	0.007	0.076
Number of obs.	337	205	132

Robust standard errors. The superscripts ****, ***, **, and * indicate the 0.1%, 1%, 5%, and 10% levels of confidence, respectively

that one needs to have in order to make a decision to rent in or rent out land. Table 6-7 shows that the security variable was significant and negatively correlated with renting in for the whole sample as well as for the subsamples. As indicated earlier, renting-in and renting-out decisions are made based on the bundle of rights one has. A husband in a matrilocal residence will have only user rights to the land, which are gained at marriage. Matrilocal residence gives men (the decision makers according to Place and Ostuka 2001a; Peters 2002) only user rights to land, and likewise a wife in a patrilocal residence will have only user rights while the husband has extra rights such as rights to sell, subdivide, rent out, and borrow land.

Table 6-7 Instrumental variable Tobit models for land rented in

	All districts b/se	Matrilineal Dominant b/se	Patrilineal Dominant b/se
Patrilocal	0.787***	0.714**	1.230*
	(0.28)	(0.35)	(0.66)
Inherited land	-0.224***	-0.278**	-0.243**
	(0.07)	(0.12)	(0.10)
Asset value	0.008****	0.015	0.007****
	(0.00)	(0.01)	(0.00)
Sex of hhh	0.150	0.406	-0.159
	(0.18)	(0.25)	(0.47)
Male labour	-0.011	-0.133	0.037
	(0.20)	(0.24)	(0.42)
Female labour	0.664***	0.497*	1.089*
	(0.25)	(0.30)	(0.60)
Cwratio	0.018	0.011	-0.000
	(0.06)	(0.06)	(0.08)
Age of hhh	0.000	-0.003	0.011
	(0.00)	(0.00)	(0.01)
Educ. Of hhh	0.011	0.034*	-0.004
	(0.01)	(0.02)	(0.01)
Security	-0.616****	-0.480****	-0.751****
	(0.10)	(0.12)	(0.21)
Patrilineal	-0.275*		
	(0.16)		
constant	-0.653**	-0.819**	-1.377**
	(0.31)	(0.41)	(0.64)
Prob > chi2	0.000	0.000	0.000
Number of obs.	337	205	132

Robust standard errors,. The superscripts ****, ***, **, and * indicate the 0.1%, 1%, 5%, and 10% levels of confidence, respectively

The land rental market is localized, and land market participation is affected by social norms. We observe in Table 6-8 (total sample) significantly (at 5% level) larger areas rented out in patrilineal areas, after controlling for inherited land size, and this may be due to higher land supply by households who can make decisions to rent out without fear of losing the land. The security variable was insignificant in Table 6-8 for area rented out and was significant (at 10% level only) in matrilineal areas in Table 6-6 for the probability of renting out. This was surprising, as we would have expected that security would have been more important for renting out decisions.

Table 6-8 Instrumental variable Tobit models for land rented out

	All districts	*Matrilineal Dominant*	*Patrilineal Dominant*
	b/se	*b/se*	*b/se*
Patrilocal	-0.980**	-0.881	-0.763
	(0.49)	(0.63)	(0.58)
Inherited land	0.384****	0.384**	0.346****
	(0.11)	(0.18)	(0.10)
Asset value	0.003	0.021***	-0.003
	(0.00)	(0.01)	(0.02)
Sex of hhh	0.293	0.106	0.796**
	(0.28)	(0.44)	(0.40)
Male labour	0.202	0.699	-1.043*
	(0.40)	(0.43)	(0.61)
Female labour	-0.712*	-0.635	-0.522
	(0.42)	(0.62)	(0.60)
Cwratio	-0.067	-0.253**	0.014
	(0.07)	(0.12)	(0.07)
Age of hhh	0.001	-0.003	0.005
	(0.00)	(0.01)	(0.01)
Educ.of hhh	-0.018	-0.041	-0.007
	(0.02)	(0.03)	(0.02)
Security	0.148	0.329	0.044
	(0.16)	(0.21)	(0.22)
Patrilineal	0.602**		
	(0.25)		
Constant	-1.333***	-0.871	-1.272**
	(0.44)	(0.72)	(0.61)
Prob > chi2	0.002	0.000	0.049
Number of obs.	337	205	132

Robust standard errors. The superscripts ****,***, **, and * indicate 0.1%, 1%, 5%, and 10% levels of confidence, respectively

Conclusions

There is strong evidence that land rental markets are developing in Malawi. Land-poor households are increasingly able to access land through the rental market. We found evidence that emerging land rental markets in Malawi redistribute land from more land-rich to more land-poor households, as seen by reduction in the Gini-coeffient for operated land as compared to for own landholding. The endowment of non-land factors, such as labor, has a significant effect on land market participation. Households with more female labor endowments were more likely to rent in land, which is a sign of imperfections in the labor market.

Due to the dual land tenure system, security over land and the bundle of rights that one acquires vary, also affecting decisions on land rental market participation. The security of men who are traditionally the main decision maker in the household (head of household) has implications for household participation in the land rental market. We found that households in patrilineal areas were more likely to rent out and rented out significantly more land than in matrilineal areas. Households in matrilineal societies do not offer men full land rights, and hence men are not the main decision makers with regard to inherited land, and this may have affected land renting-out decisions. We also found that patrilocal households rented in significantly more land than matrilocal households overall and separately in matrilineal and patrilineal areas. In addition, we found that less tenure-secure households rented in more land. Additional renting in of land may thus be a response to such tenure insecurity, yet the only evidence that tenure insecurity causes landlords to rent out less land was that households in patrilineal areas rented out more land than households in matrilineal areas.

It is a challenge to introduce a land law and land reform in a country with two such markedly different land tenure and inheritance systems as in Malawi. In contemplating the land reform in this country, it must be clearly recognized that the emerging land rental markets contribute to both efficiency and equity of land allocation by transferring land from land-abundant to labor-scarce households, even though such markets are subject to high transaction costs and are constrained by tenure insecurity due to the traditional inheritance and residence systems. Thus, land reform must be designed to reduce transaction costs and to strengthen tenure security, including tenure security of women, if it aims to promote equitable and efficient land allocation among farm households.

Notes

1. Public land is defined as that which is occupied, used or acquired by the government and any other not being customary or private, and includes settlement schemes, national parks, forest reserves and lapsed leaseholds.
2. Private land is defined as that which is held or owned under freehold or leasehold title, Certificate of Claim or is registered under the Registered Land Act
3. Customary land is that which is held or used under customary law.
4. Neutral residential arrangement where land is from a chief in neither husband's village nor wife's village. However, it is becoming difficult to acquire such land as chiefs do not have any more free land to distribute.

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Paper II

Land tenure security and investments in tree planting

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'Pachikamwini, siadzala nthochi' - At the uxorilocal residence, no bananas are planted.
(An adage from Group Village Headman Kadifula, Kasungu- Malawi August, 2006 FGD-)

Abstract

It is widely accepted that secure tenure on land induces investment. However, research in sub-Saharan African has also found high levels of investment by insecure tenure households. This study investigates under what circumstances insecure households have high investment incentives in tree planting. Data are taken from Malawi, where we find both matrilineal and patrilineal land inheritance systems. Under these systems, a household can reside in either a patrilocal, a matrilocal, or a neolocal location. Patrilocal residence households are more tenure secure than matrilocal and neolocal residence households. A random-effects instrumental-variable probit model (IVP) and a two-stage conditional maximum-likelihood model (2SCMLE) controlling for the endogeneity of tenure security were used to predict the probability and intensity of tree planting in the three residence locations. The probability of investing in trees is high in patrilocal residences and neolocal residences, but low in matrilocal residences. Although neolocal residents are insecure, they increase their tenure security with investment, while matrilocal residents do not have the ability to change their security. Therefore, it can be concluded that insecure households have higher investment incentives when they can increase their security with those investments.

Key words: tenure security, investment, patrilocal, matrilocal, neolocal

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1.0 INTRODUCTION

It is normally believed that secure land rights induce higher investment; however, attempts to link the tenure security of land and investment in sub-Saharan Africa have often been inconsistent and tenuous (Braselle et al., 2002; Deininger and Ali, 2007). The inconsistencies in the relationship between tenure security and investment make it difficult to develop policies that can induce agricultural investments. For example, some studies have found that investments in land were not related to land titles (secure tenure) (Green, 1987; Place and Migot-Adholla, 1998; Place et al., 1994), while others have reported that farmers without private titles (insecure tenure) had productive performance similar to farmers with titled land (secure tenure) (Harrison, 1992). Holden *et al.* (2008) report a positive relationship between land certification (secure tenure) and investment in Ethiopia. In informal tenure systems, Saul (1993) observes that investment did not vary between owned (secure) and borrowed fields (insecure), while Gavian and Fafchamps (1996) find that farmers diverted manure to owned fields rather than to borrowed fields. These results are derived from different areas under different contexts in terms of tenure regimes and practices. While secure tenure may induce investment because of a low risk of dispossession, which would cause returns to be reaped by others, insecure tenure may also induce investment if investment in the land secures land tenure, (Sjaastad and Bromley, 1997). The different contexts within which tenure regimes exist may differ in the extent to which investment in the land will change land tenure security. Therefore, observed differences in the extent to which land tenure security influences investment may be due to differences in the context in which studies are carried out. This paper evaluates three different contexts of tenure security, which may differ in respect to how investment in the land secures tenure and how this affects decisions by smallholder farmers in Malawi.

The lack of consensus on the linkage between investment and tenure security has been attributed to different analytical approaches in the investigation of tenure security and investment in land. Deininger and Jin (2006) find that in Ethiopia there were differences on the impacts of tenure security on investments when transfer rights are separated from security rights. Brasselle *et al*. (2002) find that controlling for the endogeneity of tenure security (where it applies) gives results opposite to those resulting from assuming exogenous tenure security. Holden *et al.* (2008) use several econometric methods to control for the endogeneity of land certification and unobserved household heterogeneity to find the impacts of low-cost land certification on investment and productivity; however, to my knowledge, no study has investigated the context in which the household makes investment decisions under different context of tenure security. Does the household have power to influence its tenure security? Since assessing the impact of security on investment requires a clear definition of the security rights variables used and how they link with investments, there is also a need to evaluate the context in which the household makes investment decisions.

Sjaastad and Bromley (1997) define the security or insecurity of tenure as the perceived probability of losing ownership rights of the land. One such right is the right to recover the returns to any investments made on a given parcel of land. This means that the tenure security that affect investment decision is not what is now but what will be in the future after the investments. The right of ownership of benefits from the parcel of land is what affects the investment decision. Rodrik (2004, points out that credible signalling that property rights will be protected is apparently more important than enacting them into law as a formal private property rights regime. Therefore, investment is likely when there is an assurance of secure tenure at the end of the planning horizon, be it a formal or informal tenure system. If a household is in a secure or insecure position and maintains ownership of the land in the future, such a household will have an incentive to invest in that land in order to increase productivity or tenure security. In contrast, if a household has ownership now but a low probability of ownership in the future (e.g., somebody else will gain ownership and reap the benefits), it will not have an incentive to invest due to a low probability of benefit ownership.

This paper shows that, *inter alia,* the decision to invest rests on a household head's perceived future tenure security and his ability to alter it. The husband (man) is usually the family's key decision maker concerning farm management, and his security position reflects the security position of the household. This paper uses household security based on the security of the man in the household. I test the following hypotheses:

i) If a male household head is secure and will continue to be secure, he will invest.

ii) If the male household head is insecure but can increase his security, he will invest.

iii) If the male household head is insecure and cannot change his tenure security, he will have less of an incentive to invest.

In short, if a household head is secure after time *t,* he will have an incentive to invest. Using data from Malawi, with the peculiar dual customary land tenure system that gives different land inheritance rights to the household head, this study shows that the impact of tenure security on investments is contextual. Men are considered household heads and the primary decision makers in most cases in Malawi, and their security thus influences households' investment decisions. I use the location of the household head as an indicator of tenure security.

2.0 REVIEW OF EXISTING LITERATURE ON INVESTMENTIN LAND

2.1 Investments and tenure security

One of the challenges that rural households may face is insecure land tenure. If the household can change tenure security (i.e., increase it), investment in security enhancement is more probable. Deininger and Jin (2006) show that in Ethiopia, households that had just experienced land redistribution were more likely to invest in tree planting (a security enhancement measure) than terracing (productivity enhancement); however, households that expressed an expectation of future redistribution showed lower investment. Brasselle *et al.* (2002) show that in Burkina Faso, immigrant households invested as much as indigenous households despite having less security. By bringing improvements to the land, additional rights could be acquired, thus increasing the household's security. In Uganda, Deininger and Ali (2007) find that a large number of tenants were willing to pay for residual property rights. Households have a higher investment incentive if they feel that they can increase their security and will be able to reap the benefits.

Results from other studies have shown that when households are secure and the tenure system is internal, investment incentives are high. Goldstein and Udry (2005) show that in Ghana, individuals who hold powerful positions in local political hierarchies have more secure tenure rights and that they invest more in their plots. Migot-Adholla *et al.* (1991) and Place *et al*. (1993) both show that long-term improvements are positively related to land rights in Rwanda. Holden *et al*. (2008) show that land certification in Ethiopia stimulates tree planting.

When some rights to land are held by another individual or authority and households are unable to change their security status and feel insecure, such households will have a low incentive to invest. Place and Otsuka (2001a) find that insecure matrilocal-matrilineal households planted fewer trees than secure patrilocal-patrilineal households in Malawi. Gavian and Fafchamps (1996) find that households applied more manure on owned plots than on borrowed ones. Borrowed plots are under specific terms of contract and revert back to the owner; consequently, the borrower feels little security in investing in such plots. Migot-Adholla (1991) reports that in Ghana (Wassa) tree crops were less likely to be planted on parcels on which farmers had only limited transfer rights. In Uganda, Deininger and Ali (2007) use overlapping land rights as an indicator of insecurity, and find that such overlapping rights reduce tenants´ incentives to invest.

2.2 Tenure security in Malawi

In Malawi, the security of tenure is based on customary systems of marriage, residence, and land acquisition that affect incentives for investment. Within the customary tenure sector, the methods of land inheritance differ according to descent practices, namely, matrilineal and patrilineal systems. These are inheritance systems where land is either passed to children through the mother's line of descent (matrilineal) or through the father's line of descent (patrilineal). The spouse who does not have land moves to settle in the partner's village, where the partner has land. Access to land therefore depends on residence practices, namely, patrilocal, matrilocal, and neolocal residence systems. This is the residence where a new family resides. It can be in the husband's village (patrilocal), the wife's village (matrilocal), or a neutral village (neolocal), i.e., neither the husband's nor the wife's village. Both can occur in a matrilineal or patrilineal society. (Kishindo, 2004, Kishindo, 1995, Peters, 2002, Peters, 1997, Place and Otsuka, 2001b).

In the matrilineal system, men are most likely to live in their wives' village. Men are the key decision makers in households, and this brings out an important disincentive that may arise for males within the matrilocal residence system (Place and Otsuka, 2001; Peters, 2002; Holden *et al.*, 2006). A major investment incentive problem arises for the man in the cases of a) not having full ownership rights to the land, b) the divorce or death of the wife, and c) land being bequeathed to his nephews (wife's brother's children) and not his children. This reduces his incentives to undertake long-term investments. Kishindo (2004) observes that while members of the local kin enjoy the lifetime use of land allocated to them, non-indigenous people do not enjoy much security, particularly in their early years of settlement. A woman's husband – as an outsider in his wife's village – is often not respected by the wife's uncles and brothers in law. The man remains a second-class citizen in the village of his marriage (Miller, 1996). In order to avoid losing rights in these circumstances, men in the matrilineal inheritance system may opt for patrilocal or neolocal residence, which gives them higher security than what they have under a matrilocal residence. The patrilocal or neolocal residence in matrilineal society is not very secure because the dominant norm is that the women should own land and men live with them. Therefore, men in such a position may opt to invest more in security enhancement to be able to claim that the land belongs to them by virtue of their investment in planting trees or building physical structures.

In patrilineal societies, women are most likely to live in the husband's village. Men are likely to inherit land and bring in their wives. There may be less of an incentive problem under patrilocal residence, as the husband, who is the main decision maker for the household, owns the land. As a result, he can make long-term investments knowing that he will reap the benefits from such efforts. This is because he is living among members of his local kin and enjoys the permanent use of his land. In some households, women inherit land and men follow to live with them in their village. This yields the same insecurity resulting from a matrilineal-matrilocal context. In the case of patrilocal residence there is more security to the men, as the inheritance system favours them and they live in their own village. Figure 1 below shows the inheritance system and location of residence.

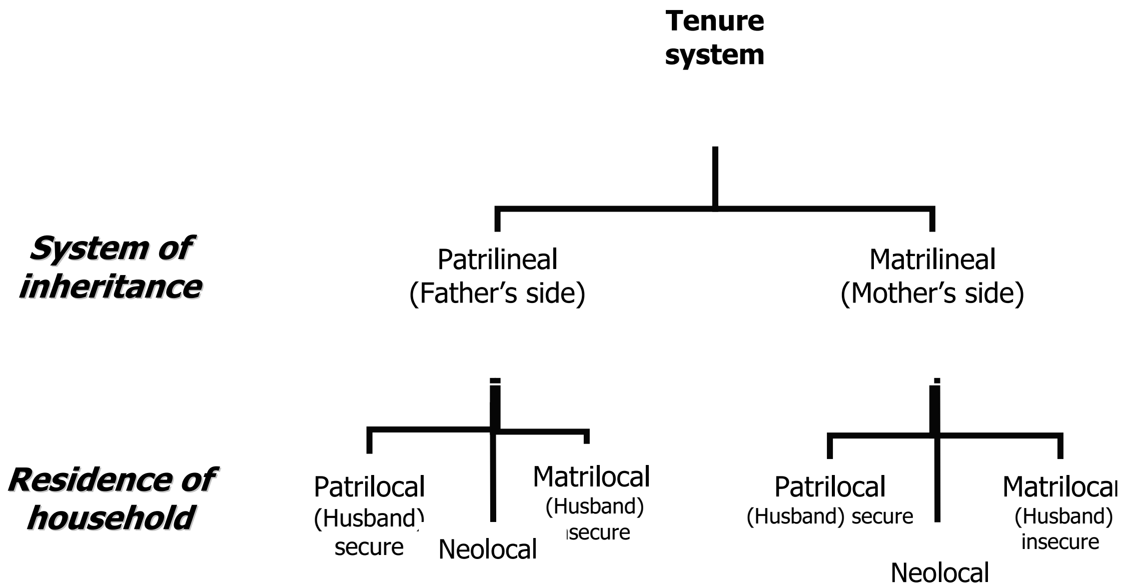

***Figure 1**: Source of individual land insecurity –*

Based on the above, household heads can be grouped into three categories.

a) Secure households heads:

<u>Patrilineal-**patrilocal**</u> land is acquired through male lineage to the husband and the residence of the household is in the husband's village of origin.

<u>Matrilineal-**patrilocal**</u> land is acquired through female lineage to the husband but the residence of the household is in the husband's village of origin.

b) Insecure households heads:

<u>Matrilineal-**matrilocal**</u> land is acquired through female lineage to the wife and the residence of the household is in the wife's village of origin

<u>Patrilineal-**matrilocal**</u> land is acquired through male lineage to the wife but the residence of the household is in the wife's village of origin

c) Insecure households heads:

<u>**Neolocal**</u> – land is either acquired from the village chief or purchased, but the residential area is in a neutral village, one that is neither the man's nor the woman's. A written document is most times available to certify that the land was purchased. Investments on this land may be necessary, as the seller or the chief can turn around after some time to claim back the land.

3.0 THEORETICAL MODEL

A large body of literature claims the primacy of liquidity constraints as an explanation of low investment activity; however, under insecure tenure conditions, the lack of incentives can also play an important role in explaining investments. Therefore, the ability to invest can be framed as a liquidity constraint and as an incentive problem (Besley, 1995). If land is perceived to be more secure at the end of the household planning horizon, then there are more incentives to invest either to increase security or to increase productivity. If land is not going to be secure, there are fewer investment incentives because the investor will not reap the benefits. Therefore, the household will focus on the level of security it will have at the end of its planning horizon.

I base the model on a man, the land user, who is assumed to be the head of the household and makes decisions for the household. If he lives in the wife's village, he will not own land and will be given land by the wife's family (land owners). He will not have full ownership rights to the land and will only partially benefit from the total output of land investments, depending on the rights given to him. If he lives in his village of origin and brings in his wife, he will have ownership rights to the land, and will be both the land owner and land user. Alternatively, he can live in a neutral village, i.e., one that is neither his nor his wife's, where he buys or requests land from the chief in that village.

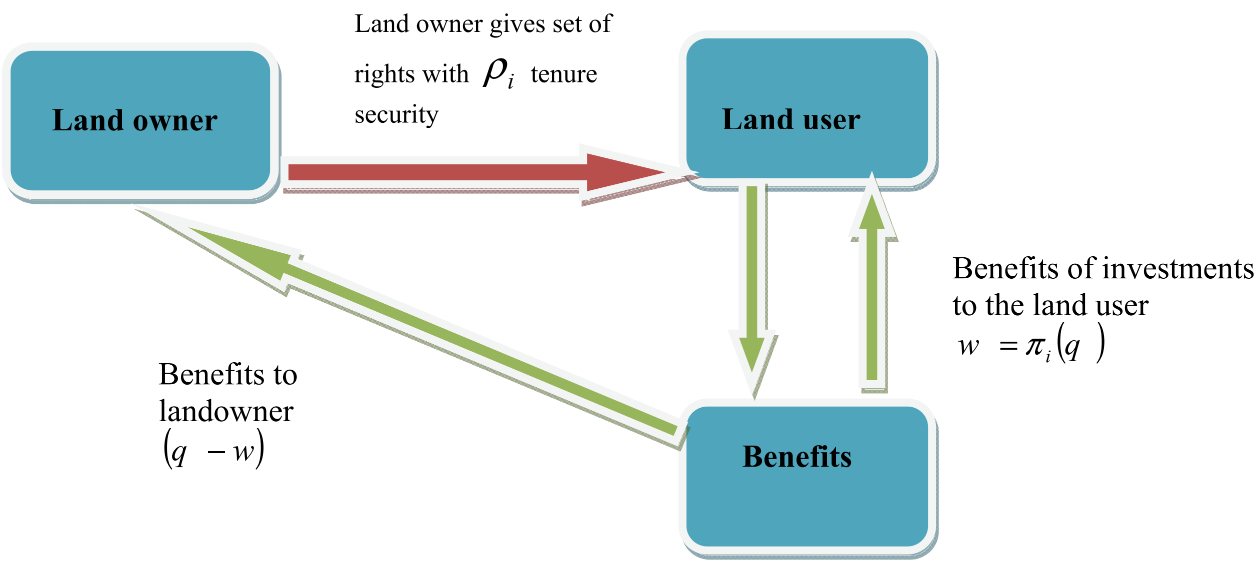

Figure 2 conceptual model

In any of the above villages, the cost of production for the household can be assumed to be *C*. The cost of production with investment $x = x_i$ is $C(x_i)$. Let the set of rights given by the land owner to the land user provide ρ_i tenure security on plot *i* in the household. Tenure security is bounded to the interval $[0,1]$, where 0 is no tenure security, and hence, the land is not usable, and 1 is total tenure security, indicating that the user is basically the owner of the land. After the investment on the land, the security can increase to π_i. Let the output in time t+1 after investment in time *t* be q. If the output is 1:1 the input, observing the output q is the same as observing investment *x,* e.g., if the input *x,* is planting trees, the output q will be the number of trees observed on a plot. Let *w* be the benefit to the household head when q is observed. Therefore, what he actually gets depends on the type of rights he gains or maintains, and therefore, $w = \pi_i q$. This *w* is the benefit accrued to the household head on the investment. This could be the ownership of a plot that he invested in by planting trees or benefits from increased soil fertility from using an agro-forestry tree or using the tree products, e.g., for firewood, tobacco sheds, or any other productive activity. The most secure the household head will pay himself all of the benefits from the investment, while insecure household head will lose some of the benefits to the owner after the divorce, death of the spouse, or land bequeathed to descendants other than his children. His utility function thus depends on the total benefits accrued to him from all of the investments made. This is given by

1) $U = w \ = P\pi_i q$.

Where $P\rho_j q$ is the net value of output and *P* is the price of output. His objective function will therefore be

2) $\underset{q}{Max} U$

Subject to:

3) $$P\pi_i q - C(x_i) \geq 0$$

The household head is assumed to be risk averse; therefore, *U(.)* is the Von Neumann-Morgenstern utility. The total revenue should be greater than the cost of the investment.

4) $$P\pi_i q - C(x_i) \geq P\rho_i q - C(x_i)$$

The net benefit after investment and change in the set of property rights is greater than the net benefits when the set of rights does not change because π_i gives more rights to the benefits than ρ_i. The Langrangian for the maximisation problem is given by:

5)

$$L = P\pi_i q - \lambda[C(x_i) - P\pi_i q] - \psi[C(x_i - C(x_i) - Pq(\rho_i - \pi_i))]$$

The FOC with respect to *q*

6) $$P\pi_i - \lambda P\pi_i - \psi P(\rho_i - \pi_i) = 0$$

Dividing through by $P\pi_i$ and rearranging:

7) $$= 1 + \lambda + \psi\left[1 - \frac{\rho_i}{\pi_i}\right]$$

Equation 7 says that at any given utility the level of marginal benefit to the household head is the sum of the marginal net benefits from participation and the marginal benefit of the incentives. Generally, $\lambda>0$; otherwise, investments are more costly than the benefits; however, if $\psi=0$, then there is no incentive constraint, and this reduces to a maximisation problem. When ψ is positive, the incentive compatibility constraint is binding. The ratio of the probabilities of being secure and insecure determines the final behaviour of the man. The statistic $\frac{\rho_i}{\pi_i}$ is known as the likelihood ratio. Given equation 7 when the tenure security after investments π_i is higher than the original tenure security ρ_i, the ratio in brackets is smaller, hence increasing the effect of ψ. If the tenure security does not change, the ratio is 1; hence, the entire second term becomes zero, and the only effect on investments are the λ, i.e., market forces (prices). Therefore, the main hypothesis of this paper is that the prospect of high security increases the probability and intensity of investment of a man, whereas a prospect of low security reduces the probability and intensity of investment. Therefore, I estimate the investment as a function of the λ and ρ. I use tree planting as an investment, first, as a dummy variable (i.e., present or absent of tree on plot *i*), and then intensity of planting trees (i.e., amount of trees planted on plot *i*). The trees are categorised into productive fertility-enhancing (agro-forestry trees - *Tephrosia vogelii, Faigherbia albida, Leucaena leucocephala, and Sesbania sesban*) and non-fertility-enhancing trees, e.g., gmelina, eucalyptus and India. The factors that affect the λ are specific to the household head because of imperfect markets; therefore, I use wealth; resources owned; e.g., land and livestock assets; and ρ as the security level, which is proxied by the residence of location.

4.0 EMPIRICAL MODEL

From the theoretical model, I have that the demand for resources is given by

$$8) \qquad y_i = x^h \beta_h + z^h \delta_h + \mu_h$$

I denote y_i to be the number of trees planted, z^h ownership rights, and x^h income variables of the household, which include wealth and resources owned, e.g., land and livestock assets. In order to isolate the impact of security on investment, I use security-enhancing and productivity-enhancing separately. Grossly lumped investment activities can give erroneous results (Deininger and Jin, 2006). Non-agro-forestry trees are used as an indicator of tenure security-enhancing investment, and agro-forestry trees are a productivity-enhancing investment on top of security. Tree planting is a good indicator of tenure security as it is visible, permanent, and manifests property rights (ibid). Other studies that have used trees to link security and investments include Ayalew, et al., 2005; De Zeeuw, 1997; Deininger and Jin, 2006; Migot-Adholla, et al., 1991; and Place and Otsuka, 2001a. I therefore focus on the coefficient $\delta_{h,}$, which shows the correlation between investments and tenure rights.

The variable "trees planted" is not strictly linear. It takes on the value of zero with a positive probability density at zero but is a continuous random variable over strictly positive values. For some households heads, an optimal choice is the corner solution of $y_i = 0$. Therefore, the variable trees planted has a mixture of discrete and continuous distributions. We are first interested in the probability of a man plating trees given the ownership rights that he possesses. Second, we are also interested in the intensity of planting trees given tenure security rights.

Estimation problems and solutions

Major problems in estimating the impacts of tenure security have been in measuring tenure rights themselves and the endogeneity of tenure rights. Several approaches have been used to solve measurement error, ranging from the simple counting of rights, or dichotomous variables, to a categorical variable based on an internally consistent hierarchy of rights (Brasselle et al., 2002); however, in all of these methods, there is a need to accurately measure the rights and security of the household. Using the rights and security position of the man in survey can lead to measurement errors due to a) overlapping rights, which may not estimate the exact position of security of the man; b) the self reporting of the rights by the man; and c) the difficulty of capturing the wide range of rights. Therefore, estimates of y_i will be inconsistent (Wooldridge, 2002).

Indicator variables are used to solve the measurement error problem. It is assumed that tenure rights are determined by the tenure security systems, i.e., matrilineal or patrilineal systems, and further by the household residential location, i.e., matrilocal, patrilocal, or neolocal. It is also assumed that a patrilocal residence gives more security to the man; therefore, a household in a patrilocal residence is assured that the man has full control of the land. Matrilocal residence provides less security to men; therefore, the household residing in a matrilocal location does not have full control of the land. Replacing tenure security rights by the location of residence puts the measurement error into the error term in equation 8. This is different from classical error in variables (CEV) in that this assumes that the measurement error has zero covariance with the location of residence; therefore, the composite error is independent of the explanatory variables.

9) $$y_i^* = L^h \delta_h + x^h \beta_h + \left(e^L \theta_L + u_h\right)$$

Where L_i is the location of residence and $e^L \theta_L$ is the measurement error estimate. The composite error term now has a zero mean and is uncorrelated with the explanatory variables; however, the efficiency of the standard error is lost, and the variance of the error term is now the sum of the variance of the error term plus the variance of measurement error.

10) $$Var\ (u_i - e_z \gamma_z) = \sigma_u^2 + \gamma_z^2 \sigma_e^2$$

The model estimates are now consistent (Wooldridge, 2002 p. 74).

Model estimation for the probability of planting trees given secure tenure.

In order to capture the probability of planting trees, I specify a reduced form of the model, wherein I only observe that either trees were planted or not, i.e., y_i *=1* if trees were planted and y_i *=0* otherwise. We are primarily interested in

11) $$y_i = 1\left[L^h \delta_h + x^h \beta_h + u_h > 0\right]$$

The coefficient δ reflects the effect of change in residence location on planting trees. This specification is basically a probit model; however, residence location is also determined by the tenure system, e.g., patrilineal or matrilineal; the mode of land acquisition, i.e., land acquired from the husband's or wife's family; the ability of the man to pay the bridal price, which is a function of his wealth; and the availability of land, which also determine the probability of planting trees. Therefore, we can write the residence location as

12) $$L^h = 1\left[T\theta + x^h \beta_{h2} + v_h > 0\right]$$

where T is the determinant of the residence location and the error terms v_h and u_h are independent of all of the exogenous variables in equation 11 and 12. If the covariance of these two error terms is not equal to zero, i.e., $\rho = corr(u_h, v_h) \neq 0$, then a probit model on equation 11 will produce inconsistent results (Wooldridge, 2002). In order to derive the likelihood function for estimating the equation, I specify the joint distribution of (y_i, L^h). Given that there are three residential areas, patrilocal, matrilocal, and neolocal, I have six possible outcomes, i.e.,

$$\begin{array}{cc} & L^h \\ y_i & \begin{Bmatrix} 0,1 & 0,2 & 0,3 \\ 1,1 & 1,2 & 1,3 \end{Bmatrix} \end{array}$$

with the following joint distribution

$$1 - \left\{ \left(\frac{1}{1 + \left[\exp\left(L^h \delta_{pat}\right) + \exp\left(L^h \delta_{neo}\right)\right]} \right) \int_{-\infty}^{-L\theta} \Phi\left[\frac{L^h \delta_h + x^h \beta_h + v_h \rho_h}{\left(\sqrt{1-\rho_h^2}\right)} \right] \exp\left(L^h \delta_{mat}\right) dv \right\}^{P\left(y_I=0 \middle| L^h = matrilocal,\right)}$$

$$\left\{ \left(\frac{1}{1 + \left[\exp\left(L^h \delta_{pat}\right) + \exp\left(L^h \delta_{neo}\right)\right]} \right) \int_{-\infty}^{-L\theta} \Phi\left[\frac{L^h \delta_h + x^h \beta_h + v_h \rho_h}{\left(\sqrt{1-\rho_h^2}\right)} \right] \exp\left(L^h \delta_{mat}\right) dv \right\}^{P\left(y_I=1 \middle| L^h = matrilocal\right)}$$

$$1 - \left\{ \left(\frac{1}{1 + \left[\exp\left(L^h \delta_{mat}\right) + \exp\left(L^h \delta_{neo}\right)\right]} \right) \int_{-\infty}^{-L\theta} \Phi\left[\frac{L^h \delta_h + x^h \beta_h + v_h \rho_h}{\left(\sqrt{1-\rho_h^2}\right)} \right] \exp\left(L^h \delta_{pat}\right) dv \right\}^{P\left(y_I=0 \middle| L^h = patrilocal,\right)}$$

$$\left\{ \left(\frac{1}{1 + \left[\exp\left(L^h \delta_{mat}\right) + \exp\left(L^h \delta_{neo}\right)\right]} \right) \int_{-\infty}^{-L\theta} \Phi\left[\frac{L^h \delta_h + x^h \beta_h + v_h \rho_h}{\left(\sqrt{1-\rho_h^2}\right)} \right] \exp\left(L^h \delta_{pat}\right) dv \right\}^{P\left(y_I=1 \middle| L^h = patrilocal\right)}$$

$$1-\left\{\left(\frac{1}{1+\left[\exp\left(L^h\delta_{pat}\right)+\exp\left(L^h\delta_{mat}\right)\right]}\right)\int_{-\infty}^{-L\theta}\Phi\left[\frac{L^h\delta_h+x^h\beta_h+v_h\rho_h}{\left(\sqrt{1-\rho_h^2}\right)}\right]\exp\left(L^h\delta_{neo}\right)dv\right\}^{P\left(y_I=0\middle|L^h=neolocal,\right)}$$

$$\left\{\left(\frac{1}{1+\left[\exp\left(L^h\delta_{pat}\right)+\exp\left(L^h\delta_{mat}\right)\right]}\right)\int_{-\infty}^{-L\theta}\Phi\left[\frac{L^h\delta_h+x^h\beta_h+v_h\rho_h}{\left(\sqrt{1-\rho_h^2}\right)}\right]\exp\left(L^h\delta_{neo}\right)dv\right\}^{P\left(y_I=1\middle|L^h=neolocal,\right)}$$

Where the first expression in $\frac{\exp\left(L^h\delta_j\right)}{1+\left[\left(\exp\left(L^h\delta_k\right)+\exp\left(L^h\delta_g\right)\right)\right]}$ (*j,k,* and *g* being residence locations) is a multinomial logit. Taking logs of the above expression gives the maximum-likelihood function for the MLE.

Following Rivers and Vuong (1988), who showed how to estimate a probit with binary endogenous variables, I can estimate the equation above and compute residuals that are used in the investment equation as an exogenous variable. The problem is that the residence location is not a binary variable as in Rivers and Vuong (ibid.), but instead is tri-variate, (there are three residence locations, patrilocal, matrilocal, and neolocal). I use a multinomial logit to predict the probability of the residence location in the first stage on the following exogenous variables: inheritance system (matrilineal or patrilineal), total land inherited, dummies for the mode of land acquisition (from wife's mother, wife's father, husband′s father, husband's mother, the local chief, purchased, or rented land), wealth indicator, and value of livestock assets. I compute residuals used in the second stage for estimating the investment equation, holding the matrilocal residence location as a basis for reference. I therefore use two-stage conditional maximum-likelihood (2SCML) and also direct estimation in an instrumental-variable probit (IVP) to check for consistence and robustness. I correct standard errors using bootstrap methods with the following equation:

14) $$y_i=1\left[L^P\delta^P+L^N\delta^N+y^h\beta_h+\hat{v}_P\,\rho^P+\hat{v}_N\,\rho^N+e^h>0\right]$$

where L^P and L^N are the patrilocal and neolocal residence locations with the matrilocal location as the reference point and v^P and v^N are corresponding error terms estimated in the first stage for each residence location. The significance of the coefficients ρ will reveal the endogeneity of the residence location. In order to test for the robustness of the results, I also estimate the model controlling for the possible correlation within plots in the same household. I use household random effects on the plot data derived from the above equation

Model estimation for intensity of planting trees given secure tenure.

As in the probability model, the residence location is endogenous and tri-variate. I compute residuals from the multinomial logit for the two residence locations and use them as exogenous variables in the intensity equation. I therefore estimate a tobit regression model.

16) $$y_I = \max\left(0, L^P\delta_P + L^N\delta_N + x^h\beta_h + \hat{v}_P\,\vartheta_P + \hat{v}_P\,\vartheta_N + w_h\right)$$

5.0 DESCRIPTIVE STATISTICS

The data used in this study come from a household survey conducted in June 2007 in six districts across Malawi. The districts are Thyolo, Zomba, Chiradzulu, and Machinga in the southern region, and Lilongwe and Kasungu in the central region. The southern region is dominated by matrilineal inheritance, while the central region is dominated by patrilineal inheritance. In all districts, there were patrilocal, matrilocal, and neolocal residence households. A total of 435 households with a total of 1,521 plots were used in this study. There were 633 plots in the patrilineal system and 888 plots in the matrilineal system. Out of the 633 plots in the patrilineal system, 63% were under patrilocal residence, 31% were matrilocal, and about 6% were neolocal. Within the matrilineal system, 18% were patrilocal, 76.2% were matrilocal, and 6% were neolocal. Table 1 below summaries the variables used in the first stage of predicting the residential area by inheritance system and residential area.

Table 1: Variables used in the multinomial logit equation: by inheritance system and location of resident

Tenure system / ***Residence***	***Patrilineal***			***Matrilineal***		
	Matrilocal	**Patrilocal**	**Neolocal**	**Matrilocal**	**Patrilocal**	**Neolocal**
Value of livestock assets (MK)	15,435.25	92,015.42	28,298.11	7,231.59	12,008.43	10,586.04
Wealth indicator (type of dwelling house)	16.80	21.46	18.81	24.92	28	26.30
Total inherited land (Hectares)	1.560	2.24	3.43	0.98	1.56	1.11
Dummy inherited from wife's mother	0.42	0.04	0	0.76	0.19	0.13
Dummy land inherited from wife's father	0.159	0.056	0.24	0.025	0.033	0
Dummy land inherited from husbands mother	0.054	0.11	0	0.068	0.35	0.094
Dummy land inherited from husband's father	0.093	0.45	0	0.0044	0.205	0.037
Dummy land received from village chief	0.16	0.13	0.72	0.065	0.15	0.56
Dummy land purchased	0.021	0.092	0	0.0074	0.0066	0
Dummy land rented	0.055	0.080	0	0.045	0.039	0.13
Total	194 (30.7%)	402 (63.5%)	37 (5.8%)	677 (76.2%)	157 (17.7%)	54 (6.1%)

In the above table, patrilocal households had the highest value of livestock assets, better dwelling houses, and large inherited land in both patrilineal and matrilineal societies. Households in matrilocal residential areas inherited land from the wife's mother or father, while households in patrilocal residential areas inherited land mostly from the husband's father or mother. The included neolocal households received land primarily from the chief of the village in which they settled.

The survey results indicate that patrilocal residence households had more planted trees than did matrilocal and neolocal residence households in both patrilineal and matrilineal systems.

Neolocal households planted more trees than matrilocal residences in the patrilineal system, but they reside in a matrilineal system. The average number of trees planted per hectare in a matrilocal residence was similar to that of a patrilocal residence in the patrilineal system, indicating that tenure security may not affect how much to invest after the decision to invest had been made. Neolocal residence households in the patrilineal system had the lowest average number of trees planted per hectare, but the highest values were found for the matrilineal system. These results show that the more secure patrilocal residence households had greater investments in trees in both matrilineal and patrilineal systems. Insecure neolocal residence households has more plots planted with trees in the patrilineal system and the highest number of trees planted per hectare in the matrilineal system, while insecure matrilocal residence households planted trees on the least number of plots in the patrilineal system and had the lowest number of trees per hectare in the matrilineal system. Although neolocal residence households are insecure, they had higher incentives to invest because that would increase their security, while matrilocal residences could not change their security status.

Matrilocal residence households had fewer resources than the patrilocal and neolocal residence households. Land size was the lowest in matrilocal residence households in both tenure systems. Patrilocal residence households were wealthier as measured by the number of livestock owned and the value of assets. This may contribute to investment because households that are wealthier will have enough resources for investment, e.g., they can hire in labour. The distance from the plot to the house did not vary much between matrilocal and patrilocal arrangements in either tenure system. Table 2 gives the average numbers of trees planted and resources owned by the households by residence location.

Table 2: Summary of variables used in the analysis

	Patrilineal			*Matrilineal*		
	Patrilocal	*Matrilocal*	*Neolocal*	*Patrilocal*	*Matrilocal*	*Neolocal*
Plots with planted trees	23%	17%	24%	31%	16%	10%
Av. no. of natural trees on plot	8	7	4	3	2	2
Household land size (ha)	2.23	1.57	3.4	1.57	0.98	1.10
Av no. of trees planted per ha	29	29	4	17	14	28
Av distance [plot to home (m)]	1030	1274	69	832	760	913
Assets owned (MK '000)	29	7.1	9.7	6	4	5.1
Livestock value (MK '000)	92	15.4	28.3	12	7.2	10.6

6.0 ECONOMETRIC RESULTS

6.1 Predicting location residence

A multinomial logit model was used to predict residence location as a first stage in the two-stage conditional maximum likelihood estimation (2SCMLE). The matrilocal residential location was used as a reference point. The results in Table 3 of Annex 1 show that households in a patrilocal residential location had more livestock assets and wealth than the matrilocal residence households. The patrilocal residence households acquired their land from the husband's side and were able to purchase land. The neolocal households had more land than matrilocal residence households and acquired land from the chief in the village where they had settled. The model prediction had a Pseudo R^2 of 0.3830. Residuals were calculated from the predicted probabilities and used in the second stage of determining the probability of planting trees and the intensity of tree planting, given the residence location.

6.1 Probability of planting trees

Random effects instrumental probit and 2SCMLE models on the probability of planting trees given the location of a residence as an endogenous explanatory variable were estimated. Matrilocal residence was dropped in the estimation and used as a reference location. Control variables included the size of the land, the distance from plot to home, the average slope of the plot, the level of soil erosion, the perception of the plot's fertility, the number of natural trees on the plot, and household characteristics, such as years in marriage at the location of residence, the household size, the educational level of the household head, and livestock as an asset indicator.

The results in Table 4 of the Appendix exhibit the expected hypothesised signs on the effect of residence location on the probability to plant non-agro-forestry and agro-forestry trees. The probability is positive and significant in both matrilineal and patrilineal societies, indicating that there is a higher probability of trees being planted by households in patrilocal residences than by households living in matrilocal residences. The neolocal residence coefficient for the probability of planting non-agro-forestry trees is positive, but only significant in the patrilineal society. This also indicates that there is a higher probability of households planting trees in neolocal residences than in matrilocal residences. For agro-forestry tree planting, the patrilocal residence coefficient is positive and significant. The neolocal residence coefficient for the probability of planting agro-forestry trees is positive, but not significant. The 2SCMLE results (Table 4 of the Appendix) show that the error terms for both patrilocal and neolocal contexts are significant, indicating the endogeneity of the patrilocal and neolocal residence location in the probability of the planting trees model. Therefore, using the two-stage or instrumental-variable method gives a consistent estimator. The results also show no difference in the signs of the residence location variable, which shows that the results are robust.

The total land-holding size was negative in the non-agro-forestry models, except for the patrilineal society; however, plot size was positive and significantly affected planting trees in matrilineal societies. Therefore, there is a higher probability for a household to plant trees where the household has more land. Household characteristics also affect the probability of planting trees. The duration of the tenure, which was indicated by the number of years the household has lived in the area, was negative and significant. This indicates that the younger households have a higher probability of planting trees. As land is becoming scarce, there is a higher probability of conflicts; planting trees thus enables a household to ensure its security.

The distance from plot to home was negative in all non-agro-forestry tree models, indicating that trees are likely to be planted on plots closer to home. The number of natural trees on the plot was used as a control variable because we assumed that it would not be necessary for a household to plant trees when the plot already has natural trees. Amazingly, the variable is positive and significant, indicating that the more natural trees on a plot, the higher the probability of planting trees. This may indicate that the act of planting trees in itself, is important, as it is used as a seal of ownership. Therefore, even though a plot has natural trees, a household needs to plant its own trees that it can show to claim ownership of the land.

6.2 Intensity of trees planted

The 2SCMLE and instrumental tobit models results are depicted in Tables 5 and 6 of the Appendix, wherein they show that patrilocal residence location affects the amount of trees planted in both patrilineal and matrilineal societies. The coefficients are all significant at 10%, with larger coefficients in the patrilineal (17.17 in 2SCMLE and 13.565 in IVTobit) in comparison to the matrilineal society (7.763 in 2SCMLE and 9.022 in IVTobit). The neolocal residence households' coefficient was positive and significant for the intensity of planting agro-forestry trees. Neolocal households may have a higher incentive to plant more trees because they may need to establish their security. The other driving forces for the intensity of tree planting are household size and total land holdings. A large household demands a large tract of land to meet its food and resource needs, and its plants fewer trees. The distance from the plot to the home also indicates that households plant trees on plots that are closer to home.

7.0 DISCUSSION

The discussion in this paper begins by looking at previous studies on tenure security and investments. When many studies have different and inconsistent findings in terms of the relationship between tenure security and investment, these differences may reflect contextual differences. Using the data in Malawi, I show that when a household is secure now and in the future, it has a high incentive to invest. I also show that incentives to invest are high for insecure households that can change their security by investing, while insecure households that cannot change their security have a low incentive to invest.

The results show that households that are secure, i.e., those in a patrilocal residential location, have a high incentive to invest in tree planting. As land is mostly inherited by men in patrilocal residences, a man is able to ensure his security and is able to make long-term investment decisions. Therefore, both non-agro-forestry and agro-forestry trees are likely to be planted by these secure men. They are ensured to reap the benefits of their investments. Secure households have been less contradictory, as most studies find that their investment incentives are high.

The most contradictions in the relationship between tenure security and investment have been observed in households perceived as insecure. In some cases, they are found to invest, and in some cases, e.g., households threatened by land distribution in Ethiopia, they do not invest. This study shows that when the household is tenure insecure, the probability of investing in trees is low only when the tenure security cannot be changed. Male-headed matrilocal households are insecure and can never claim ownership of their land; they thus have a lower incentive to invest. The land they cultivate may even be inherited by the nieces from the wife's side and not their own children. Therefore, they cannot reap the benefits of their investment, nor can they let their own children inherit the land. When land ownership tenure rights are controlled by a person other than the user of the land, the probability of investment is low. This has been shown by others elsewhere, e.g., Goldstein and Udry (2005), Deininger and Ali (2007), and Deininger and Jin (2006).

On the other hand, when the household is insecure but is ensured of changing its tenure security, investment incentives are high. Households in neolocal residences have a higher probability of planting trees even though they are immigrants into an area. When a household moves to a neutral place, the land is either bought from or given by the chief in the areas of settlement, and in most cases, a notification in the form of a written document is provided. The man, as the household head, assumes ownership of the land. Visible investments are important, as they can be used as evidence that the farmer has developed the land in case of disputes. These can be used by children in the future to show the boundary and demarcation of their inheritance. A tree planted by a parent or grand-parent is undisputed evidence of ownership; however, these households, have a lower probability of planting agro-forestry trees. Their main objective is to increase security, and they may not necessarily look for productive trees.

8.0 CONCLUSION

Several empirical studies have been done to link tenure security and investments in sub-Saharan Africa, but have found inconsistent results. These inconsistencies have been attributed to the methodological approaches used and erroneous empirical estimation; however, measurement errors in the security variable and poor definition of the context in which the security is analysed can also explain these inconsistencies. Using data from smallholder households in Malawi under three different contexts of tenure security proxied by residence location, I show that signalling a secure tenure in the future increases investment incentives. When tenure security is high, there are higher investment incentives. When tenure security is low, investment incentives are high when the tenure security can be increased. In other words, when high tenure security is ensured in the future, there is a higher incentive to invest. Therefore, it is important to understand the context in which the households exist when assessing the linkage between tenure security and investment.

In Malawi, the new land policy (Government of Malawi, 2002) will, for the first time, formalise customary land, giving it legal status; however, the existence of the registration title held by a man in a matrilocal situation may not guarantee the security of his tenure under cultural practices, as the lineages may resort to behaviour that may compel him to leave (Kishindo, 2004). Therefore, even though the policy recognises customary land, the current cultural practices (as seen in the results above) will still give men who reside in the spouses' village less security and hence will affect their investment decisions. Simply replacing the traditional systems with individual legal land titles will not do away with this insecurity. There is a need to address the real fundamental problem of security, i.e., ensure the future ownership of land for the land user or the compensation for investment in the case of eviction.

This study also reveals the hidden inequality and insecurity of women. If land given to women is secure, investments incentives should be high in either of the matrilineal or patrilineal systems. Another possibility is that women do not have the power and ability to invest or influence investments in a household. All of these show the vulnerability and insecurity of women. Therefore, policy reforms need to address intra-household inequalities.

9.0 REFERENCES

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ANNEX - REGRESSION RESULTS

Table 3: First stage Multinomial logit of residence (1=matrilocal;2=patrilocal;3=neolocal)

Residence	**Patrilocal**			**Neolocal**		
	Coefficient	**Standard Error**	**P>z**	**Coefficient**	**Standard Error**	**P>z**
Patrlineal	1.539614	0.1815513	**0.000**	-0.2077081	0.3049588	0.496
Livestock Asset	5.83e-06	2.28e-06	**0.010**	1.53e-06	3.34e-06	0.648
Wealth indicator	0.021267	0.0056471	**0.000**	0.0006285	0.0099166	0.949
Total household land(ha)	0.0131466	0.0707053	0.852	0.3680609	0.1010255	**0.000**
Land inherited from wife's mother	-1.923929	0.4317145	**0.000**	-2.590903	0.7440887	**0.000**
Land inherited from wife's father	-0.6243834	0.4731021	0.187	0.1688385	0.7384535	0.819
Land inherited from husband's mother	1.240457	0.4399688	**0.005**	-0.7471822	0.7921788	0.346
Land inherited from husband's father	2.102712	0.4672384	**0.000**	-0.9239489	0.994754	0.353
Land acquired from chief	0.2077432	0.4356165	0.633	1.39167	0.6611892	**0.035**
Land purchased	1.03178	0.5721731	**0.071**	-33.80935	1.77e+07	1.000
Land rented	0.1031241	0.4719581	0.827	0.1101528	0.760382	0.885
Constant	-3.161714	0.5157403	0.000	-2.031029	0.8092499	0.012

(residence matrilocal is the base outcome)
Number of obs= 1435; LR chi2(22) = 945.79
Prob > chi2 = 0.0000; Log likelihood = -761.75478
Pseudo R^2 = 0.3830

Table 4 Two Stage Conditional Maximum Likelihood Estimation: Probability of Planting Trees

	Probability of planting trees		Probability of planting agro-forestry trees
	Matrilineal society	**Patrilineal society**	
Patrilocal residence	0.544*	0.427	0.492*
	(0.33)	(0.32)	(0.28)
Neolocal residence	0.039	0.132	0.099
	(0.28)	(0.41)	(0.29)
.residual $\hat{}$ *patrilocal*	-0.196	-0.786**	-0.127
	(0.37)	(0.39)	(0.35)
.residual $\hat{}$ *neolocal*	0.112	0.817	-0.485
	(0.63)	(1.00)	(0.75)
Number of natural trees on plot	0.022****	0.004	0.010**
	(0.01)	(0.00)	(0.00)
Size of plot (ha)	1.020****	-0.064	0.179**
	(0.24)	(0.10)	(0.08)
Total size of inherited land (ha)	-0.049	0.172****	-0.088
	(0.10)	(0.04)	(0.07)
Household size	-0.071**	-0.101***	0.004
	(0.03)	(0.04)	(0.03)
Perceived fertility of plot	-0.082	0.053	0.020
	(0.09)	(0.12)	(0.10)
Number of years on the plot	-0.013**	0.003	-0.004
	(0.00)	(0.01)	(0.00)
Slope of the plot	0.020	0.052	0.037
	(0.11)	(0.14)	(0.12)
Erosion level on plot	-0.049	0.046	-0.009
	(0.06)	(0.07)	(0.06)
Distance from home to plot	-0.000***	-0.000***	0.000
	(0.00)	(0.00)	(0.00)
Highest educational level of head	-0.128*	-0.275****	0.025
	(0.07)	(0.08)	(0.07)
District Dummy			
Kasungu		-0.442**	-0.296
		(0.18)	(0.22)
Thyolo			0.146
			(0.30)
Zomba	0.208		0.196
	(0.20)		(0.24)
Machinga	-0.202		0.172
	(0.22)		(0.25)
Chiradzulu	0.092		0.638**
	(0.19)		(0.26)
Constant	-0.237	-1.055	-1.119
	(0.76)	(0.98)	(0.87)
Prob > chi2	0.000	0.000	0.197
Number of observations	670	447	1117

Significant level (=0.10; ** =0.05; †=0.01; ‡= 0.001) and standard errors in parenthesis*

Table 5 Two Stage Conditional Maximum Likelihood Estimation: Intensity of Planting Trees

	Intensity of planting trees		Intensity of planting agro-forestry trees
	Matrilineal society	**Patrilineal society**	
Patrilocal residence	7.763*	17.177*	1.478
	(4.49)	(8.89)	(8.18)
Neolocal residence	2.091	1.640	15.855**
	(3.76)	(10.93)	(6.67)
$.residual \hat{\ } patrilocal$	-2.887	-27.229**	4.146
	(5.14)	(10.87)	(9.00)
$.residual \hat{\ } neolocal$	-5.311	-12.182	-14.019
	(8.71)	(25.53)	(14.21)
Number of natural trees on plot	0.577****	0.064	0.142****
	(0.08)	(0.05)	(0.04)
Size of plot (ha)	12.853****	-0.372	3.426**
	(2.93)	(2.43)	(1.67)
Total Size of inherited land (ha)	-2.070	2.507**	3.442***
	(1.40)	(1.06)	(1.27)
Household size	-0.888**	-1.756*	-1.770**
	(0.39)	(1.02)	(0.80)
Perceived fertility of plot	-1.674	-1.076	-2.133
	(1.27)	(3.06)	(2.30)
Number of years on the plot	-0.101	0.024	-0.056
	(0.07)	(0.14)	(0.11)
Slope of the plot	-1.458	1.623	-1.750
	(1.60)	(3.75)	(2.91)
Erosion level on plot	-0.401	1.501	1.989
	(0.77)	(1.95)	(1.24)
Distance from home to plot	-0.002***	-0.008***	-0.006***
	(0.00)	(0.00)	(0.00)
Highest educational level of head	-0.702	-5.830***	-1.906
	(0.99)	(2.11)	(1.48)
District Dummy			
Zomba	1.587		0.609
	(2.74)		(6.31)
Machinga	-2.339		0.779
	(3.04)		(6.39)
Chiradzulu	1.128		11.556*
	(2.63)		(6.92)
Kasungu		-8.105	-13.289*
		(4.93)	(7.08)
Thyolo			4.488
			(8.07)
Constant	3.071	-3.204	-8.347
	(10.42)	(24.77)	(18.57)

sigma _constant	14.544****	27.705****	21.377****
	(0.92)	(2.15)	(3.28)
	0.000	0.000	0.000
Number of observations	670	447	1117

Significance level (=0.10; ** =0.05; †=0.01; ‡= 0.001) and standard errors in parenthesis*

Table 6: Random Effects Instrumental Variable Probit and Instrumental Variable Tobit Models

	Instrumental variable probit model		Instrumental variable tobit model	
	Matrilineal	Patrilineal	Matrilineal	Patrilineal
Patrilocal	0.639*	0.514**	9.022*	13.565*
	(0.34)	(0.25)	(4.76)	(7.21)
Number of natural trees on plot	0.021***	0.004	0.555****	0.057
	(0.01)	(0.00)	(0.08)	(0.05)
Size of plot (ha)	0.964****	-0.052	12.135****	0.203
	(0.24)	(0.09)	(2.88)	(2.44)
Total Size of inherited land (ha)	-0.101	0.139****	-2.736*	2.202**
	(0.11)	(0.04)	(1.53)	(1.02)
Household size	-0.079***	-0.060*	-1.044***	-1.232
	(0.03)	(0.03)	(0.40)	(0.86)
Perceived fertility of plot	-0.058	0.051	-1.470	-0.471
	(0.09)	(0.11)	(1.23)	(2.97)
Number of years on the plot	-0.011**	0.004	-0.061	0.066
	(0.00)	(0.00)	(0.07)	(0.14)
Slope of the plot	0.013	0.046	-1.364	0.834
	(0.11)	(0.13)	(1.55)	(3.53)
Erosion level on plot	-0.022	0.044	-0.127	1.831
	(0.05)	(0.06)	(0.73)	(1.74)
Distance from home to plot	-0.000***	-0.000**	-0.002***	-0.005**
	(0.00)	(0.00)	(0.00)	(0.00)
Highest educational level of head	-0.100	-0.195***	-0.399	-4.182**
	(0.07)	(0.07)	(0.93)	(1.97)
Zomba	0.293		2.578	
	(0.19)		(2.62)	
Machinga	-0.125		-0.914	
	(0.22)		(3.00)	
Chiradzulu	0.181		1.813	
	(0.18)		(2.48)	
Kasungu		-0.399**		-6.686
		(0.16)		(4.51)
constant	-0.186	-0.651*	-2.422	-19.184*
	(0.41)	(0.37)	(5.70)	(10.41)
athrho _cons	-0.115	-0.379***		
	(0.12)	(0.13)		
lnsigma _cons	-1.234****	-0.930****		
	(0.03)	(0.03)		
alpha _cons			-5.744	-25.042***
			(5.51)	(8.99)
lns _cons			2.673****	3.296****
			(0.06)	(0.07)
lnv _cons			-1.234****	-0.931****
			(0.03)	(0.03)

Prob > chi2	0.000	0.000	0.000	0.004
Number of observations	696	473	696	473

Paper III

Soil fertility and input use in maize production under a customary land tenure system in Malawi

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Abstract

*Soil fertility depletion from soil erosion and nutrient mining is a major problem affecting agriculture in Malawi. To address this problem, the Government of Malawi has been promoting the integrated use of organic manure and inorganic fertiliser, including a fertiliser subsidy aimed at poorer farmer*s. *Soil scientists have established that these technologies perform different functions in the soil and thus that they should be used complementarily in order to improve soil fertility. However, empirical research in social economics has found that farmers use organic manure and inorganic fertilisers as substitutes for each other. Due to the lack of a market for organic manure and an inefficient market for inorganic fertilisers, the use of these inputs depends on farmers' resource endowments. Using data from smallholder farmers in Malawi, and controlling for the resource endowments of the farmers, the use of organic and inorganic fertilisers is found to be complementary. However, large amounts of input use are constrained by the resource endowment of the farmer, mainly livestock, labour and liquidity assets, and hence show a negative relationship, which has been taken as substitution when resource endowments are not fully controlled. Therefore, the current fertiliser subsidy in Malawi may not reduce organic fertilisers, but may help to increase their use. Importantly, due to labour and livestock constraints, poor farmers may not easily adopt organic manure use.*

Key words: Soil-fertility, inorganic fertiliser, organic manure, complementary, resource endowments

1.0 INTRODUCTION

It is widely acknowledged that poor soil fertility is the principal constraint to production by smallholder farmers in Africa. Over decades, smallholder farmers have removed large quantities of nutrients from the soils without using sufficient organic manure or inorganic fertiliser to replenish them. Sanchez (2002) has estimated an annual loss equivalent to US$4 billion in fertiliser from nitrogen, phosphorous and potassium over the last 30 years in 37 Sub-Saharan African countries. This loss has negatively affected the production of both food and cash crops. In an effort to address this problem, researchers in different disciplines have conducted studies to find better solutions to replenish the soil's fertility. Soil scientists have established that soil fertility is better improved by the addition of both organic manure and inorganic fertilisers because they perform different functions in the soil (Palm, et al., 2001, Vanlauwe, et al., 2002, Vanlauwe and Giller, 2006, Woomer and Swift, 1994). From an economic point of view, this finding implies that these inputs should enter the production function as complements. On the other hand, some social economic studies have shown that smallholder applications of inorganic and organic fertilisers appear to be substitutes (Omamo et al. 2002; Debela et al. 2007). However, these studies do not control for the resource endowments of farmers. There is no market for organic manure, and the market for inorganic fertilisers is hampered by inefficiencies and cash constraints, thereby making the use of these inputs dependent on the farmer's resource endowments. This issue raises the following empirical question: based on their resource endowments, are smallholder farmers using organic manure as a substitute for inorganic fertilisers? As these inputs are used to replenish soil fertility, does inherent soil quality determine the type and intensity of the inputs used? This paper assesses how smallholder farmers use organic manure and inorganic fertilisers on soils with varying fertility under the customary land tenure system.

A review of smallholder farmers' experiences with soil fertility management practices reveals a growing use of diverse technologies that occurs both indigenously and through participation in agricultural projects (Omamo, et al., 2002, Place, et al., 2003). Economic and resource endowment considerations are usually the central issue when farmers decide to invest in any cropping system, including soil fertility management (Eaton, 1996). Place et al. (2003) observe that while biophysical research in soil fertility management is progressing rapidly, more research is needed on farmers' practices, including their innovations and the integration of individual components. This research will not only help the development of better policies that can be easily adopted by the smallholder farmers, but may also help to reduce the decline in soil fertility and increase production and livelihoods.

Soil fertility can be seen as a capital stock on which farmers invest variable inputs, such as seeds and fertilisers. If the capital stock declines, the farmer must invest more in other inputs, such as inorganic fertiliser or organic manure, to maintain a high yield. The traditional way to overcome nutrient depletion is the use of inorganic fertilisers (Sanchez, 2002). In Malawi, due to high transport costs, small volumes and inefficient distribution systems, inorganic fertilisers are very costly. Sanchez (2002) reports that a spot check on inorganic fertiliser prices in 2001 revealed that a tonne of urea costing US$90 in Europe was sold at US$770 in Malawi. This cost is a huge constraint on smallholder farmers who cannot afford to buy inorganic fertilisers at such prices and can only buy small quantities, which then have to be rationed among crops and plots. Organic manure has been promoted as a solution to soil fertility replenishment. However, there are limits to the amount of organic manure that can be produced on-farm, particularly where labour or livestock ownership are binding and no market is yet developed. Therefore, the use of either organic manure or inorganic fertiliser hinges more on farmers' resource endowments, hence the need to control for them in assessing their relationship. This study controls for the resource endowments of smallholder farmers in an assessment of the relationship between organic manure and inorganic fertilisers. The use of these technologies is assumed to depend on the inherent soil quality of a given plot. Farmers' perception of the level of soil quality determines how much of the technology is used in order to maximise output.

This paper's contribution to knowledge is three-fold. It shows the relationship among inputs; inorganic fertiliser and organic manure as practised by smallholder farmers on plots with different types of soil. Household model is used to show that farmers' input-use decisions are motivated by both output and the soil fertility stock based on their resource endowments. Secondly, the paper uses empirical data to show the relationship between soil fertility and input use. Lastly, the paper uses the farmers' perceptions of soil fertility instead of measuring factors such as soil depth, soil colour, nitrogen level or water retention levels. Farmers were asked to rank their plots in terms of inherent soil fertility, hence approaching the problem from a farmer's eyes because,

1) Farmers' decisions are made based on their perceptions of the levels of soil fertility. Researchers have emphasised the need to solicit farmers' perceptions and monitor their decisions (Eaton, 1996).

2) Farmers' perceptions are the combined effects of multiple physical factors, e.g., soil depth, weed composition, soil colour and texture, and hence represent a one-stop shop for assessing soil fertility; e.g., sandy soils are deep but have poor water retention capacity, hence nutrients easily leach from them, making them infertile.

3) Farmers' major indicator is their long-term observation of the output from the land. This indicator is based on the factor of production. Desbiez et al. (2004) have found that farmers' perceptions of soil fertility are more 'holistic' than those of researchers, as they include factors they feel influence the soils and crop growth in their fields. Hence, using farmers' perception in this analysis will help to avoid omitted variables and measurement errors that are introduced when finite specific soil fertility variables, e.g., soil depth, are used.

In most studies of the adoption of soil fertility technologies, the analysis uses only a single technology decision and ignores the possibility of joint dependency of the inputs. Some studies assume sequential decisions regarding technologies and use a two-stage approach (Chirwa, 2003, Debela, et al., 2007, Omamo, et al., 2002). Because the use of organic manure or inorganic fertiliser affects the use and amount of the other, i.e., there is a joint dependency, a simultaneous equation is used in this paper. The simultaneous equation is corrected for censoring with a probit model to determine whether the two inputs are used as complements or substitutes. The equation controls for resource endowment and the perceived fertility of the plot, as they may affect the amount of input used; e.g., if a plot is perceived to be very fertile, a farmer may decide to use less organic manure and inorganic fertilisers, instead using them on a less fertile plot. In addition, a non-parametric model is used to map out the relationship of organic manure and inorganic fertilisers at different application quantities.

2.0 SOIL FERTILITY MANAGEMENT IN MALAWI

Soil fertility decline in the form of nutrient mining and soil erosion is a major problem in Malawi. Bishop (1992) reports that the erosion of topsoil and the exhaustion of soil fertility are the most serious forms of soil degradation in Malawi. Total nutrient loss has been estimated at 30 kg nitrogen and 20 kg potassium per hectare of arable land each year (Stoorvogel and Smaling, 1990). This loss has been attributed to high land pressure, resulting in continuous cultivation and fragmentation of land. Without the adequate addition of both organic and inorganic fertilisers and the implementation of soil erosion control measures, declining yields are inevitable.

Farmers have adopted a range of soil fertility improvement technologies to remedy the problem. These remedies include use of inorganic fertiliser, introduction of livestock and compost manure, agro-forestry and growth of legumes, especially soya beans, groundnuts and pigeon peas. Inorganic fertiliser, manure and legume intercropping are well-established practices, but others, such as composting and agro-forestry, are relatively new (Place et al., 2003). Inorganic fertiliser is the main soil replenishing method. However, its use among smallholder farmers is hampered by high prices and a poor delivery and distribution system, which is mainly the result of poor road and market infrastructure (Nakhumwa, 2004, Nakhumwa, et al., 1999, Ng'ong'ola, et al., 1997). The Food Agriculture Organisation (FAO) estimates that farmers in Malawi use approximately 26 kg/ha of inorganic fertiliser, which is far below recommended amount of 200 kg/ha urea. The other alternative is the use of organic manure from livestock and compost. The Government estimates that 81% of the manure used by smallholder farmers currently comes from livestock, while 19% is compost. This manure is used on a total of just above 400,000 hectares (Government of Malawi, 2007).

Most farmers have practised a combination of technologies that complement each other. The economic consequence of using complementary inputs is higher efficiency relative to when the inputs are used independently. Tchale and Sauer (2007) explore the relative efficiency of maize-producing farms in Malawi by focusing on the efficiency impact of integrated soil fertility management practices compared to the exclusive use of inorganic fertiliser. They conclude that integrated methods hold potential for improving the efficiency of smallholder farmers by ensuring increased output (up to 31% higher than farmers using only chemical-based soil fertility management practices). However, with imperfect markets for inorganic fertiliser and output, and missing markets for organic manure, the use of these methods will significantly depend on household characteristics and resource endowments.

Research on soil fertility management in Malawi has mainly centred on the economics of soil erosion (Barbier and Bishop, 1995, Bishop, 1992, Bishop, 1995, Eaton, 1996, Mangisoni, 1999, Nakhumwa, 2004) the effects of soil erosion losses, the impact of conservation measures, (Bishop, 1992, Eaton, 1996), and factors affecting the adoption of conservation measures (Chinangwa, 2006, Chirwa, 2003, Nakhumwa, 2004). However, little is available on actual farmers' practices in using organic manure and inorganic fertiliser on different soil fertility plots.

3.0 THEORETICAL MODEL

Theoretical model is developed to study the behaviour of farmers with different resource endowments on plots with differing soil quality. Several studies have developed theoretical models focusing on land degradation and input use. The most notable of these studies is McConnell, (1983), who introduces soil loss and soil depth into a model of crop production. McConnell uses soil loss as a decision variable for the farmer. (Saliba, 1985) criticises the approach, as it does not consider input use as an addition to soil quality. Several other variations to the McConnell model have since been developed, notably, (Barbier and Bishop, 1995, Barrett, 1991, Clarke, 1992, Grepperud, 1993, LaFrance, 1992, Saliba, 1985, Shiferaw and Holden, 1997, Shively, 1996) . The general approach of most of these studies has been to determine soil quality using net changes (i.e., the amount of nutrients removed against nutrients added into the soil) as an additional decision variable for the household in its maximisation decisions. The difference in the models has been how the soil quality variable is defined. McConnell (1983) defines it as the net change in the top soil's depth due to soil erosion and natural regeneration, while Saliba (1985) does not include a damage function in the motion variable. La France includes the rate of cultivation and soil conservation, while Clarke (1992) combines long-term and short-term investments as additions into the soil. Clarke uses the production function as an additional damage function that affects soil quality; however, he does not explicitly include damage from erosion.

Clarke (1992), includes the production function as damage to soil quality, indicating the mining of mineral nutrients and then investments as additions to the soil. This model assumes perfect markets for investments and outputs from agriculture (as did most of the others). Factor markets in developing world settings are, in many cases, missing, thin or imperfect. In this setting, household asset endowments play a crucial role in influencing the decision and level of input use (de Janvry, et al., 1991, Holden and Shiferaw, 2001). As indicated earlier, the market for inorganic fertiliser is constrained by high prices and availability in some areas. The organic manure markets do not yet exist. No households reported buying manure, and no study has reported any transactions in organic manure. I thus develop a model with household resource endowments affecting the decision and amount of organic and inorganic fertiliser that is used.

The model

Soil fertility can be taken as one of many inputs to agricultural production, and its relative importance varies with farming systems. Where there is abundant land, a household can simply open another site with sufficient fertility when soil fertility declines. However, when land is scarce, as is the case in Malawi, a household must use the same piece of land year in, year out. The addition of inputs such as inorganic fertiliser, organic manure and investments in soil conservation technologies are the only options for a household that aims to maintain high yields. While I am ultimately concerned with the long-term effects of inorganic fertilisers and organic manure on land-use patterns, I develop a static model of household choice in an environment of missing markets for manure. This parsimonious introduction underscores the importance of resource endowments when factor markets do not exist. Assume that the household maximises utility, where utility is a function of consumption (*c*) and leisure (*Le*):

(1) $$U = U(C, L_e)$$

The household has at its disposal a production function

(2) $$q = f\left(L_a, \overline{A}, X_{fer}, X_{man}, S\right) = 0$$

where L_a is total agricultural labour, $\overline{A}$ is the land endowment of the household and is assumed fixed, X_{fer} is inorganic fertiliser, X_{man} is inorganic manure and S is the current soil fertility. The production function $f(*)$ is increasing in the current use of inorganic fertilisers $\left(f'_{x^f} > 0\right)$, organic manure $\left(f'_{x^m} > 0\right)$ and soil fertility $\left(f'_s > 0\right)$. Soil fertility S is given by

(3) $$S_t = f(S_{t-1} + I_{t-1} + S_{ch})$$

The soil fertility S is current soil fertility S_t is a function of previous period soil fertility S_{t-1} last period investments I_{t-1} and basic land characteristics $S_{ch.}$ The household is faced with a monetary budget constraint for tradable inputs, i.e., labour and inorganic fertilisers,

(4) $$p_{fer} X_{fer} + s_{fer} X_{fer} + wL_{hi} = Pf(*) + wL_{ho}$$

where p_{fer} is the market price for fertiliser, P is the market price for agricultural output and w is the labour wage rate. The household earns income from selling output and hiring out labour. This income is used to pay for inorganic fertiliser and labour. A self-sufficiency constraint for all non-traded organic manure available for crop production is calculated as

(5) $$X_{man} = \mu(Liv)$$

where ε is a vector of the farmyard manure production per animal *(Liv)* by animal type that is utilised as farmyard manure and L_{man} is labour for manure, that is, both labour to carry the manure from animal houses to the field and labour to make compost manure. Time constraints for the household are given by

(6) $$L_a = L_{fa} + L_{hi}$$

(7) $$L_f = L_{ho} + L_{fa} + L_{man}$$

(8) $$T_f = L_f + L_e \quad ; \quad L_e = T_f - L_{ho} - L_{fa} - L_{man}$$

where L_a is agricultural labour L_{fa} is family labour on one's own farm, L_{hi} is hired-in labour, L_f is total family labour and L_{ho} is hired-out labour. This optimisation problem can be rewritten as the Lagrangian:

(9) £:

$$U = U(C, L_e) + Pf(L_a, \overline{A}, X_{fer}, X_{man}, S) + wL_{hi} - \lambda[p_{fer} X_{fer} + s_{fer} X_{fer} + wL_{hi}] + \mu(Liv)$$

First-order conditions with respect to production outputs and inputs are of the form:

(10) $$\frac{\partial U}{\partial X_{fer}} = Pf' - \lambda(p_{fer} + s_{fer}) \qquad \text{for inorganic fertiliser}$$

(11) $$\frac{\partial U}{\partial X_{man}} = Pf' - \mu'(Liv) \qquad \text{for organic manure.}$$

The marginal rate of technical substitution is $\dfrac{\partial U}{\partial X_{fer}} \Big/ \dfrac{\partial U}{\partial X_{man}} = \dfrac{\lambda(p_{fer} + s_{fer})}{\mu'(Liv)}$. It is negative if organic manure and inorganic fertilisers are substitutes and positive if the two are complements. Note that, for organic manure, the ownership of livestock and family labour determine its use, unlike the use of inorganic fertiliser, which is determined by market prices. With the current fertiliser subsidy in Malawi, it is expected from this model that only households with livestock can adjust their use of manure, as those without livestock do not have access to organic manure. There is no market for organic manure, and its use mainly depends on the household asset endowment of livestock. Therefore, households that do not have livestock may not use organic manure, and I observe zero values in this case as well. I therefore hypothesise that household assets, such as family labour and livestock, determine the use of organic manure and that inorganic fertiliser is mainly determined by the wealth status of the household. I use the household assets to determine the household's wealth status. The use of inorganic fertiliser depends on the markets, while the use of organic manure is entirely dependent on household asset endowments.

The main question in this study is the relationship between organic manure and inorganic fertiliser. Assuming that that they are substitutes, their technical rate of substitution (TRS) will be negative. I hypothesise that households use organic manure to substitute inorganic fertilisers; hence, their TRS is negative. The use of the inorganic fertilisers and organic manure is a joint decision, so we use the simultaneous equations

(12) $$x_{hi}^{f} = \alpha_i^{f} + \beta_i^{f} x_{hi}^{m} + \varpi_i^{f} Z_h + \phi_i^{f} A_{hi} + \varepsilon_{hi}$$
$$x_{hi}^{m} = \alpha_i^{m} + \beta_i^{m} x_{hi}^{f} + \varpi_i^{m} Z_h + \phi_i^{m} A_{hi} + v_{hi}$$

Where (x_{hi}^{m}) and (x_{hi}^{f}) are the amount of organic manure and inorganic fertilisers used by the household in kg/ha. Household asset endowments are given by (Z_h) which include the labour endowment, both family labour and hired labour, and the wealth status of the household, which was captured by valuing major household assets, e.g., furniture and agricultural equipment, at their market prices in 2007. The value of livestock assets was captured by valuing all livestock owned by the household using local market prices. I also include household managerial ability as indicated by age and education. The tenure security of the household was included, as it also affects the investment decision in two ways. First, secure households invest more because they are assured of obtaining returns. Second, due to high investments, secure households accrue more assets in the long run and thus have a greater ability to invest more in the short run. (A_{hi}) are plot-level characteristics of plot i belonging to household h. These characteristics include the perception of soil fertility, distance from home, the size of the plot (ha), slope and long-term investment on the plot, such as contour ridges and vetiver grass.

4.0 EMPIRICAL METHOD

4.1 Soil fertility

One of the main variables used in this study is the farmer's perception. Household heads were asked about the general soil fertility of each plot[6]. Each household rated plots as poor, average or fertile. It is assumed that relative farmer perception on soil fertility is consistent across households, which is a strong assumption. However, without variation in soil fertility on each plot (which requires a plot panel data set for a long period) it is used to compare the different soil fertility levels. This variable is tested against other exogenous factors to evaluate its validity. Therefore, the model is given by

$$S^* = X'\beta + \varepsilon \qquad (13)$$

where S^* is the soil fertility and X are exogenous variables (e.g., soil texture, slope, soil erosion, distance from home to plot) affecting S^* and beta is a set of coefficients for the variables. The error term ε is assumed to be normally distributed across observations. S^* is unobserved. We observe that:

[6] A plot was defined by major crop grown. The major crop on a mixed crop stand was used to demarcate the plot. Therefore, if a parcel was grown with different crops on pure stands, each stand was considered a plot.

$$S = \text{poor soil if } 0 < S^* < \omega_1$$

(14) $$S = \text{average if } \omega_1 < S^* < \omega_2 \text{ and}$$

$$S = \text{fertile if } \omega_2 < S^*$$

where ω is an unknown parameter, which will be estimated and the error term ε is normal with a mean of zero and variance of one. An ordered probit is used, where the probability of soil fertility is given by:

$$\text{Prob}\left(S = J \middle| X\right) = 1 - \Phi\left(\varepsilon_i - X'\beta\right)$$

4.2 Relationship among inorganic fertiliser, organic manure and soil fertility

From the specified theoretical model,

Fertiliser Use = f[Manure Use ,exogenous variables]
Manure Use = f[Fertiliser Use ,exogenous variables].

Two major problems are noted in the above specification, data censoring and endogeneity. Not all farmers used the inputs. Input use was only observed when it was greater than zero. Therefore, the observed input use was censored at zero. Using OLS gives inefficient estimates. A Tobit model with zero as the lower limit gives efficient estimates. Inorganic fertiliser use can be estimated by the tobit specification:

(15) $$x_{hi}^f = \max\left(0, x_{hi}^m \beta_i^f + Z_h^f \varpi_i^f + A_{hi}\phi_i + \varepsilon_{hi}\right)$$

where x_{hi}^f is inorganic fertiliser used in kg/ha by household *h* on plot *i*. x_{hi}^m is the amount of organic manure used on plot *i* by household *h,* Z_h^f are household characteristics affecting the decision to use inorganic fertiliser on plot *I* as well as the amount of fertiliser used, and A_{hi} are plot *i.* characteristics belonging to household *h.* With ε_{hi} being independent and normally distributed, the expected amount of inorganic fertiliser can be estimated, given the explanatory variable x_{hi}^m, Z_h^f, A_{hi} i.e. $E(x_{hi}^f | x_{hi}^m, Z_h^f, A_{hi})$. This estimation can be done by deriving the probability of using inorganic fertiliser $P\left(x_{hi}^{f} > 0 \middle| x_{hi}^{m}, Z_{h}^{f}, A_{hi}\right)$ and expectation given positive use $E\left(x_{hi}^{f} \middle| x_{hi}^{m}, Z_{h}^{f}, A_{hi}, x_{hi}^{f} > 0\right)$, but

(16) $$x_{hi}^{m} = x_{hi}^{f}\beta_{i}^{m} + Z_{h}^{m}\varpi_{i}^{m} + A_{hi}\phi_{i}^{m} + v_{hi}.$$

Therefore, x_{hi}^{m} in equation 15 correlates with ε_{hi}, hence it introduces endogeneity into the tobit model. Using Z_{h}^{m} household characteristics that influence only organic manure and can be excluded from the equation 15, a reduced form equation is derived from equations 15 and 16

(17) $$x_{hi}^{m} = Z_{h}\varpi_{h} + A_{hi}\phi_{i}^{m} + v_{hi} = Z_{h}^{f}\beta_{i}^{f} + Z_{h}^{m}\beta_{i}^{m} + A_{hi}\phi_{i}^{m} + v_{hi}$$

where $\beta_{i}^{m} \neq 0$ in equation is =0 in equation 15. I assume that v_{hi} is independent of Z_{h}^{f} and A_{hi} and normally distributed. The equation above cannot just be a linear projection, as in the linear-model case. I assume that $(\varepsilon_{hi}, v_{hi})$ are independent of Z_{h}^{f} and are a bivariate normal with a mean of zero. I apply full MLE, similar to the Smith-Blundell two-step procedure. The Smith-Blundell proposes an OLS in the first stage and a tobit in the second stage. However, the dependent variables (organic manure or inorganic fertilisers) are censored at zero; therefore, OLS for the first stage is inconsistent. I therefore use Tobit in both stages.

(i) Tobit x_{hi}^{m} on *Z*, and *A* obtain residuals, $\hat{v}_{hi}$.

(18) $$x_{hi}^{m} = \max\left(0, Z_{h}^{f}\beta_{i}^{fm} + Z_{h}^{i}\beta_{i}^{mm} + A_{hi}^{m}\phi_{i}^{m} + v_{hi}\right)$$

(ii) Tobit of x_{hi}^{f} on Z_{h}^{f}, A x_{hi}^{m} and $\hat{v}_{hi}$,

(19) $$x_{hi}^{f} = \max\left(0, x_{hi}^{m}\beta_{i}^{f} + Z_{h}^{f}\varpi_{i}^{f} + A_{hi}\phi_{i} + \hat{v}_{hi}\theta_{hi} + e_{hi}\right)$$

Where

(20) $$\varepsilon_{hi} = \theta_{hi}v_{hi} + e_{hi}$$

Using the instrumental tobit model assumes that the decision to use, which carries a specific probability, has the same variables of similar magnitude as the decision of how much to use, which is the second truncated regression. This relationship is true for soil fertility, which varies from when the input is not used to when it is used. This model is used to show the marginal effects of soil fertility on the input. However, when allowing the decision of how much to use to be different between the decisions of whether to use the input, the instrumental tobit model may not give consistent estimates. The households that used the organic and inorganic fertilisers may face other constraints, in addition to soil fertility. A two-tier model or Cragg Model (Wooldridge, 2002) is used in the two-stage decision process. The two-tier model is given as;

(21)

$$P\left(x_{hi}^{f}=0\middle|x_{hi}^{m},Z_{h},A_{hi}\right)=1-\Theta\left(x_{hi}^{m}\beta+\hat{v}_{hi}\,\theta_{hi}+Z_{h}\gamma+A_{hi}\phi_{hi}\right)$$

$$\log\left(x_{hi}^{f}\right)\left|\left(x_{hi}^{f},x_{hi}^{m},\hat{v}_{hi}\,Z_{h},A_{hi}>0\right)\sim Normal\left(x_{hi}^{m}\beta+\hat{v}_{hi}\,\theta_{hi}+Z_{h}\gamma+A_{hi}\phi_{hi},\sigma^{2}\right)\right.$$

The first model is the probit model for whether or not to use an input, while the second one is a lognormal regression on how much input to use. Due to the endogeneity of the inputs, I use the two-stage method, which is similar to that used in the instrumental tobit model, but the second stage is the truncated model instead of the tobit model.

4.3 Allowing for correlation in error terms in the manure and fertiliser equations

If the two inputs, manure and inorganic fertilisers, are used as either complements or substitutes, the use of one may affect the use of the other. This relationship then becomes a system of the demand for inputs.

(22)

$$x_{hi}^{f}=\alpha_{i}^{f}+\beta_{i}^{f}x_{hi}^{m}+\varpi_{i}^{f}Z_{h}+\phi_{i}^{f}A_{hi}+\varepsilon_{hi}\qquad if\qquad x_{hi}^{m}+e_{hi}>0$$
$$x_{hi}^{f}=0\qquad otherwise$$

Let *R* be *Z* and let *A* affect the decision for whether to use an input, i.e., household and plot characteristics, and let x_{hi}^{m} affect how much input to use. Allowing such a system will mean that error terms from the equations correlate and that the decision equation error *e* and the main equation *ε* will correlate, leading to censoring. I then estimate these in a system after correcting for censoring. Let the correction factor be *δ,* such that the unconditional mean of x_{hi}^{f} becomes

$$E\left(x_{hi}^{f}\middle|R\right)=\Phi(R\alpha_i)x_{hi}^{m}\beta_i+\delta\phi(R\alpha_i) \tag{23}$$

We estimate the equation

$$x_{hi}^{f}=\Phi(R\alpha_i)x_{hi}^{m}\beta_i+\delta\phi(R\alpha_i)+\xi_{ij}$$

by first obtaining ML probit estimates of α and estimating correction factors

$$\frac{\phi\left(R\hat{\alpha}_i\right)}{\Phi\left(R\hat{\alpha}_i\right)} \quad if \quad x_{hi}^{f}>0 \text{ and } \frac{\phi\left(R\hat{\alpha}_i\right)}{1-\Phi\left(R\hat{\alpha}_i\right)} \quad if \quad x_{hi}^{f}=0 \tag{24}$$

where $\phi(\bullet)$ and $\Phi(\bullet)$ are the standard normal probability density and cumulative probability density, respectively. These are used to correct the variables in the main equation for censoring. I therefore estimate the equation using a censored system in two steps, applying a seemingly unrelated regression to

$$x_{hi}^{f}=\Phi\left(R\hat{\alpha}_i\right)x_{hi}^{m}\beta_i+\delta\phi\left(R\hat{\alpha}_i\right)+\xi_{ij}\,. \tag{25}$$

4.5 Non-parametric method using local constant kernel estimation

Let x_{hi}^{f} be the amount of inorganic fertiliser on plot *i* by household *h,* x_{hi}^{m} be the amount of organic manure on plot *i* by household h and s_{hi} be the fertility of the soil on plot *i.* belonging to household *h*. We observe that $g\left(x_{hi}^{m}\right)=E\left(x_{hi}^{f}\middle|x_{hi}^{m},s_{hi}\right)$ is a function of *x* and *s,* i.e., the expected amount of inorganic fertilisers given the amount of organic manure and fertility of the soil. Therefore, the joint PDF can be denoted as $f_{x_{hi}^{f},x_{hi}^{m}}\left(x_{hi}^{m},s_{hi},x_{hi}^{f}\right)$, and the conditional PDF of $x_{hi}^{f}\middle|x_{hi}^{m},s_{hi}$ can be given by $f\left(x_{hi}^{f}\middle|x_{hi}^{m},s_{hi}\right)$. However, the conditional PDF is unknown.

(26) $$E\left(x_{hi}^{f}\middle|x_{hi}^{m},s_{hi}\right)=\int x_{hi}^{f}f\left(x_{hi}^{f}\middle|x_{hi}^{m},s_{hi}\right)dx_{hi}^{f}=\frac{\int x_{hi}^{f}f_{x_{hi}^{f},x_{hi}^{m},s_{hi}}\left(x_{hi}^{m},s_{hi},x_{hi}^{f}\right)dx_{hi}^{f}}{f\left(x_{hi}^{m},s_{hi}\right)}=g\left(x_{hi}^{m},s_{hi}\right)$$

by replacing the unknown PDF with its standard normal kernel estimate *(K),* yielding $\int x_{hi}^{f}\hat{f}\left(x_{hi}^{m},s_{hi},x_{hi}^{f}\right)dx_{hi}^{f}$, where

(27) $$\hat{f}\left(x_{hi}^{m},s_{hi},x_{hi}^{f}\right)=\frac{1}{nh_0h_1.....h_q}\sum_{i=1}^{n}K\left(\frac{\left(x_{hi}^{m},s_{hi}\right)_i-\left(x_{hi}^{m},s_{hi}\right)}{h}\right)k\left(\frac{x_{hi}^{f}-\left(x_{hi}^{f}\right)_i}{h_0}\right)$$

Let x_{hi}^{m} *and* s_{hi} = X and x_{hi}^{f} =Y for clear notation in the equation above $K\left(\frac{X_i-x}{h}\right)=k\left(\frac{X_{i1}-x_1}{h_1}\right)\times......\times k\left(\frac{X_{iq}-x_q}{h_q}\right)$ and where h_0 is the smoothing parameter associated with *Y.* Thus, we have

(28) $$\int y\hat{f}_{y,x}(x,y)dy=\frac{1}{nh_0h_1......h_q}\sum_{i=1}^{n}K\left(\frac{X_i-x}{h}\right)\int yk\left(\frac{y-Y_i}{h_0}\right)dy$$

(29) $$=\frac{1}{nh_1.........h_q}\sum_{i=1}^{n}K\left(\frac{X_i-x}{h}\right)Y_i$$

I therefore can estimate $E(Y|x)\equiv g(x)$ (Li and Racine, 2007) by

(30) $$\hat{g}\left(X=\frac{\int y\hat{f}_{y,x}(x,y)dy}{\hat{f}(x)}\right)=\frac{\sum_{i=1}^{n}Y_iK\left(\frac{X_i-x}{h}\right)}{\sum_{i=1}^{n}K\left(\frac{X_i-x}{h}\right)}$$

Using this estimate, I obtain a series of slopes for each h. In parametric estimation, there is only one coefficient for each variable, which is basically the mean of all possible coefficients. However, in non-parametric estimation, several coefficients are obtained at different levels of the explanatory variable, giving a clearer picture of the relationship between the inorganic fertiliser and the organic manure at different amounts applied. This relationship between inorganic fertilizers and organic manure is shown by plotting the coefficients on a graph.

5.0 DATA AND DESCRIPTIVE STATISTICS

I use data collected in the June 2007 household survey. It includes a total of 437 households in central and southern Malawi. The sample consisted of a total of 1,605 plots, with an overall mean plot size of 0.34 ha (0.43 ha for the Central Region and 0.28 ha for the Southern region). The average total land size for a household was 1.5 ha (2.05 ha for the central region and 1.08 ha for the southern region). Farmers were asked to indicate the fertility levels of their plots using a scale of 1 to 3, with 1 indicating low fertility and 3 indicating high fertility. Most farmers responded to the question with a background experience of yield levels with and without inorganic fertiliser. Plots that they felt always needed inorganic fertiliser to have any meaningful harvest were perceived as having low fertility, while plots that can have a substantial yield without inorganic fertiliser were perceived as being fertile. From the farmers' perceptions, 28% of the plots were reported to be of poor fertility, 49% were reported to have average fertility and 23% of the plots were reported as being fertile. Most of the soils classified as fertile were clay with flat terrain, while sandy soils were mostly classified as infertile.

The farmers reported the amount of inorganic fertiliser that they applied (in kilograms) on each plot in the 2006/07 growing season and its total expenditure in Malawi Kwacha (MK). About 40% of the plots were treated with inorganic fertiliser, half of which (23% of the plots) was subsidised fertiliser.

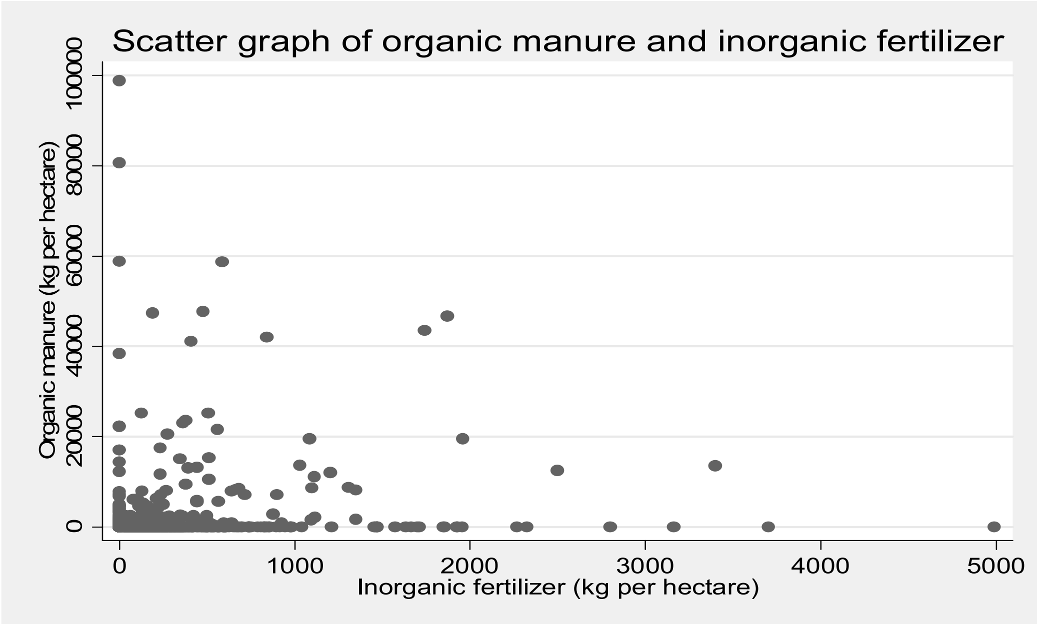

Figure 1: Scatter graph of manure and inorganic fertiliser.

Of all the subsidised fertilizers 23% was applied on plots where organic manure were used and 77% of the subsidised fertilizer was applied with no organic manure. The amount of organic manure applied on each plot was recorded in kilograms per plot. Out of the 1,605 plots, 22% were treated with organic manure. Figure 1 shows a substitution relationship between manure and inorganic fertiliser. As the amount of inorganic fertiliser applied increases, the amount of manure decreases. Long-term fertility enhancement measures were mainly soil erosion control structures, such as contour bunds and vetiver grass. These were recorded as dummies, as being present on the plot or not. About 34% of the plots had contour ridges and only 6% had planted vetiver grass. The presence of contour bunds and vetiver grass correlated with higher fertility plots. Agro-forestry and intercrops with legumes such as groundnuts and pigeon peas were also recorded on each plot as dummies (1 if present and 0 otherwise). Agro-forestry trees included growth of *Gliricidia sepium, Tephrosia vogelli, Faidherbia albida, Leucaena leucocephala* and *Senna siamea,* and about 15% of the plots had at least one agroforestry tree planted. Of these, 25% were planted on infertile plots, 55% were on average fertile plots and 20% were on fertile plots.

Table 1: Amount of input used and household characteristics

Variable	*Fertiliser =0 manure=0*	*Fertiliser=0 manure=1*	*Fertiliser =1 manure=1*	*Fertiliser =1 manure=0*
Average total Fertiliser used by household (kg)	0	0	142	122
Average total manure used by household (kg)	0	331	1526	0
Percentage of plots with subsidised fertilizer	0	0	23	77
Total hired labour	0.21	1.98	3.93	1.82
Total family labour	2.23	2.74	2.83	2.58
Age of household head	49.5	45.6	44.5	46.0
Household head, yrs of school	3.2	5.3	5.3	4.9
Highest educ. attained by household head	0.9	1.0	1.2	1.1
Household size	4.8	6.1	5.7	5.5
Value of asset change from 2006-2007 (MK)	350	198	3,154	2,809
Value of assets in 2007 (MK'000)	2.98	12.28	9.51	14.16
Value of livestock assets in 2007 (MK'000)	5.06	40.96	20.78	43.12
Dwelling house type as Wealth indicator	18	21	25	22

The main damage variable collected on each plot was the level of soil erosion. Farmers were asked to rank the level of soil erosion on their plot using a scale of 0 to 3, with 0 indicating no erosion, 1 indicating slight erosion, 2 indicating moderate erosion and 3 indicating severe erosion. About 41% of the plots were recorded as having no soil erosion, with 25% being slight, 15% being moderate and 19% being severe. Most of the plots recorded with severe erosion were also recorded as being infertile, and areas with less erosion were recorded mostly as being fertile.

Table 1 shows the characteristics of households grouped according to input use. Households that used neither organic manure nor inorganic fertiliser (column 1) were resource-poor in livestock assets and household assets and were the least educated. Their dwelling houses were also of poor quality as compared to the rest of the sample. Households that used only manure without fertiliser had the second highest value of livestock assets. However, they had more liquidity constraints, as indicated by the lowest value of change in assets. This value was computed from new items that the household had bought between 2006 and 2007. Households that used both fertiliser and manure had a higher value of assets, a higher value of asset change and a higher amount of hired-in labour. These relationships indicate higher liquidity, which they could use to hire-in labour and buy inorganic fertiliser. The last column in table 1 shows households that used inorganic fertiliser but no manure. These were also resource-rich, as indicated by their having the highest values of livestock, assets owned and asset change. From this table, it can be noted that using both inputs depends on the resource endowments of the household. Cash availability, as indicated by the asset change variable, is important for purchasing inorganic fertiliser, while livestock assets are important for manure as well as inorganic fertiliser. Most households that sold livestock between 2006 and 2007 indicated that they used the money thereof to purchase inorganic fertiliser.

Several crop yields were recorded, but the study focuses on maize, the main food crop. Maize is grown by almost every farmer in Malawi and thus gives a very good basis for analysis. Production shifters were also recorded. These include managerial ability proxied by the education and age of the household head, and wealth, which was proxied by the type of house the household lives and the residence location as a proxy for tenure security.

6.0 ECONOMETRIC RESULTS AND DISCUSSION

The results and discussion section follows the hypotheses, where the relationship between the inputs and soil fertility are analysed using the instrumental tobit model and the relationship between inorganic fertilisers and manure use is analysed using Cragg's Models and censored seemingly unrelated regression. However, I first test the validity of the perception of soil fertility by regressing the soil fertility perception on soil fertility indicators, such as texture, soil erosion, slope and long-term investments, such as contour ridges and vetiver grass.

6.1 Farmers' soil perception as an indicator of soil fertility

Equation 3 indicates that change in soil fertility is affected positively by investments in soil conservation and negatively by nutrient mining and soil erosion. Using these variables in an ordered probit of soil perception, the expected signs of the explanatory variables are as expected and are significant. The coefficient on soil erosion is negative and significantly related to perceived soil fertility indicating that eroded plots are less fertile. The slope is also negative and significant, indicating that fertile plots are flatter. Three categories of soil texture were indicated for each plot, with 1 being sandy (perceived as low nutrient and more erodible), 2 being loam and 3 being clay soils (perceived as more fertile and less erodible). This variable also showed high correlation with the perceived soil quality. Table 4 in the appendix presents the complete results. Probit models for each of the fertility levels showed the same findings. Poor plots have high erosion, are steeper and have sandy soils. Fertile plots are flatter, have less soil erosion and have clay soil. Therefore, the farmer's perception of soil fertility is a good indicator of soil quality. This variable is used in the instrumental tobit, Cragg and the SUR models for analysis of the relationship between soil fertility and fertilisers (organic and inorganic).

6.2 Relationship between soil fertility and inorganic fertiliser

As indicated in the econometric model, the instrumental tobit model assumes that the explanatory variables have a linear effect when the dependent variables change from zero to positive. To understand the effects of soil fertility on the use of inorganic fertiliser, the soil fertility variable was separated into three dummy variables: low fertility, medium fertility and high fertility. This separation permitted calculation of the partial effects of soil fertility on fertiliser use. Instrumental Tobit results showed that there is a positive and significant increase in fertiliser use as we move from low-fertility to medium-fertility plots. However, moving further to high-fertility plots from low-fertility plots was positive but not significant. The instrumental Cragg's model has similar results for medium-fertility plots, but the relationship was negative for the high-fertility plots (i.e., using only plots where fertiliser was applied). The partial effects *(PE)* of soil fertility on fertiliser obtained by use of the instrumental Tobit model (table 2 below) were calculated as the difference of the marginal effects *(ME)* of each soil fertility level (low, medium and high fertility soil) given by:

(27) $$ME_i = \Phi\left(\frac{x_i\beta_i}{\sigma}\right)x_i\beta_i + \sigma\phi\left(\frac{x_i\beta_i}{\sigma}\right)$$

where *i.* is the level of fertility (low, medium and high) and the partial effects of soil fertility on fertiliser were calculated by subtracting one soil level from the other.

(28) $PE_{j \to i} = ME_i - ME_j$ where j. and i. are levels of fertility.

The instrumental Tobit results showed declining but positive marginal effects. For example, by moving from a low-fertility plot to a medium-fertility plot, a household increases fertiliser use by 12%. By contrast, by moving from a medium-fertility to a high-fertility plot, a household reduces fertiliser use by 4%. The Cragg's model (using only household with positive fertiliser use) shows that, as the plot fertility increases from low to medium, fertiliser use increases by 15% on average, while an increase to high fertility reduces the use of fertiliser by 12%. This finding agrees with other studies (Kim et al., 2001) that found fertiliser use to be a substitute for soil fertility in the short term. Therefore, it can be concluded from this study that, as soil fertility increases, the amount of fertiliser that is used is reduced (a substitution relationship).

Table 2; Partial effects of soil fertility on fertiliser use

Change in soil fertility	*Instrumental Tobit model* *Percentage change in fertiliser used* *(%)*	*Cragg's model* *Percentage change in fertiliser used* *(%)*
Low to medium	12	15
Medium to high	-4	-12

6.3 Relationship between soil fertility and manure.

The use of manure positively correlated with high soil fertility in the instrumental Tobit model; the opposite was observed in the Cragg's model. These findings are expected as the instrumental Tobit model includes non-users in its likelihood estimates. The partial effects of soil fertility and manure use were similar in sign to the coefficients. The Cragg's model indicated that negative amounts of manure were used as soil fertility increased. This relationship indicates that, as with fertiliser use, manure and soil fertility are negatively correlated. Households use more manure on very low-fertility soils than on more fertile soils. As soil fertility increases from low to medium, the amount of manure that is used is reduced by 35% (table 3) and reduced by another 5% for very fertile plots. This finding also shows a substitution relationship between soil fertility and manure use.

Table 3: Partial effects of changing soil fertility on manure used from

Change in soil fertility	*Tobit model* *Percentage change in manure used* *(%)*	*Cragg's model* *Percentage change in manure used* *(%)*
Low to medium	-11	-35
Medium to high	77	-5

6.4 Relationship of manure and inorganic fertiliser use.

6.4.1 Parametric results

Results of the instrumental Craggs's models show that manure use and fertiliser are positively correlated (table 5 in the appendix). Fertiliser was significant at 0.001% in the instrumental Cragg's model. The fertiliser models also showed a significant positive relationship with manure. This finding indicates that inorganic fertiliser and organic manure are used as complements and not as substitutes. Subsidized fertiliser also shows positive relationship, even though it was only 23% of the plots that had subsidised fertilizer with organic manure (Table 6 in annex). However, squared values were negative and significant at 0.001%, indicating a negative relationship at high amounts of both organic manure and inorganic fertilisers. To further understand this relationship, the partial effects of each of the inputs were incorporated into both models. As indicated in the theoretical model, the instrumental tobit model assumes that the explanatory variables have the same effect when zero and positive. However, this model may not show true behaviour; hence, Cragg's model was used to show the level of change among households that only have a positive use for the inputs.

Using the instrumental Tobit model and the Cragg's model partial effects for fertiliser use and manure use were calculated. Table 4 shows the partial effect analysis. For both fertiliser and manure, partial effects were positive showing that use of the two inputs is complementary. An increase in 1 kg/ha of manure induces a 0.12 kg /ha increase of fertiliser, and an increase of 1 kg/ha of fertiliser induces a 23.4 kg/ha increase in manure, i.e., the Cragg's model results. However, this complementary relationship does not indicate the types of plots on which the inputs were applied.

Table 4; Partial effects of inorganic fertiliser on manure

	Instrumental Tobit model Mean change Kg/ha	*Cragg's model Mean change Kg/ha*
Fertiliser on manure	0.25	0.12
Manure on fertiliser	0.34	23.4

Policy advice based on such results would agree with the soil scientist's claim and accept that farmers are using the inputs in the right way. However, a closer look using nonparametric analysis gives very important information that can be further used to enhance the use of these inputs.

6.4.2 Nonparametric results

To further understand this relationship, nonparametric analysis of fertiliser and manure use on plots of varying fertility was carried out. Using local constant kernel estimation, a non-parametric model was estimated and the gradient of the estimates was plotted on two graphs. Figure 2 shows the first plot of the estimates, which is the set of gradients or coefficients of organic manure on inorganic fertiliser. There is a positive relationship at lower values, but as values increase, the relationship is negative, showing substitution at high input use. There is no market for manure; hence, manure can be used to a certain level depending on household resources, e.g., livestock or family labour, while if they have money, they can use more inorganic fertiliser obtained from the market. Therefore, inorganic fertilisers and organic manure are used as substitutes at higher amounts due to resource constraints that cannot allow the higher use of organic manure. This insight is very important, as policy advice for promotion of the use of both inputs demand different approaches. Manure use cannot be promoted by providing credit. It can be shown that, at a certain amounts, the use of manure drops when fertiliser use can be increased. Therefore, looking at factors that affect manure use, e.g., the number of animals or establishing a market for manure, could yield some new policy approaches.

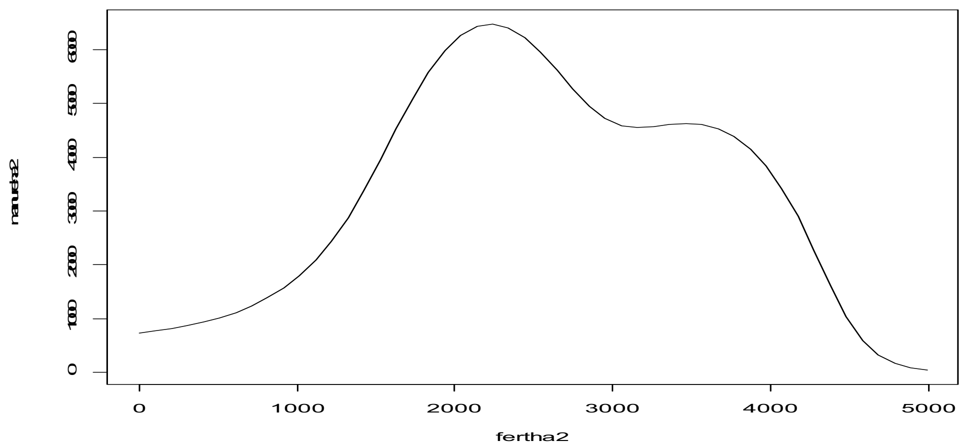

Figure 2: Graph of nonparametric estimate (using Kernel method) of fertiliser and manure

Another insight that comes from the graphs is that, at zero use of inorganic fertiliser, manure use is positive. This insight is also very important, as manure is used by households that cannot afford fertiliser in the market. The Government has since reported an increase in the use of organic manure after the increase in the prices of inorganic fertilisers. These households are able to use their own resources to apply manure on their plots, although they do not have cash to buy fertiliser. Therefore, promoting organic manure could also help the poor households that cannot afford inorganic fertiliser. These are hidden factors and are not revealed in the parametric analysis.

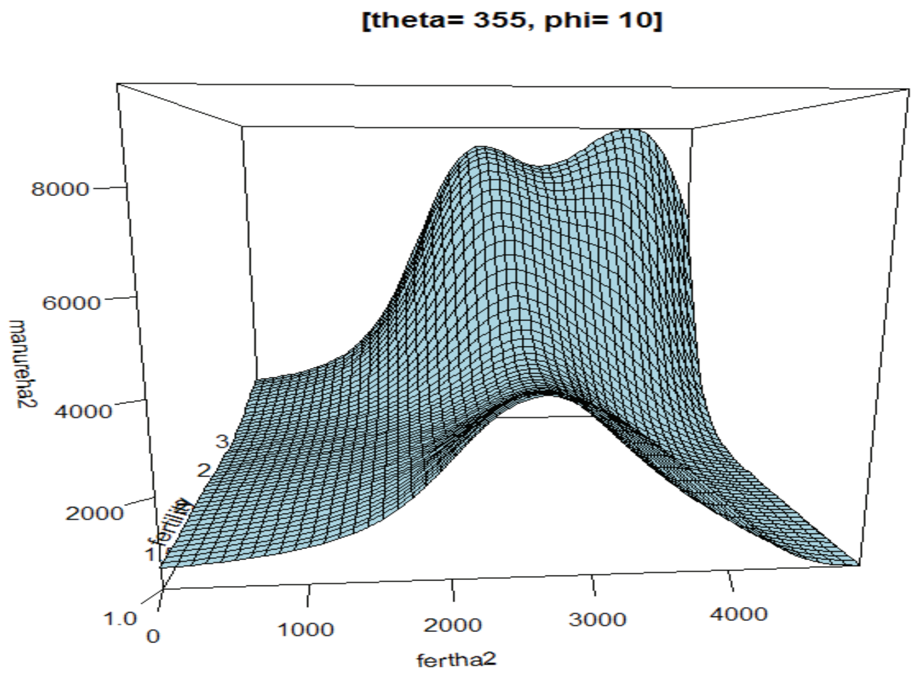

Figure 3:Graph of nonparametric estimate (using Kernel method) of fertiliser and manure with varying soil fertility

The graph 3 is similar to graph 1, however, this graph reflects the fertility of the plots. The relationship between manure and fertiliser is similar for plots with different fertility levels. A higher use of fertiliser yields a negative relationship. However, it is worth noting that, at higher levels of fertility, higher amounts of fertiliser and manure are used. As the farms depend on their output for the next year's inputs, the well-off farmers, i.e., those with higher output, have more resources and are able to use more resources, thereby making their plots more fertile.

6.5 Farmer's characteristics

At very low levels of adoption of both inputs, more manure is used than inorganic fertiliser (Figure 3). The major resource for manure is family labour, while inorganic fertiliser demands financial resources. From the regression results, it can be noted that family labour endowments positively correlated with manure use, while hired labour positively correlated with fertiliser use. Households that hire labour are relatively better off and hence able to buy inorganic fertiliser. At very low adoption levels, the business provides the only resource available for household use, family labour, to replenish soil fertility using manure. Livestock is also important, as it determines the use of manure. Households that had more livestock assets were likely to apply manure (SUR results). Wealthier households used more inorganic fertiliser as compared to poorer households. Households with higher asset change from 2006 to 2007 also used more fertiliser. The current fertiliser subsidy in Malawi targeting the poor households will likely not affect the use of manure by these households. Only 23% of the subsidised fertilizers plots were combined with organic fertilizer indicating that the poor households that have been targeted are likely not to have livestock which is the source of organic manure. However, unlike a universal subsidy, which will provide subsidised fertiliser to both rich and poor farmers, the use of organic manure may be reduced by the rich farmers who use large amounts of inorganic fertilisers, as at a higher input use, farmers tend to prefer inorganic fertilisers to organic manure. Tenure security as indicated by patrilocal residence did not significantly affect manure or fertiliser use. Short-term input use has generally been shown to have no positive relationship with tenure security.

7.0 CONCLUSION

The decline in soil fertility is a major cause of the decline in productivity in the SSA. Technologies that may be romoted have different resource requirements and effectiveness and thus, with no market, adoption depends on farmers' resource endowments. Using data from Malawi, smallholder farmers' adoption practices are analysed for short-term input use (organic manure and inorganic fertiliser). As the inputs are used to replace or conserve soil fertility, the adoption practices are analysed under different soil fertility levels. Results show that organic manure and inorganic fertiliser are used as complements at low amounts, but show a substitution relationship at higher amounts. Resource constraints, mainly for organic manure, restrict the amount that is used. Inorganic fertiliser and organic manure are used less frequently on fertile land. Therefore, policies that aim at improving the soil fertility in the long run can help to reduce the cost of production in the short term. In addition, farmers will demand lesser input on fertile plots.

Different resources also determine the inputs that a household can readily use. As manure markets are not developed, livestock assets are important and determine the possibility of a household using manure on their plots. Cash (or assets that can be easily sold) are important for the use of inorganic fertilisers.

As soil science recommends the combined use of organic and inorganic fertilisers, policies for soil fertility management should address issues of resource endowment, mainly livestock. The promotion of such policies will not only promote use organic manure, but may help create a market for inorganic fertilisers, as livestock can be easily sold. In Malawi, the Government, through the Ministry of Agriculture Extension service, has been encouraging smallholder farmers to make and use organic manure, especially with the increasing cost of fertiliser, i.e., using manure as a replacement for inorganic fertilisers. The current fertiliser subsidy should continue to target poor households, as the better-off households can afford to buy inorganic fertiliser. At the same time, providing cheaper fertiliser to such households will induce higher inorganic fertiliser use and less organic manure use.

ANNEX

Variables used in the analysis

Variable	Description of variable
quantity_o~r	Quantity of fertiliser used on a plot
manurequant	Quantity of manure used on the plot
soilerosion	Soil erosion level (0= none; 1=slight; 2=moderate; 3=severe
Fertility level	Perceived fertility level by farmers
Lowfert	Low level of fertility level
medfert	Average level of fertility level
highfert	High level of fertility level
distancep_h	Distance from home to plot
numberofpl~s	Number of plots owned by household
sizeha	land size of plot (ha)
slope	Slope on plot (1=flat; 2=slight;3=steep)
texture	Texture of the soil (1=sandy; 2=loam; 3=clay)
contour	Contour bunds dummy 1=present 0 otherwise
vetiver	Vetiver grass dummy 1=present 0 otherwise
agrof	Dummy for presence of agro-forestry trees on a plot
hlabour	Total hired labour on the plot in hours for the season
flabour	Total family labour in hours for the season
livestocka~t	Number of livestock owned by household in livestock units
weath_ind	Wealth indicator for the household
avg_schyears	Number of schooling years for the household head
District dummies	
thyolo	High-density and very steep terrain and loam clay soils
zomba	High-density fairly steep terrain loam soils
chiradzulu	High-density fairly steep terrain loam soil
machinga	High-density flat terrain very sandy soils and very low rainfall
Kasungu	Low-density flat terrain with sandy loam soil
Lilongwe	Low-density flat terrain close major city with sandy loam soils

Table 4;Probit and Ordered probit models of fertility

	Probit models for fertility			*Ordered probit*
	Low	*Medium*	*High*	
Fertility Variables	*b/se*	*b/se*	*b/se*	*b/se*
manurequant	-0.000	-0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)
quantity_o~r	-0.003***	0.001	0.002	0.002***
	(0.00)	(0.00)	(0.00)	(0.00)
soilerosion	**0.140********	**-0.058***	**-0.102****	**-0.125********
	(0.04)	(0.03)	(0.04)	(0.03)
slope	**0.266********	**0.054**	**-0.367********	**-0.323********
	(0.07)	(0.07)	(0.08)	(0.06)
texture	**-0.510********	**0.156******	**0.394********	**0.457********
	(0.06)	(0.05)	(0.06)	(0.05)
agrof	-0.050	-0.008	0.073	0.056
	(0.11)	(0.10)	(0.12)	(0.09)
distancep_h	-0.000**	0.000	0.000	0.000**
	(0.00)	(0.00)	(0.00)	(0.00)
sizeha	-0.102	0.118*	-0.059	0.018
	(0.07)	(0.06)	(0.07)	(0.04)
contour	-0.075	-0.006	0.114	0.096
	(0.08)	(0.08)	(0.09)	(0.07)
vetiver	-0.165	-0.059	0.278*	0.262*
	(0.17)	(0.15)	(0.16)	(0.14)
thyolo	-0.431***	-0.466****	0.969****	0.765****
	(0.15)	(0.14)	(0.16)	(0.14)
zomba	-0.086	0.154	-0.095	0.014
	(0.13)	(0.12)	(0.15)	(0.11)
chiradzulu	-0.245*	0.351***	-0.270	0.062
	(0.14)	(0.13)	(0.17)	(0.11)
machinga	0.025	0.035	-0.134	-0.059
	(0.14)	(0.13)	(0.16)	(0.11)
kasungu	-0.236*	-0.100	0.446***	0.341***
	(0.12)	(0.11)	(0.14)	(0.11)
_cons	0.207	-0.362**	-1.363****	
	(0.17)	(0.16)	(0.20)	
cut1_cons				-0.003
				(0.15)
cut2_cons				1.585****
				(0.15)
Prob > chi2	0.000	0.000	0.000	0.000
Number of obs	1335	1335	1335	1335

Level of significance (=0.10; **= 0.05; ***= 0.01; ****= 0.001)*

Table 5: IVTobit and 2 stage Craggs's model -how much fertiliser and manure used

	IVTobit Model		***2 stage Cragg model***	
	Manure	***Fertiliser***	***Manure***	***Fertiliser***
Fertiliser (kg/ha)	2.276		0.013****	
	(13.80)		(0.00)	
$Inorganic - \hat{ferilizer}\_error$	9.713		-0.007**	
	(13.53)		(0.00)	
Fertiliser squared	-0.005*		-0.000***	
	(0.00)		(0.00)	
Manure (kg/ha)		0.022		0.000****
		(0.01)		(0.00)
$Organic \hat{-} manure\_error$		0.009		-0.000
		(0.01)		(0.00)
Manure squared		-0.000*		-0.000***
		(0.00)		(0.00)
Medium fertility	1375.073	61.767	-0.644**	0.125
	(1352.71)	(39.96)	(0.29)	(0.09)
High fertility	1781.310	19.959	-0.879***	-0.130
	(1495.51)	(55.04)	(0.31)	(0.13)
Distance from plot to home	-0.185	-0.006	0.000	-0.000
	(0.42)	(0.01)	(0.00)	(0.00)
Size of plot (ha)	-2074.134	-134.862****	0.674	-0.752****
	(2042.15)	(36.97)	(0.46)	(0.09)
Contour ridges	-187.285	5.676	-0.531**	0.063
	(1068.25)	(35.27)	(0.23)	(0.08)
Vetiver grass	23.796	86.744	-0.782*	0.242
	(2155.97)	(67.48)	(0.45)	(0.15)
Hired labour	68.781	4.232***	-0.019	0.005
	(65.70)	(1.41)	(0.02)	(0.00)
Family labour	611.814	-4.461	0.206**	-0.078**
	(409.05)	(14.83)	(0.09)	(0.03)
Livestock asset	4609.376****	30.432	-0.264***	-0.208*
	(467.98)	(45.96)	(0.09)	(0.11)
Wealth indicator	-46.630	0.361	-0.012	0.005
	(40.87)	(1.30)	(0.01)	(0.00)
Value of asset change from 2006-2007	-0.075	0.002	-0.000*	0.000**
	(0.09)	(0.00)	(0.00)	(0.00)
Age of Household head	-11.333	-0.194	0.003	0.003
	(38.46)	(1.26)	(0.01)	(0.00)
Year of education of H/H head	330.049	13.183**	-0.049	0.020
	(239.20)	(5.38)	(0.05)	(0.01)
Patrilocal	5251.781**	-15.489	-0.074	-0.054
	(2104.19)	(74.51)	(0.45)	(0.17)
$Patri\hat{l}ocal\_error$	-5630.303**	47.823	-0.208	0.093
	(2429.97)	(81.01)	(0.52)	(0.19)

Zomba	-4692.015***		-1.113***	
	(1615.14)		(0.36)	
Chiradzulu	-979.879	-85.583	0.497	-0.124
	(2447.09)	(55.09)	(0.59)	(0.13)
Machinga	-4735.443**	7.671	-1.001**	0.231
	(2055.10)	(60.57)	(0.44)	(0.14)
Kasungu	-5709.985***	-20.949	-0.270	0.042
	(1760.75)	(55.53)	(0.40)	(0.13)
Thyolo		116.706*		0.026
		(59.45)		(0.13)
Constant	-1.27e+04****	-69.903	6.607****	5.503****
	(3154.59)	(150.42)	(0.76)	(0.35)
Sigma constant	7434.458****	372.249****	1.120****	0.746****
	(489.04)	(13.46)	(0.07)	(0.03)
Prob > chi2	0.000	0.000	0.000	0.000
Number of observations	602.000	602.000	133.000	417.000

Level of significance (=0.10; **= 0.05; ***= 0.01; ****= 0.001)*

Table 6: IVTobit and 2 stage Craggs's model –Manure used on subsidised fertilizer.

	Tobit Model b/se	Cragg Model b/se
Subsidised fertilizer dummy	4880.060*	0.162
	(2896.28)	(0.50)
medfert	6059.571**	0.659
	(2978.01)	(0.53)
highfert	8105.170**	-0.445
	(3593.82)	(0.63)
distancep_h	-2.470*	0.001***
	(1.27)	(0.00)
sizeha	837.020	-0.145
	(1699.33)	(0.47)
contour	8410.996***	0.646
	(2740.88)	(0.50)
vetiver	5334.483	-0.108
	(4007.86)	(0.60)
hlabour	104.514	-0.010
	(121.99)	(0.03)
flabour	-316.204	-0.320**
	(943.99)	(0.16)
livestock	4641.378	0.111
	(3104.17)	(0.61)
weath_ind	58.441	0.018
	(104.57)	(0.02)
asset	-2.130	0.005
	(25.99)	(0.01)
assetchange	-0.145	-0.000
	(0.18)	(0.00)
agehhead	-10.842	-0.029
	(94.73)	(0.02)
yrseduce	697.731*	0.014
	(365.62)	(0.08)
patrilocal	5094.645*	-0.199
	(2646.24)	(0.57)
kasungu	-9368.207***	-1.983****
	(2848.36)	(0.51)
_cons	-3.04e+04****	8.979****
	(7695.91)	(1.44)
sigma		
_cons	14547.960****	1.375****
	(1512.64)	(0.13)
Prob > chi2	0.000	0.000
Number of observations	493.000	59.000

Table 6: ML estimates of the equations for manure and inorganic fertiliser

Variables	*Seemingly unrelated regression corrected for censoring* Manure: *Parameter estimate*	Manure: *Std error*	Fertiliser: *Parameter estimate*	Fertiliser: *Std error*
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **fertiliser**	6.486****	1.363		
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **fertiliser squared**	-0.002**	0.0009		
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **manure**			0.025***	0.0079
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **manure squared**			-2.35e-07	1.71e-07
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **medium fertility**	14.625	350.922	24.88	32.573
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **high fertility**	567.156	639.384	-18.903	42.659
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **distance from plot to house**	-0.141	0.145	-0.016	0.011
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **size of plot (ha)**	90.155	263.94	-121.78****	26.11
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **contour ridges**	-464.7	363.524	-16.729	29.49
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **vetiver grass**	-683.11	596.47	14.013	56.62
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **hired labour used on plot**	-0.485	11.88	0.274	1.248
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **family labour used on plot**	114.89	162.057	-20.986**	10.677
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **livestock assets**	156.90	437.64	-26.35015	38.47
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **wealth indicator**	9.573	11.706	-1.247	1.019
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **asset change**	-0.0602	0.043	0.003**	0.0016
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **age of household head**	-5.287	11.199	1.287	1.032
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **Yrs of education for head**	106.541**	54.705	4.75	4.46
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **Thyolo**	-794.891	621.66	-37.529	74.143
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **zomba**	-1573.933***	533.552	-76.081	61.122
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **Chiradzulu**	-425.089	672.180	-45.966	54.516
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **Machinga**	-898.638	774.103	-22.207	67.918
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$ x **Kasungu**	-1241.466**	542.656	-40.367	56.002
$\Phi\left(z_{ij}\hat{\alpha}_i\right)$	-1776.43	2088.775	212.949	259.49
$\phi\left(z_{ij}\hat{\alpha}_i\right)$	-465.7499	3925.899	-414.768	350.625

Constant	1746.992	1953.447	164.029	273.481
Number of Observations		605		

Level of significance (0.10 ** 0.05 *** 0.01 **** 0.001)*

Seemingly unrelated regressions						
Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
manureha	605	22	3228.563	0.0792	79.74	0.0000
fertha	605	22	287.9049	0.1139	109.36	0.0000

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Paper IV

Does secure land tenure affect technical efficiency in maize production?

(A two stage bootstrap efficiency estimation procedure)

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Abstract

Patrilocal residence is preferred to matrilocal residence in many communities in Malawi. Under patrilocal residence, households have more secure land tenure because household heads (men) own the land they cultivate. However, little is known as to whether this increase in tenure security leads to increase in technical efficiency through increase in investments. This paper uses a non-parametric frontier, two stage bootstrap efficiency estimation procedure to analyze the technical efficiency of farmers in the maize-based farming systems. In addition, propensity matching methods using nearest neighbour and a truncated regression are used to assess whether difference in tenure security can explain the differences in levels of technical efficiency. The study finds that technical efficiency is higher in patrilocal than matrilocal residence households. This difference is attributed to secure land rights in patrilocal residence location that encourages investments like contour ridges that increase their technical efficiency.

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1.0 INTRODUCTION

As land becomes scarce, customary land institutions evolve to the benefit of powerful or efficient member of the society. A notable change is individualization of land rights and acquisition of full rights by men particularly male heads of households (Bruce and Migot-Adholla, 1994; Lastarria-Cornhiel, 2001). In Malawi, a study on land tenure institutions practices by Place and Ostuka (2001a) found that patrilocal residence (men dominated) is becoming more common than matrilocal residence (women dominated). This was observed in 57 communities located throughout the country. The patrilocal residence practice gives more security to men as they have both user and ownership rights of land. In the matrilocal residence practice, men acquire user rights only as the land belongs to the wife and her matrilineage. Secure land tenure has long been argued to give high investment incentives, which in turn increase production efficiency (Sjaastad and Bromley, 1997). Does the patrilocal residence system lead to higher investment by men and hence have higher technical efficiency than the matrilocal residence system? This paper evaluates whether households in patrilocal residence have higher maize technical efficiency than households in matrilocal residence.

Secure land tenure is linked to land investments through the reduction of risk as the owner is assured of capturing the returns on the investments. Secure land tenure reduces incidences of disputes, hence freeing up resources for production e.g. cash and labour which would otherwise have been used for litigation, thereby increasing production (Barrows and Roth, 1989). Investments, however, can also increase tenure security. Sjaastad and Bromley (1997) developed a model of indigenous land rights in sub-Saharan Africa and showed that total gain from investment is a sum of increase in production efficiency and tenure security. Insecure households that can increase their security, invest more in security enhancing practices or technologies than production enhancing technologies (Lunduka, 2008). Deininger and Jin (2006) separated production and security enhancing investment and found that, in Ethiopia, secure households invest more in production enhancing technologies e.g. terracing while insecure households invest more in security enhancing technologies e.g. tree planting. Goldstein and Udry, (2005) also showed that in Ghana, individuals who hold powerful positions in the local hierarchy have more secure tenure rights and as such they invest more in soil fertility improvement and consequently have substantially higher output than individuals in low ranking positions. This paper therefore, hypothesize that households in patrilocal location of residence are more secure and have higher technical efficiency in maize than households in matrilocal location of residence.

2.0 Technical efficiency and land tenure

Technical efficiency is one component of overall economic efficiency. However, in order to be economically efficient, a firm must first be technically efficient (Herrero and Pascoe, 2002). Technical efficiency is the ability of the firm or farm to maximize output for a given set of resource inputs. Its ability to use the inputs at its disposal in optimal proportions given their respective prices and the available production technology is allocative efficiency (Forsund et al. 1980). The product of the two efficiencies gives economic efficiency. For a farm or firm to maximise profit, it is required to produce the maximum output given the level of inputs employed (i.e. be technically efficient), use the right mix of inputs in light of the relative price of each input (i.e. be input allocative efficient) and produce the right mix of outputs given the set of prices (i.e. be output allocative efficient) (Kumbhaker and Lovell 2000). Given the setting in Malawi where there are high imperfections and missing markets for both inputs (e.g. organic manure and household labour) and outputs, determining prices is very difficult, hence it is impossible to accurately measure allocative efficiency. Therefore, this study focuses only on technical efficiency which is the farmer's ability to maximize output for a given set of inputs.

Many studies have attributed the lower levels of technical efficiency in sub Saharan Africa to the policy changes resulting from the structural reforms (Owusu and Ng'ambi 2002; Government of Malawi, 2002). However, technical efficiency has been lower in sub Saharan Africa than other continents before the structural reforms of the last two decades, hence the lower efficiency cannot be only explained by the reforms. Other factors that influence technical efficiency include farmers' education, availability of extension, credit, market access and farmers' access to improved technologies through the market or public policy interventions. In Malawi, Tchale et al. (2004) found that higher levels of technical efficiency are obtained when farmers use integrated soil fertility options compared to the use of inorganic fertilizer only. Use of such soil fertility improvement structures (e.g. contour structures and agro-forestry trees) do require secure tenure.

There is also evidence in Malawi that adoption of agricultural productivity-enhancing technologies is positively associated with the size of cultivatable land (Green and Ng'ong'ola, 1993; Zeller et al., 1998; Chirwa, 2003). Doward (1999) finds a significant positive relation between output per capita and farm size, while Chirwa (2002a) find farmers with small land holdings to be technically inefficient.

3.0 Estimation of technical efficiency

Two types of procedures have been used in empirical estimation of technical efficiency: parametric and non-parametric frontiers. These methods are based on definitions of technical and allocative efficiency in production. They are based on what are called frontiers, as proposed by FARELL (1957). A frontier defines the maximum possible limit to observed production. The extent to which a farm's production is in relation to the frontier is taken as a conventional measure of its efficiency. The measurement of farm specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier. If a firm's actual production point lies on the frontier it is perfectly efficient. If it lies below the frontier then it is technically inefficient, with the ratio of the actual to potential production defining the level of efficiency of the individual firm (Herrero and Pascoe, 2002).

DEA estimates

There are mainly two non-parametric methods used to estimate production frontier:- the data envelopment analysis (DEA) and the free disposal hull (FDH) (Park, et al., 2000). Both estimators cover the data with the smallest set that has some typical properties of a production set. They can be defined as follows,

$$1)\quad \psi = \left\{ (x, y) \in \Re_{+}^{p+q} \middle| x \quad can \quad produce \quad y \right\}$$

where ψ is efficiency x and y are inputs and outputs respectively with quantities q and prices p. DEA relies on convexity assumption. The production technology might admit increasing returns to scale, i.e., the output increases faster than the inputs. DEA measures the efficiency relative to a non-parametric maximum likelihood estimate of an unobserved true frontier, conditional on observed data resulting from an underlying data-generating process (DGP) (Simar and Wilson, 2007). The method gives efficiency scores for each output. A problem in the procedure of generating DEA efficiency scores is that they are serially correlated (Simar and Wilson, 2007). The correlation arises in finite samples from the fact that perturbations of observations lying on the estimate frontier will in many, and perhaps all, cases cause changes in efficiencies estimated for other observations (ibid). This affects the subsequent analysis and even inference of the efficiency. To correct for this, Simar and Wilson (2007) procedure is followed that uses a bootstrap procedure which permit valid inference and improves statistical efficiency in the second-stage regression.

Parametric estimations incorporate a measure of random error. This involves the estimation of a stochastic production frontier, where the output of a firm is a function of a set of inputs, inefficiency and random error. An often quoted disadvantage of the technique, however, is that they impose an explicit functional form and distribution assumption on the data (Herrero and Pascoe, 2002). Almost all studies in Malawi except Tchale et, al (2006), estimating technical efficiency used a parametric approach. In order to accommodate their choice of the parametric approach, they used a sub-sample of farmers that grew maize in a mono-cropping system. While this is correct for methodological convenience, in practice it is an unrealistic assumption because farmers engages in mixed cropping as a risk-averse behaviour to insure against possible failure of one crop, diversity food and cash sources and even improve soil fertility. The use of DEA approach allows the consideration of relative efficiency within an intercropping system.

DEA is a non-parametric approach so does not take into account random error. Hence, it is not subsequently subject to the problems of assuming an underlying distribution about the error term. However, since DEA cannot take account of such statistical noise, the efficiency estimates may be biased if the production process is largely characterised by stochastic elements (Herrero and Pascoe, 2002). Therefore, comparing DEA estimates without controlling for other factors is erroneous. In this study uses propensity matching methods to compare the DEA scores of patrilocal and matrilocal residence household, where plot and household specific characteristics are used to correct for the bias from the DEA scores. In the second stage of the analysis plot and household characteristics are controlled for in order to take care of the DEA bias in a stochastic production system like one in Malawi.

In Malawi, the study that used DEA on smallholder farmers, assessed effects of agricultural policies on production efficiency (Tchale, et al., 2006). A two stage procedure to analyze how the agricultural polices affect production efficiency was used. However, the procedure did not take into consideration the Data Generation Procedure of the efficiency score in the first stage that introduces serially correlated efficiency scores making the estimation in second stage biased (Simar and Wilson, 2007). This is improved by applying a two stage bootstrap procedure, proposed by Simar and Wilson, (2007). This permits valid inference and improves on statistical efficiency. Three variable inputs; fertilizer, manure and labour per hectare are used, on output, maize to estimate output oriented efficiency scores in the first stage. To compare patrilocal and matrilocal location of households' residence, matching methods are used on observable household characteristics. These are used to match and compare the patrilocal households to matrilocal households. In the second stage, a truncated regression is used on the efficiency scores against plot and household characteristics (which include residence location as tenure security indicator) to assess factors that affect efficiency of maize production.

4.0 MALAWI LAND TENURE SYSTEM

In Malawi, within the customary tenure sector, the methods of land transfer differ principally according to descent practices, namely, matrilineal system where land is inherited through the female side and patrilineal system where land is inherited through the male side. In both inheritance systems there are three residency practices, namely, patrilocal (residing in the husband's village), matrilocal (residing in the wife's village) and neolocal (residing in a neutral village) (Place and Otsuka, 2001b).

In the matrilocal residence practice, a woman inherits land, but is supposed to report to her brothers or uncles on some decisions pertaining to the use of the land e.g. selling and renting. This has a number of implications that can affect investment in the land and efficiency on the use of the land. First, when the woman is married, the husband (who is supposedly the decision maker), cannot make some decisions together with the wife without consulting the brothers or uncles because of lack of certain rights e.g. right to sell or rent out land. Lunduka et al. (2008) found that lack of such rights in matrilocal residence affected the household's decision to participate in land markets thereby affecting their production efficiency as they could not adjust land according to their resource endowments. A second case concerns rights to land following death of a spouse or divorce. In the case where the widower resides in the deceased's village, continued rights to land are not at all guaranteed (Kishindo, 2004). Hence, this makes the land insecure and creates disincentives for long-term investments. Where either death or divorce becomes more likely, the spouse may increase activities that enhance short-term returns at the expense of long-term returns. Lunduka (2008) found that the probability of investments in agro-forestry and non agro-forestry trees was low in matrilocal residence as compared to patrilocal and neolocal residence. A third situation is that in matrilocal residence, mainly in the matrilineal system, land passes from uncles to nephews or nieces, bypassing own children. These arguments do not imply that the husband does not care about the welfare of his wife and children. Yet, he will behave more myopically under the matrilocal residency system than under the patrilocal residency system, even if he has affection for his family because his investments are inherited by distant relations rather than his own children. These three affect the use of land and may reduce land productivity.

In patrilocal residence practice, that is, the man's village is the matrimonial home and the man pays *lobola* or bride price to the wife's parents to establish his right to take his wife and children to his own village. This in turn signifies that the man owns the land. This increase investment incentives for men as threats to eviction are minimal. Land is passed on to own children hence the man can invest more in long-term practices. Lunduka (2008) found that households in patrilocal residence invested more in agro-forestry trees that improve soil fertility and land productivity.

In the neolocal residence practice, marriages are negotiated on neutral ground and these marriages tend to disadvantage women as the man most times assumes ownership of the land. Both man and woman leave their home and settle in a neutral village where the land is either bought or given by the resident chief. The land ownership is mostly given to the head of the household, the man. This is more secure for men if there is enough evidence of ownership of the land. However, huge investments on security are most times made to ensure security which may reduce land productivity in the first years of settling. This residential practice, however, is not considered in this paper.

5.0 THEORETICAL FRAMEWORK

The investigation uses the framework of a stochastic frontier. The primary characteristic of a stochastic frontier model is that it envelops rather than intersects data (Kumbhakar and Knox Lovell, 2000). The stochastic frontier production function has two error terms one to account for random effects (e.g., measurement errors in the output variable, weather conditions, diseases, etc. and the combined effects of unobserved/uncontrollable inputs on production) and another to account for technical inefficiency in production.

The stochastic frontier production function can be written as

$$2) \quad Q = f\left(L_a\beta_{La} + X_{fer}\beta_{fer} + X_{man}\beta_{man}\right)\exp\left(V_i - U_i\right)$$

where Q is agricultural output, L_a is labour X_{fer} is inorganic fertiliser, X_{man} is organic manure and βs are vectors of unknown parameters. Importantly, the stochastic frontier model has an error term with two components assumed to be independently distributed of each other and of the regressors. V_i is a random variable which is assumed to be independently and identically distributed (iid) and independent of Ui and Ui is a random variable that is assumed to account for technical inefficiency in production. Following Battese and Coelli (1995), U_i is assumed to be independently distributed as truncation (at zero) of the normal distribution where

3) $U_i = z_i\delta + g_k\vartheta + T_i\tau$

Where, z_i are household-specific variables that may cause inefficiency and g_k are plot specific variables e.g. slope, texture and fertility while T_i is the household tenure security. The farm-specific stochastic production frontier representing the maximum possible output (Q^*) can be expressed as

4) $Q^* = f(L_a\beta_{La} + X_{fer}\beta_{fer} + X_{man}\beta_{man})\exp(V_i)$

Equation (2) may be rewritten using equation (4) as

5) $Q = Q^* \exp(-U_i)$

Thus, technical efficiency of the i^{th} household, denoted by TE_i, is given by

6) $TE_i = \dfrac{Q}{Q^*} = \exp(-U_i)$

This means the difference between Q and Q^* is embedded in the Ui and captures inefficiency effects relative to the stochastic frontier. If $Ui = 0$, then Q is equal to Q^*. This means production lies on the stochastic frontier and hence technically efficient and the farm obtains its maximum possible output given the level of inputs. If $Ui > 0$, production lies below the frontier and the farm/firm is technically inefficient . The graph below depicts production graphs of two households with different tenure security.

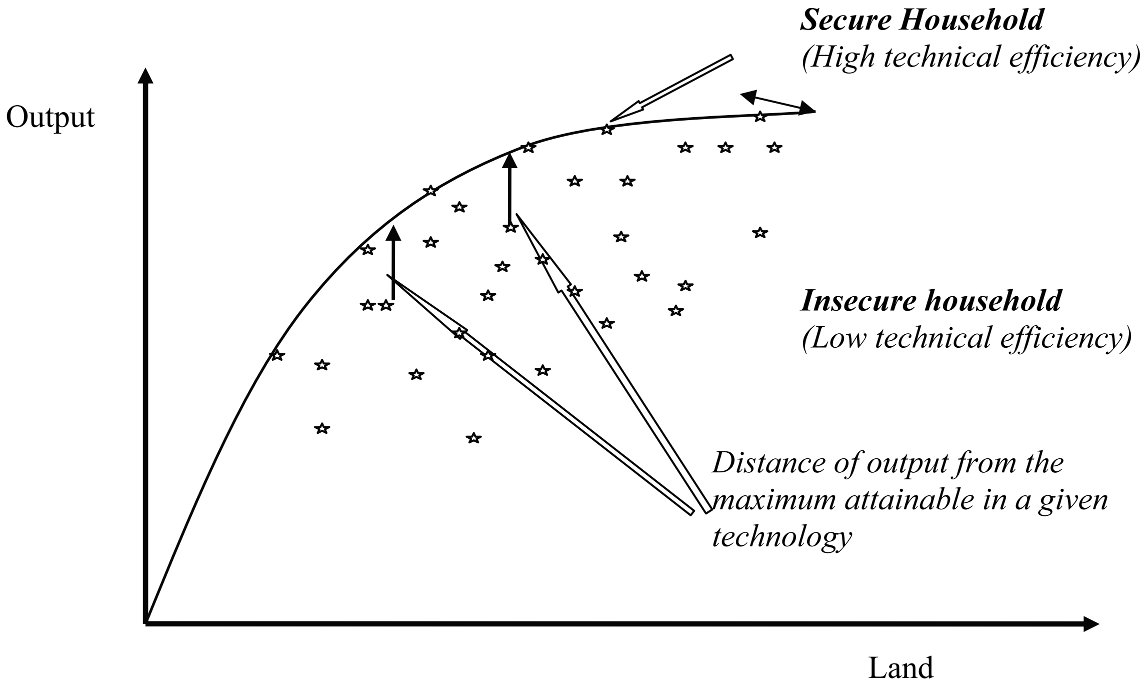

Figure 1 diagram of an example of a production technology graph for secure and insecure households

6.0 METHODLOGICAL APPROACH

6.1 The DEA scores

The DEA scores rely only on the free disposal assumption on ψ ; i.e., if *(x, y) Є* ψ then all pairs *(x', y')* such that $x' \geq x$ and $y' \leq y$ belong to ψ (Park et al, 2000). The estimator of ψ is then defined as the free disposal hull of the set χ:

$$7)\quad \psi = \left\{(x.y) \in \Re_{+}^{p+q} \middle| y \leq y_i, x \geq x_i, \qquad (x_i, y_i) \in \chi \right\}$$

It is the smallest free disposal set containing all the observations. Efficiency score is measured in terms of Shephard output distance functions, which are the reciprocals of the Farell output efficiency measures. The efficiency scores can be calculated either as input oriented i.e. based on inputs used or output oriented based on output. In this study output oriented efficiency scores are calculated and used.

Efficiency scores were calculated using the Frontier Efficiency Analysis with R (FEAR) software, where the bootstrap procedure was applied to reduce biasness of the scores. The Frontier Efficiency Analysis with R (FEAR) software used, consists of a library that can be linked to the general-purpose statistical package R. The routines included in FEAR allowed computing DEA efficiency scores while assuming variable returns to scale (Wilson, 2006). Commands are also included to facilitate implementation of the bootstrap methods described by Simar and Wilson (2007). Appendix A presents the homogenous bootstrap algorithm commands used in the estimation of the DEA efficiency scores. The DEA efficiency scores (output oriented) were calculated from three inputs labour, fertilizer and manure costs per hectare on maize yield value. Efficiency scores on each maize plot were measured by their distance to an estimated production frontier. The efficiency scores were between one and zero, where one is the most efficient score and zero less efficient score.

6.2 Average differences

Using average efficiency scores to determine if there are differences between the two tenure systems is prone to biases because the DEA score assume no statistical noise. This can be confounded with different plot or household sources of technical efficiency. Therefore, matching methods with nearest neighbour using propensity scores was used on plot and household characteristics. Residence location is used as a proxy for tenure security. Residence location is assumed the treatment and efficiency scores of maize production is assume the outcome. Gain in efficiency due to being secure can be written as

(8) $$x_i = \psi\left(p_k^p, L_i^p\right) - \psi\left(p_k^m, L_i^m\right)$$

where p_k^p and p_k^m are plot in patrilocal and matrilocal residence households respectively and L is household location (L_i^p =household .i in patrilocal residence and z_i^m is household i in matrilocal residence). Using expectations

(9) $$x_i = E\left(p_k^p, L_i^p - p_k^m, L_i^m \middle| P_i = 1\right) = E\left(p_k^p, L_i^p \middle| P_i = 1\right) - E\left(p_k^m, L_i^m \middle| P_i = 1\right)$$

This can be estimated by subtracting the two expectation of efficiency given each of the plot and household characteristics. However, a household in patrilocal location of residence $E\left(p_k^m, L_i^m \middle| P_i = 1\right)$ is not observed because a household cannot be in both patrilocal and matrilocal residence location places at the same time. Therefore, counterfactual $E\left(p_k^m, L_i^m \middle| P_i = 0\right)$ is used i.e. finding a similar household in matrilocal location of residence that can be compared with the household in patrilocal location of residence. Using an assumption of conditional independence, $E\left(p_k^m L_i^m \perp P \middle| z_i, g_k = 1\right)$, the expected efficiency given the household $\left(z_i\right)$ and plot characteristics $\left(g_k\right)$ of household being in matrilocal (*P_i=0*) is equal to the expectation of the efficiency given the household and plot characteristic of household being in patrilocal *(P_i=1)*

$$E\left(p_k^m, L_i^m \middle| z_i, g_i, P_i = 0\right) = E\left(p_k^p, L_i^p \middle| z_i, g_i, P_i = 1\right) \tag{10}$$

Using propensity score matching from logit model $\rho\left(P_i = 1 \middle| z_i, g_i\right) = \rho\left(z_i, g_i\right)$, households are grouped into blocks using nearest neighbough matching methods that have similar characteristics and that can be compared. The above expectation of difference in efficiency can then be written as

$$x_i = E\left(p_k^p, L_i^p - p_k^m L_i^m \middle| P_i = 1, \rho\left(z_i, g_i\right)\right) = E\left(p_k^p, L_i^p \middle| P_i = 1, \rho\left(z_i, g_i\right)\right) - E\left(\hat{p_k^m} L_i^m \middle| P_i = 0, \rho\left(z_i, g_i\right)\right) \tag{11}$$

6.5 Test if tenure affects efficiency in the production.

A two-tier model is used on the efficiency scores to test impact of security (proxied by residence location). The model is specified as

$$\psi_i = f\left(g_i, z_i, L\right) \geq 1 \tag{12}$$

where g_i are plot variables and long-term input variables that can affect efficiency like soil conservation structures, and soil characteristics like soil fertility, z_i are household head characteristics and L is the residence location variable. Soil characteristics (soil erosion, slope, texture) are highly significantly correlated with soil fertility and soil fertility is again correlated with input use (Lunduka , 2009). This implies that there is omitted variable bias in the inefficiency scores. Therefore, plot characteristics are controlled for in the second stage of the analysis using a truncated model. The truncated model is given as

(13) $$P(\psi = 1|g,z,L) = 1 - \Theta((g,z,L)\gamma)$$

$$\log(\psi)|(g_k, z_i, L, \psi \geq 1) \sim Normal(g_k\beta_k, z_i\beta_i, \sigma^2)$$

The first model is the probit model on efficiency being equal to one while the second one is lognormal regression on efficiency being greater that 1 i.e. the expectation *E(ψ|g,z,L,ψ>1)* using properties of lognormal distribution. The maximum likelihood function is

(14)

$$\ell = \prod_{i=1}^{710} \frac{1}{\sigma_\varepsilon} \phi\left(\frac{\psi - (g_k, z_i, L)\beta}{\sigma_\varepsilon}\right)\left[1 - \Phi\left(\frac{1 - (g_k, z_i, L)\beta}{\sigma_\varepsilon}\right)\right]^{-1}$$

Where $\phi(\bullet)$ and $\Phi(\bullet)$ represent the standard normal density and distribution functions respectively. The following model is estimated

7.0 DATA AND DESCRIPTIVE STATISTICS

The data used in this report was collected from six districts of Thyolo, Chiradzulu, Zomba, Machinga, Lilongwe and Kasungu. The primary sampling units were Enumeration Areas (EAs) following the integrated household survey of 2004 by the National Statistical Office, Malawi. The household population figures used for the EAs are from the 1998 Population census. For Thyolo, Chiradzulu and Machinga districts at least two EAs were randomly selected, whilst three EAs were selected for Zomba, Kasungu and Lilongwe and at least 30 households were randomly selected from each of the selected EA in all the districts. A detailed household questionnaire was administered to get household and agricultural plot information. A plot was defined based on major crop grown. Data used in this study is based on maize plot data only. Maize is grown by all households interviewed and hence we assumed a normal distribution of the maize plots.

Table 2 in appendix provides descriptive statistics for the variables used in the analysis. The descriptive statistics show that a total of 710 plots were planted with maize of which 405 were in matrilineal- matrilocal, 60 were in matrilineal- patrilocal, 100 plots in patrilineal-matrilocal and 145 plots in patrilineal-patrilocal. Land size was highest for plots in patrilocal residence both in matrilineal and patrilineal inheritance systems. Plot quality did not show major differences and had no definite pattern. Input use varied between the areas but showed less significant variation. However, both fertilizer and labour use on maize plots was systematically lower on patrilocal residents' plots both in the matrilineal and patrilineal systems. The yield was higher in patrilocal residence, but only in patrilineal society. However, patrilineal society had higher yield as compared to matrilineal society.

Households in patrilocal were both wealthier than matrilocal in terms of their assets and size of livestock holding owned. These assets could come from investments over a period of time as well as saving and can be used in accessing short term agricultural inputs like inorganic fertilizer, hired labour, hybrid seeds and pesticide. All these lead to an increase in productive efficiency. Other household variables like age, education and household size showed insignificant differences.

8.0 RESULTS

8.1 DEA results

The DEA efficiency scores for each maize plot were obtained using the computer program FEAR and corrected for bias by subtracting the bootstrap bias estimate from original distance function scores. The efficiency scores ranged from 0.007 to 1 with one being the most efficient plot score and 0.007 being most inefficient plot score. The patrilocal residence household's plots had a higher efficiency score means of 0.7612, than that of 0.74988 in matrilocal resident households' plots. Table one below shows the T-test results and summary of the DEA efficiency scores. In both matrilineal and patrilineal system, patrilocal residence scores were higher than the sample mean of 0.74988 indicating that patrilocal residence households were more efficient than households in matrilocal residence.

Table1: Mean DEA scores by residence location and T test.

Group	*Obs*	*Mean*	*Std. Err.*	*Std. Dev.*	*[95% Conf.*	*Interval]*
Matrilocal	505	0.74528	0.0041577	0.093432	0.7371111	0.7534481
Patrilocal	205	0.761237	0.0067953	0.097295	0.7478385	0.7746347
combined	710	0.749887	0.0035567	0.094771	0.742904	0.7568698
diff		**-0.01596**	**0.0078311**		**-0.0313318**	**-0.0005821**

diff = mean(0) -mean(1) t = -2.0377

Ho: diff = 0		degrees of freedom = 708
Ha: diff < 0	Ha:diff!=0	Ha: diff > 0
Pr(T < t) = 0.0210	Pr(T >t)=0.042	Pr(T > t) = 0.9790

In order to test for differences between matrilocal and patrilocal residence efficiency scores, matching methods were used where propensity scores were estimated using a logit model on observable household and plot characteristics. Using methods of matching, results show that there is a positive gain in efficiency score when household is patrilocal. The plots in patrilocal residence households were matched with matrilocal households using plot and household specific characteristics. The results show that patrilocal household plots had on average higher DEA score after controlling for plot and household characteristics using nearest neighbour matching. Table 2 below presents the matching methods results. Propensity score matching results for the plot and household characteristics are in annex 3. Using nearest neighbough matching method, an average difference of 0.031 in efficiency scores for households in patrilocal and matrilocal residence location is observed. Using method of matching within radius, an average difference of 0.026 in efficiency scores for households in patrilocal and matrilocal location of residence is observed. Both methods show that efficiency scores for patrilocal residence location plots are higher than matrilocal residence location.

Table 2: ATT estimation with Nearest Neighbour Matching method (equal weights version) Analytical standard errors

Number of treated (patrilocal)	*Number of control (Matrilocal)*	*ATT (Average change in DEA score in Patrilocal)*	*Std. Err.*	*t*
154	357	**0.024**	0.013	1.851
Note: the numbers of treated and controls refer to actual nearest neighbour matches				

Bootstrap statistics

Variable	*Reps*	*Observed*	*Bias*	*Std. Err.*	*[95% Conf. Interval]*	
bootstrap1	399	0.0309986	-0.0034001	0.0126347	0.0061596	0.0558376 (N)
					0.0040822	0.054376 (P)
					0.0103474	0.065746 (BC)
N = normal, P = percentile, BC = bias-corrected						

ATT estimation with Nearest Neighbour Matching method (equal weights version) Bootstrapped standard error

Number of treated (patrilocal)	*Number of control (Matrilocal)*	*ATT (Average change in DEA score in*	*Std. Err.*	*t*

	Patrilocal)			
154	379	**0.031**	0.013	2.453

Note: the numbers of treated and controls refer to actual nearest neighbour matches

To visualise if the efficiency scores in patrilocal are higher, a cumulative graph against log efficiency scores was plotted. The graph below shows that patrilocal efficiency scores dominated the matrilocal efficiency scores, because their cumulative density lies to the right in the graph.

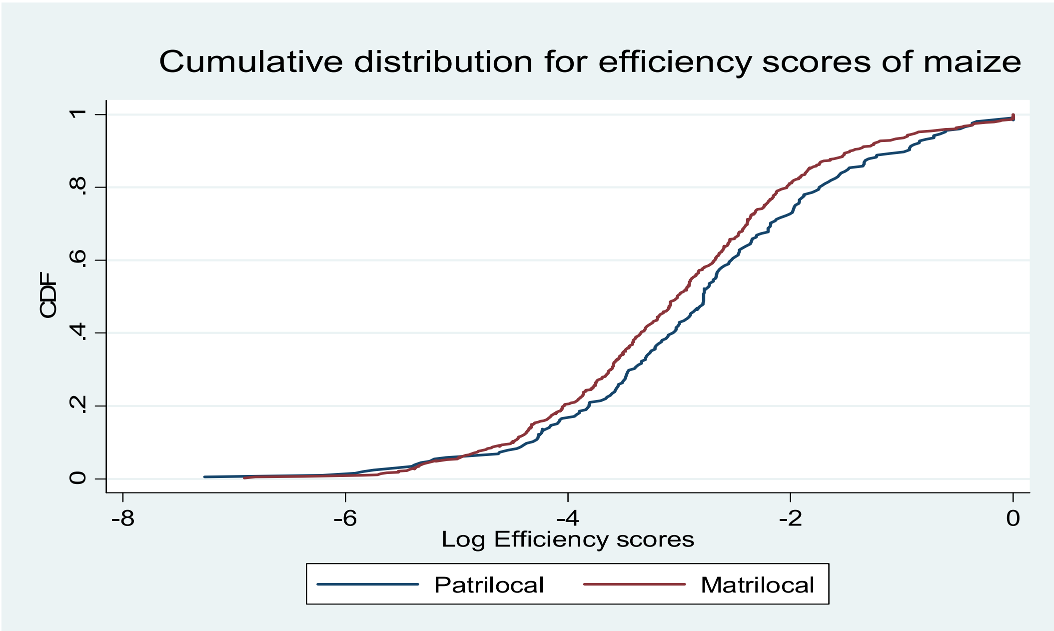

Figure 2: Cumulative distribution for efficiency scores for patrilocal and matrilocal residence location households plots

Another propensity matching analysis was done on the actual maize yield and indicated that patrilocal households have 122 kg of maize more on average that matrilocal household. Table in annex 4 presents the results.

8.2 Factors affecting efficiency

It has been established that there are significant differences in DEA estimates between patrilocal residence and matrilocal residence. However, what are factors the contributing to the differences? Several studies have estimated the second stage by assuming a censored normal (tobit) specification for DEA scores (. The tobit specification is sometimes motivated by the observation that several values in estimates are equal to unity, suggesting a probability mass of 1 (Simar and Wilson, 2007). However, it is important to recall that the underlying true model does not have this property. Therefore a truncated regression is used to test several factors that could contribute to the differences in efficiency scores. Variables used are household characteristics, plot characteristics, and variety of maize. Hybrid maize gives more output than local varieties, hence it is important to control for the variety of maize that was planted on a particular plot.

The truncated regression in table 2 in annex 1 shows that, residence location affects the DEA scores. The model for the whole sample and sub sample of patrilineal society shows that patrilocal residence is positive and significant while matrilineal society sub sample is just positive but not significant. Zelenuyk, (2006) showed that the power of significance test in dummies in the two stage efficiency analysis demands large sample size, because the variation on the regressant is fairly small and is poorly defined by dummy variable whose variation is also small. However, having a significant dummy variable indicates a likely large difference and importance.

As indicated in the introduction patrilocal residential area provides secure tenure mainly for men in the household and this affects their investment decision and also adjustment of the cultivable plot to optimal size according to their resource endowments. Lunduka et al (2009) found that patrilocal residence household in both matrilineal and patrilineal societies have higher probability of renting-in land as compared to matrilocal households. Lunduka (2008) also found that patrilocal resident households planted more agro-forestry trees which improve soil fertility and in turn increase land productivity. Such adjustments to land size and investment help the secure patrilocal resident households to be more efficient than matrilocal resident households.

Therefore the use of resources becomes efficient and long term investments, e.g. contour ridges or trees, also pay back. Long term investments on land were captured with the observed presences of vetiver grass and contour ridges. These are important structures as they control soil erosion and help maintain soil fertility. The contour variable has positive and significant coefficients in the patrilineal society model. Investment in such structures are made when households feel secure on the plots (Lunduka, 2008). The variety of maize planted on the plot was also controlled for. Hybrid variety was used as a point of reference. Both composite and local varieties have negative coefficient implying lower technical efficiency. This indicates that planting local and composite varieties reduces efficiency as compared to hybrid. This is obvious as hybrids are high yielding even though they require more resource inputs e.g. inorganic fertilizer.

9.0 Conclusion and policy recommendation

As land is becoming scarce, land ownership has been biased towards men in Malawi. Secure ownership of land has been argued to increase investment incentives which lead to higher production efficiency. The men dominated tenure systems show higher technical efficiency in maize production than the women dominated systems. The results show that secure households (patrilocal residence) are more efficient than insecure households (matrilocal residence). Men in patrilocal residence location own more assets, like livestock, and invest more in productive and long-term technologies like contour ridges and vetiver grass; hence they are more efficient than matrilocal residence households. It can be concluded that the residence of location as a proxy for the tenure security of the men affects technical efficiency. Secure household are more efficient than insecure household.

This study has shown that tenure security affects technical efficiency in maize. This may induce inequality between men and women as the tenure security emanates from roles given to men and women in the different inheritance systems. The theory of induced institutional innovation developed by North (1990) indicates that if the people that have power are able to benefit from the change in institution there is likely going to be a change to their benefit. Men in patrilocal have more power and own bigger plots as indicated by the descriptive statistics. This power motivates them to use resources efficiently and increase their output. However, in a bid to ensure fairness and equity between men and women dominated societies it is important to ensure that policies e.g. the land policy reform, addresses the intra-household issues. The current policy in Malawi is advocating provision of land titles based on current customary practice. However, the current customary practice does not provide enough security mainly for men in matrilocal residence because the wives do not have enough power and control over the land they inherit. Therefore a special policy intervention needs to be developed that can ensure security even in such areas and situations. The major source of lack of security is the threat of loss of investment after death of spouse, or divorce, or eviction. Inclusion of policies such as compensation for any investment made on land could give more incentives for households to invest on plots and increase technical efficiency.

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Annex 1:

Table 1. Descriptive statistics of variable used in the analysis.

Variable	**Total sample**	**Matrilineal**		**Patrilineal**	
		Matrilocal	**Patrilocal**	**Matrilocal**	**Patrilocal**
Output and inputs variables					
Maize output (kg/ha)	1315	1219	1506	1235	1301
Manure used (kg/ha)	375	295	355	529	734
Fertilizer (kg/ha)	182.95	199.18	176.61	156.46	158.51
Total labour (Days/ha)	29.19	33.23	21.66	24.74	24.09
Plot variables					
Average plot size (ha)	0.42	0.32	0.44	0.49	0.63
Fertility perception (1=poor; 2=average; 3=good)	1.86	1.84	1.75	1.88	1.95
Slope of plot	1.5	1.5	1.4	1.5	1.5
Soil texture on plot	1.7	1.7	1.5	1.8	1.8
Distance from home to plot (meters)	803.98	713.16	563.96	1004.24	1007.74
Soil erosion level on plot	0.82	0.79	0.86	0.91	0.82
Vetiver grass dummy 1=present 0=absent	0.006	0.051	0.016	0.11	0.103
Contour bunds dummy (1=present 0=absent)	0.407	0.476	0.366	0.36	0.262
Household wealth variables					
Wealth indicator of the household	23.36	24.81	27.56	16.25	22.22
Value of livestock (MK)	31,533	6,894	9,159	16,551	121,250
Household characteristics					
Average household size	5.4	5.2	6.1	6.0	5.5
Dependant ratio	1.29	1.28	1.24	1.35	1.29
Age of household head	45.24	44.38	48.6	47.08	44.92
Average years in school of household head	4.87	5.12	4.38	4.38	4.70
Number of observations	710	405	60	100	145

Table 2; Truncated regression of DEA scores on other covariates

	Whole sample	Patrilineal Society	Matrilineal Society
Patrilocal residence	0.264**	0.376**	0.027
	(0.12)	(0.19)	(0.18)
Wealth indicator	0.004	-0.011	0.011***
	(0.00)	(0.01)	(0.00)
Age of household head	-0.008**	-0.007	-0.007*
	(0.00)	(0.01)	(0.00)
Slope of plot	-0.011	-0.072	-0.012
	(0.08)	(0.16)	(0.10)
Distance from plot to home	-0.000	-0.000	-0.000
	(0.00)	(0.00)	(0.00)
Number of natural trees on plot	0.003	0.002	-0.006
	(0.00)	(0.00)	(0.01)
Dependency ratio	0.116*	0.109	0.182**
	(0.07)	(0.10)	(0.08)
Household size	-0.011	0.089**	-0.082**
	(0.03)	(0.04)	(0.03)
Plot with contour ridges	0.252**	0.532***	0.193
	(0.11)	(0.20)	(0.12)
Plots with vetiver grass	0.015	0.024	-0.085
	(0.22)	(0.34)	(0.28)
Livestock assets value	0.000	0.000	0.000***
	(0.00)	(0.00)	(0.00)
Local maize varieties	-0.040	-0.002	-0.040
	(0.04)	(0.07)	(0.05)
Composite maize varieties	-0.008	-0.037	0.020
	(0.07)	(0.12)	(0.09)
_cons	-2.954****	-3.169****	-2.929****
	(0.29)	(0.52)	(0.35)
sigma	1.205****	1.214****	1.139****
_cons	(0.04)	(0.06)	(0.04)
Prob > chi2	0.034	0.080	0.004
Number of observations	558.000	190.000	368.000

Standard errors in parenthesis

*The superscript****,***,** and * indicate0.1%,1%,5%, and 10% levels of confidence, respectively*

Annex 2 :Syntax of commands used in R using FEAR for the calculation of DEA efficiency scores using a bootstrap method.

```
maize<-read.dta("D:/soil paper/finalmaize.dta")
attach(maize)

x=matrix(nrow=3,ncol=710)
x[1,]=fertha1
x[2,]=manureha1
x[3,]=labourha1
y=matrix(nrow=1,ncol=710)
y[1,]=valmaize1

dhat=dea(XOBS=x,YOBS=y,RTS = 1, ORIENTATION = 1, XREF = NULL, YREF = NULL,
IS.EFF = NULL, errchk = TRUE)

tmp=boot.sw98(XOBS=x, YOBS=y, NREP = 1000, DHAT = NULL, RTS = 1,
ORIENTATION = 2,
        alpha = 0.05, CI.TYPE=2,XREF = NULL, YREF = NULL, DREF = NULL,
        OUTPUT.FARRELL = FALSE, NOPRINT = FALSE, errchk = TRUE)
```

Annex 3 Algorithm to estimate the propensity score

```
The treatment is patrilocal
 patrilocal |      Freq.     Percent        Cum.
------------+-----------------------------------
          0 |        505       71.13       71.13
          1 |        205       28.87      100.00
------------+-----------------------------------
      Total |        710      100.00
```

```
Estimation of the propensity score

Iteration 0:   log likelihood = -328.08273
Iteration 1:   log likelihood = -257.63876
Iteration 2:   log likelihood = -253.63645
Iteration 3:   log likelihood = -253.35835
Iteration 4:   log likelihood = -253.33105
Iteration 5:   log likelihood = -253.33078
Iteration 6:   log likelihood = -253.33078

Logistic regression                           Number of obs   =        556
                                              LR chi2(16)     =     149.50
                                              Prob > chi2     =     0.0000
Log likelihood = -253.33078                   Pseudo R2       =     0.2278
```

patrilocal	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Plot size (ha)	0.2444862	0.2153915	1.14	0.256	-0.1776734	0.6666458
Fertility on plot	0.2372861	0.1868141	1.27	0.204	-0.1288628	0.603435
Soil erosion on plot	0.0883566	0.1052853	0.84	0.401	-0.1179987	0.294712
Soil texture	-0.4225497	0.1777034	-2.38	0.017	-0.7708421	-0.0742574
Slope on plot	-0.138736	0.1952599	-0.71	0.477	-0.5214384	0.2439663
Distance from home to plot	-0.0000233	0.0000945	-0.25	0.805	-0.0002084	0.0001619
Age of household head	0.0177923	0.0089745	1.98	0.047	0.0002027	0.035382
Quantity of tree planted	0.0204224	0.0135415	1.51	0.132	-0.0061184	0.0469632
Value of livestock assets	4.87E-06	2.71E-06	1.8	0.072	-4.41E-07	0.0000102
Education of household head	0.4442712	0.1649517	2.69	0.007	0.1209719	0.7675706
Average household education	-1.102325	0.3051488	-3.61	0.000	-1.700406	-0.5042444
Household size	0.0027648	0.0529469	0.05	0.958	-0.1010093	0.1065389
Dependant ratio	-0.0950335	0.1390848	-0.68	0.494	-0.3676347	0.1775678
Matrilineal	-2.001479	0.2409261	-8.31	0.000	-2.473686	-1.529273
_cons	0.4715705	0.7544986	0.63	0.532	-1.00722	1.950361

```
Note: the common support option has been selected
The region of common support is [.04155592, .99937916]
```

```
Description of the estimated propensity score
in region of common support
                 Estimated propensity score
-------------------------------------------------------------
      Percentiles      Smallest
 1%     .0504152       .0415559
 5%     .0629102        .044553
10%     .0771713       .0446982       Obs                 537
25%     .1124167       .0447454       Sum of Wgt.         537

50%     .1782537                      Mean           .2857432
                        Largest       Std. Dev.      .2307359
75%     .4503493       .9983881
90%     .6573592       .9983936       Variance       .0532391
95%     .7080187       .9984365       Skewness       1.111072
99%     .9983319       .9993792       Kurtosis       3.270309
******************************************************
Step 1: Identification of the optimal number of blocks
Use option detail if you want more detailed output
******************************************************
The final number of blocks is 10

This number of blocks ensures that the mean propensity score
is not different for treated and controls in each block

**********************************************************
Step 2: Test of balancing property of the propensity score
Use option detail if you want more detailed output
**********************************************************
The balancing property is satisfied

This table shows the inferior bound, the number of treated
and the number of controls for each block
  Inferior |
  of block |      patrilocal
of pscore  |         0          1 |     Total
-----------+----------------------+----------
  .0415559 |       108          5 |       113
        .1 |       165         24 |       189
        .2 |        29         20 |        49
        .3 |        15         17 |        32
        .4 |        22         19 |        41
        .5 |        18         23 |        41
        .6 |        21         21 |        42
        .7 |         4         12 |        16
        .8 |         1          3 |         4
        .9 |         0         10 |        10
-----------+----------------------+----------
     Total |       383        154 |       537

Note: the common support option has been selected
*******************************************
End of the algorithm to estimate the pscore
*******************************************
```

Annex 4: ATT results on maize yield.

ATT estimation with Nearest Neighbour Matching method
(equal weights version)Analytical standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
154	383	**122.066**	420.226	0.290

ATT estimation with Nearest Neighbour Matching method
(equal weights version)Bootstrapped standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
154	383	**122.066**	419.594	0.291

Note: the numbers of treated and controls refer to actual nearest neighbour matches

Annex

Questionnaire number

INTRAHOUSEHOLD DECISION MAKING IN ALLOCATION OF RESOURCES (2007)
Household Questionnaire

HOUSEHOLD IDENTIFICATION	NAME		CODE
Household			
Name of village			
Traditional Authority			
District			
Name of interviewee			**Sex** 1= Male 2=Female
Residence area	Husband's village		
	Wife's village		
	Neutral Village		
Name of Enumerator			
Date of interview	**Date:………./……………/2007** **Start time:………..:…………..** **Finish time:………:…………..**		**Checked by:** **……………………………..** **Approved:** **…………………………......**
Reasons for not conducting interview:			**Household location GPS Coordinates:** **N…………………………………** **E…………………………………**

A. Provide the details of each household member

Member ID	**Name of household member** **A1**	**Sex** **A2**	**Relationship with respondent** **A3**	**Marital status** **A4**	**Age** **A5**	**Education** **A6**		**Main occupation** **A7**	**How many months did the name live here in the last 12 months** **A8**
						Number of years of schooling	*Highest level of education completed*	*What is the name of profession or activity?*	
01									
02									
03									
04									
05									
06									
07									
08									
09									
10									
11									
12									
13									
14									
15									
16									
17									
18									
		1=female 2=male	1= husband 2= wife 3= son 4= daughter 5= Grandchild 6=Brothet 7=sister 8=neice 9= nephew 10=other relatives (specify)	1=Married 2=Widowed 3=Divorced 4= separated 5=Never married			0=none 1=std 1-4 2= std 5-8 3= Attend sec 4=MSCE 5=Techn. Colle 7=University	0=none 1= Farming 2=bussiness 3=ganyu (labour) 4=Salaried work 5=schooling 6=Unemployed 7=other (specify)	

C. Social economic characteristics

Quality of Main house C1		**Toilets owenership and type C2**		**Source of water C3**		**Source of energy C4**	
Walls **C1a**		*Does house hold own a toilet* **C2a (0=No, 1=Yes)**		*Source* **C3a**		*Source lighting* **C4a**	
Roof **C1b**		*Kind of toilet* **C2b**		*quality* **C3b**		*Source cooking* **C4b**	
Floor **C1c**		*If no toilet, what is used* **C2c**		*avalaibility* **C3c**			
Windows **C1d**							

Type of house						Water source			Energy	
Walls	Roof	floor	windows	Kind of toilet	Altenative toilets	source	quality	Availability	lighting	cooking
1= Poles and mud 2= Sundried walls 3= compacted earth 4=burnt bricks walls 5= plastered and painted walls	1=Grass Thatched 2=Iron sheets 3=Tiled 4=cement sheets	1=cement 2=mud	1=wooden 2=glass 3=grass 4=without windows 5= opening 6=others	1=Flush sewer system 2=Flush septic 3=latrine with san plat 4=Traditional latrine 5=VIP latrine	1= bush 2= river/ lake 3=neighbours 4=others	1=river/lake 2=protected well 3=unprotected well 4=borehole 5=Communal piped 6=household piped 7=other	1= bad 2=moderate 3=good	1=All year round 2=In wet season only 3=some breakdowns	1=Electricity 2=paraffin 3=candles 4=wood 5=grass 6=touch 7=other	1=firewood collected 2=purchased firewood 3=made charcoal 4=purchased charcoal 5=paraffin 6=electricity 7=crop residues 8=others

D. Changes in Assets owned by the household

Items	Did you buy this item last year? D1	How many units did you buy? D2	How much did you pay for it? (MK) D3			Did you lose or sell any item last year? D5	If sold	
							why? D6	what was the price? D7 (Mk)
Car								
Ox cart								
Bicycle								
Wheelbarrow								
Hoe								
Panga								
Axe								
Sickle								
Handsprayer								
Treadlepump								
Engine pump								
Bed								
Chair table								
Chair sofa								
Ridger								
Table								
Sewing machine								
Radio								
Plough								
Pressing iron								
Cell Phone								
Others (specify)								
	0=no (go to D5) 1=yes					0 = no 1 =lose 2 = sell		

E. Time use and labour

Member ID	What day of the week was yesterday? E1	How many days did you spend collecting firewood last week? E6	How many hours did you spend collecting firewood yesterday? E7	How many hours yesterday did you spend on household agricutulral activities? E9	At peak time during the agricultural season how many hours per day did you engage in ganyu? E11	At peak time during the agricultural season how many hour do you spend you field? E12
01						
02						
03						
04						
05						
06						
07						
08						
09						
10						
11						
12						
13						
14						
15						
16						
17						
18						
	See code					

Code

E1 1=Mon 2=Tue 3=wed 4=Thur 5=Fri 6=Sat 7=sun

Plot data

F. How many plots does the household have?..................................
Ask for each plot the household owns or rents in or rents out or fallow

Plot ID	Name of plot	Distance from home to the plot	Physically measured size with GPS (meter square)			What is the general texture of the soil?	What is the slope of the plot?	What is the general fertility of the plot?	How did you acquire this plot?	If you were to sell this plot today how much could you sell if for?
	F1	*F2*	*Coordinates N/S F5*	*Coordinates W/E F6*	*Size F7*	*F9*	*F10*	*F12*	*F13*	*F14*
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
	Give name of crop grown or fallow See codes on FC					1=sandy 2=loam 3=clay	1-flat 2-slight 3-steep	1-very fertilie 2-average 3-not fertile	1=granted by local leaders 2=Inherited from mothers side (wife) 3=Inherited from fathers side(wife) 4=Inherited from mothers side (husband) 5=Inherited from fathers side(hasband) 6=Rented 7=purchased 8=farming as tenant	

F15 If you need more land for cultivation do you have any available for you?

1-Yes………...How?..
2-No………… why?...

Fs. -Security of the plots

Plot ID	Who will inherit this plot from you *Fs1*	Under what circumtances can you stop cultivating this plot *Fs2*	Who can grab the land away from you? *Fs3*	What are you doing to ensure that you don't lose the plot? *Fs4*	Have you had conflicts on the plot *Fs5*	What type of conflicts did you have? *Fs6*	where was this conflict resolved *Fs7*	Can you register this plot? *Fs9*	If you were to register in whose name would it be? *Fs10*
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
	1=Sons 2=daughters 3=both (children) 4=brothers 5=sisters 6=others	1=Divorce 2=Death of spouce 3=Emmigration 4= end of contract 5= none	1=Village Chief 2=Brother 3=Brother in law 4=Sister in law 5=none 6= owener 7=government 8= uncle 9= others	1=Plant tree 2=Plant vertiva and 3=rhodes grass 4= registered 5=none 6=others	0=No 1=Yes	1=Border disputes 2=Plot owenship 3=others	1=Familieas 2=Village chief 3=Group village 4=TA 5=Magestry court	0= no 1= yes	1=Sons 2=daughters 3=both (children) 4=brothers 5=sisters 6=Wife 7=husband 8= others (specify)

Fri .If there is a plot that was rented in answer table below

Rented in plot (wobwereka)

Plot ID	**Did you rent in land last growing season?** *Fri1*	**Why did you rent the plot?** *Fri2*	**Duration of rent** *Fri5*	**Type of contract** *Fri6*	**Will contract be renewed this year** *Fri7*	**Share cropping**		**Fixed rent How much did you pay for the plot?** *Fri10*
						Rate of share croping *Fri8*	**How much did you pay for the plot if sharecropping?** *Fri9*	
1								
2								
3								
4								
5								
	0- no 1- yes	1=Increase land 2=Secure more land 3=grow cash crop 4=others	Number of seasons	1-Fixed rent 2-sharecroping 3-borowing free	0= no 1= yes 2=maybe			

Fro : Rented out plot (wobwereketsa)

Plot ID	**Did you rent out the plot?** *Fro1*		**Why did you rent out the plot?** *Fro2*	**Duration of rent** *Fro5*	**Type of contract** *Fro6*	**Will contract be renewed this year** *Fro7*	**Share cropping**		**Fixed rent How much did get from the rent** *Fro10*
	Last yr	*This yr*					**Rate of share croping** *Fro8*	**How much did you get for the plot if sharecropping?** *Fro9*	
1									
2									
3									
4									
5									
6	0- no 1- yes		1=cash 2=assist others 3=more land 4=others	Number of seasons	1-Fixed rent 2-sharecroping 3-borowing free	0= no 1= yes 2=maybe			

Fsb: Plot bought

Plot ID	Where did you buy the plot? *Fsb1*	Why did you buy, the plot? *Fsb2*	How much did you pay for the plot? *Fsb5*
1			
2			
3			
4			
5			
	1=same village 2=other village	1=Secure more land 2=grow cash crop 3=grow food crops 4= seek fertile land 5=others	

Fss: Plot sold

Plot ID	To whom did you sell the plot? *Fss1*	Why did you sell, the plot? *Fss2*	How much did you get for the plot? *Fss5*
1			
2			
3			
4			
5			
	1=person from same village 2=other village 3=immigrant 4=urban dweller	1=cash 2=assist others 3=more land 4=others	

Fm: Land market conditions

	Rent in plots *Fm1*	Rent out plots *Fm2*	Bought plots *Fm3*	Sold plots *Fm4*
Was the chief informed? 0= no 1= yes				
Were there any witnesses?				
Will the contract be renewed				
Give reason for above answer				
Do you have any obligation agreed in the contract as to what should be done or not done on the plot? Give a reason for the terms				

Fc: Crops grown on each plot

Plot ID	What crops were grown on this plot this season?				Identify type of Cropping System	Which plots where left fallow this cropping season?	What factors are taken into account in making decision on what crops to grow on each plot or leaving the plot fallow? (in order of priority starting with the most important)				What major reasons did the household have for monocropping or mixed cropping? (in order of priority starting with the most important)			
	1st *Fc1*	2nd *Fc2*	3rd *Fc3*	4th *Fc4*	*Fc5*	*Fc6*	*Fc7*				*Fc8*			
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
	Crop codes 1 Maize Hybrid 2 Compost Maize (OPV) 3 Maize Local 4 Beans Dry 5 Beans Green (Zitheba) 6 Peas 7 Ground nuts 8 Tobacco 9 Cassava 10 Pigeon peas 11 Irish potato 12Sweet Potato 13Cabbage		14 Tomatoes 15 Onions 16 Lettuce 17 Rape 18 Mpiru 19Pumpkins 20 Garlic 21 Cucumber 22 rice 23Millet 24 sorgum 25 sugarcane 26 other (specify)		1= Mixed cropping 2= Monocropping 3= Intercropping	0=No 1=Yes	1= Land availability 2= Labour availability 3= Prevailing market prices 4= Seeds, fertiliser, availability 5= Meeting household basic consumption needs Credit 6= Past crop performance (in previous seasons 7=Expected rainfall patterns??? 8= Crop rotation 9=Other (specify)				1= Maximise revenue from land 2= Allow positive complementarity efects among crops (e.g. N-fixing,) 3=Save time and labour in crop management 4=To produce quality standards for exclusive for marketing 5= other			

Fer: Soil erosion and control measure

Plot id	Do you have natural trees on the plot?	How many trees are there?	Name any 3 common natural trees on the plot	Name trees that were planted on the plot *Fer2*		How much soil erosion was there on your plotthis year? *Fer3*	Do you have any soil erosion control measures on the plot? *Fer6*			Which one of the following did you apply last growing season? (Ask for each of these) *Fer7*								What is the major reason for applying conservation mesures? *Fer8*		What costs are associated with applying this technique? (MKV) *Fer9*	Indicate extra hours used by applying the different techniques in a week? *Fer10*
	Fer1a	*Fer1b*	*Fer1c*	tree	How many					1	2	3	4	5	6	7	8				
1																					
2																					
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					
11																					
12																					
	0- no 1- yes		**Write the chichewa names in the box and below the table**	0= none 1-Gmelina 2-Eucalyptus 3-Mango 4-Cacia siamea 5-Oranges		0-none 1- slight 2-moderate 3-severe	1=vertivar/ elephant grass 2=Contour bunds 3=contour ridges 4- box ridges 5- ridges 6-terraces 7- manure 8- none 9- others			1= intercrop. maize and gliricidia 2=intercrop. maize and pigeonpea 3= intercrop. maize and tephrosia vogelii (mtetegza) 4=groundnut/pigeonpea intercrop with maize 5= intercrop. Faigherbia albida with maize (Nsangu) 6= intercrop. hybrid maize and Leucaena leucocephala 7= intercrop. maize and sesbania sesban 8= other (specify)								1-improve soil quality 2-incentives given 3-advise from extesion workers 4-increase yeild 5-control soil erosion 6-Other Specify…….			

G. Input use
List crops and inputs on each plot in the past cropping season

Plot ID	Crop Code	SEEDS					PESTICIDES			FERTILISER					
	G1	Source G2	Type / Variety G3	Amount G4		Cost G5	Source G6	Type/ Name G7	Cost G8	Type/ Name G9	Source G10	Amount G11		Cost G12	Did you use subsidized fertilizer on this plot G14
				Quantity	Unit							Quantity	Unit		
1															
2															
3															
4															
5															
6															
7															
8															
		1= own 2=bought 3= received 4=coupons 5= others					1= own 2=bought 3= received 4=coupons 5= others			1=CAN 2=Urea 3=23.21 0 +4s 4=20 20 0 5 D compound 6= SA 7=others	1= own 2=bought 3= received 4=coupons 5= others				0=No 1=Yes

Gs: For households with accessed subsidized fertilizer

How many coupons were you given this year? *Gs1*	**Did you use all the coupons in buying fertilizer?** ***Gs2***	**How many bags did you buy?** ***Gs4***	**Type/ Name Of the fertilizer bought** ***Gs5***	**Amount** ***Gs6***		**Cost** ***Gs7***	**Did you sell any coupons this year?** *Gs8*	**How many coupons did you sell this year?** ***Gs9***	**For what price did you sell them (MK)**	**Did you buy any coupons this year?**	**If you bought some coupons, How many**	**At what price did you pay for the coupons (MK)** ***G10***	**method of fert. application**	
				Quan	**Unit**								**On which crops did you apply the S fertilizer** ***Gs11***	**When did you apply the fertilizer to your maize crop ?** ***Gs12***
	0=No 1=Yes		1=CAN 2=Urea 3=23.21 0 +4s 4=20 20 0 5 D compound 6= SA 7=others				**0=No 1=Yes**			**0=No 1=Yes**			Use crop code	1=when planting 2=after germina 3=at knee height 4=before tassel 5=other (specify)

Why did you fail to access subsidized fertilizer last year? ……………………………..

Gi: Input use cont

Plot ID	Crop code	Manure				Labour			
		Did you apply any manure on this plot? *G15*	What was the type of manure? *G16*	Amount of manure *G17*	*Unit*	*Did you hire any Nganyu labour to work on this plot?* G18	For how many man days did you hire the labour? *G19*	How much did you pay for the labour?	
								Cash *G20*	In kind *G21*
1									
2									
3									
4									
5									
6									
7									
8									
9									
		0=No 1=Yes	1=Compost 2=wastes 3=livestock 4=green manure 5= tobbacco stems 6=others	1= basket 2= oxcart 3=pail 4=wheeelbarrow 5=bags (50kg) 6=bags (90kg) 7= bales 8=Nkhokwe 9= lichelo (basin) 9=others		0=No 1=Yes	Number of worker times days of work		code

H. Harvest

How much did you harvest past year.

Plot ID	Crop code			Harvest 2006/2007						Indicate the state of the yield in the 5 past years.	Indicate the major reasons for the change
				1st		2nd		3rd			
	H1			***Quantity*** ***H2***	***Unit Code*** ***H3***	***Qunatity*** ***H4***	***Unit code*** ***H5***	***Quantity*** ***H6***	***Unit code*** ***H7***	*H8*	*H9*
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
	Use Crop codes			1= basket 2= oxcart 3=pail 4=wheeelbarrow 5=bags (50kg) 6=bags (90kg) 7= bales 8=Nkhokwe 9= lichelo (basin) 9=others						0= increasing 1= decreasing 2= constant	

Hs: Sales and markets

		If answer to Hs2 is YES								If answer to Hs2 is NO	
Crop code	**Did you sell your crops last season?**	**How much of the harvest was sold?**		**Name of market**	**Distance from home**	**Type of market**	**Who bought your farm produce?**	**What was the total value of money you got from the sales?**	**How are/were prices dertemined**	**Why wasn't some of their produce sold?**	
		Qty	*Units*								
Hs1	*Hs2*	*Hs3*	*Hs4* *(use codes)*	*Hs5*	*Hs6*	*Hs7*	*Hs8*	*Hs9*	*Hs10*	*Hs11*	
	0 = No 1 = Yes	1= basket 2= oxcart 3=pail 4=wheeelbarrow 5=bags (50kg) 6=bags (90kg) 7= bales 8=Nkhokwe 9= lichelo (basin) 9=others			Walking 5 Km/hrs Oxcart 4km/hr Bicycle 15km/hr	1= Farm-gate 2= Local (primary) markets 3= District Assembly markets 4= Urban markets 5 =Auction floor 6=Other (specify)	1= small scale Traders 2= NGOs 3=Other villagers 4=Wholesale buyers 5=ADMARC 6=NASFAM 7= Auction 8=Other (specify)		1= Negoitated 2=Predertemined by GoM/ADMARC 3=Set by the traders 4=Set by te farmer 5=other (specify)	1= Harvested too little 2= Prices were too low 3= Didn't know where to sell 4= There were no potential buyers 5= Other (Specify)	

H. Marketing. (For each crop that was sold, please ask)

Crop code	**What was the means of transport to the market?** ***Hs12***	**What was the cost of transport to the market?** ***Hs13***	**When did the household sell the crop?** ***Hs14***	**Why did the household opt to sell/store at that period?** ***Hs15***		**If they stored, What kind of storage mechanisms did the household use?** ***Hs16***		**How long was the produce stored in months?** ***Hs17***	**Did you incur any problems when you stored your crops for sale?** ***Hs18***		**Did you grade your produce before selling?** ***Hs19***
	1 Head load 2 Ox cart 3 Bicycle 4 Vehicle 5 Wheel barrow 6 others		1= Immediately after harvest 2= They stored and sold at later date 3=Sold some after harvets but stocked some for sale at later period 4= Other	1=Household needed an immediate source of income 2=To take advantage of prevailing high prices at the time 3=Lacked storage place/ mechanism 4= Wanted to wait for better prices after harvest season 5=Others (specify)		1=Granary (Nkhokwe) 2=In the home kept in Bags, sacks, baskets 3=Late harvest 4=pit storage 5=Other (specify)			1=Theft 2= Loss of quality 3=Destruction by pests 4= Prices never went up 5= Other (specify)		0= No 1= Yes

FO: Farmer Organisations

Do you belong to a farmer farming organisation? ***Fo1***	**What kind of organisation is it?** ***Fo2***	**If yes to FO1**					
		How long have you been a member? F03		Why did you join the organisation? Fo4	What 3 important functions does the FO carry out? Fo5		
		Years	Months				
0=No **1=Yes**	1= Farmer cooperative 2=Farmer club 3=Association 4= Other (specify)				0= Nothing 1=Helps farmers access inputs on loan 2=Markets produce for farmers 3=Provides extension advice 4=Others (specify)		

Hm. Market Information

(NOTE: If they did not sell last season you can ask with reference to the years when they sold their produce in the past)

Crop code	Where did you source information about crop prices *Hm1*			Where did you source information about potential buyers and business partners? *Hm2*			Where did you source information about crop grades required on the market before you sell? *Hm3*			Was the information you sourced received reliable? *Hm4*	Was it timely enough for you to make use of it? *Hm5*	What costs were incurred to acquire this information? *Hm6*	How did you use the information *Hm7*
	0= Nowhere 1=Relatives and friends (other farmers) 2=Government offices 3=Traders 4=NGOs 5=Companies (agro processors) 6=Extension workers 7=Radio 8=Newspapers 9=Own market research 10=Potential buyers 11=Others (specify)			0=Nowhere 1=Relatives and friends (other farmers) 2=Government offices 3=Traders 4=NGOs 5=Companies (agro processors) 6=Extension workers 7=Radio 8=Newspapers 9=Own market research 10=Potential buyers 11=Others (specify)			0= Nowhere 1=Relatives and friends (other farmers) 2=Government offices 3=Traders 4=NGOs 5=Companies (agro processors) 6=Extension workers 7=Radio 8=Newspapers 9=Own market research 10=Potential buyers 11=Others (specify)			0= No 1= Yes	0= No 1= Yes		1= To make production decisions 2= To make marketing whether to sell their produce or not 3= To make decision where to sell 4= To negotiate for better prices for their produce 5=Others (specify)

Hm8: If the information was not reliable explain why. ____

____

____

I.Livestock ownership and livestock sales in the past 12 months

Livestock code I1	How many do you have now? I2	How many were sold? I3	When were they sold? I4	At what price were they sold? I5	Why were they sold? I7	How many were slaughtered and consumed in HH? I9	How many have been received? I10	How many bought? I11	How many were stolen? I13	How many have died? I14
Cattle										
Goats										
Sheep										
Pigs										
Chickens										
Doves										
Guinea fowl										
Rabbit										
Duck										
Turkey										
Bees										
Others										
			codes							

J. Access to credit

J10 Did you apply for any loans in the past 12 months? 1=Yes 0 =No **….**
J11 If you applied, were you given? 1=Yes 0 =No **…..**
J12 If not given, state reason …………………………………………………………………………………………………….
J13 If didn't apply, why? ……………………………………………………………………………………………………..

If J10 and J 11 are 1, fill the table below

Loan No J1	What are the names of persons or institutions whom you or anyone in the household obtained a loan in the past 12 months J2	Kind of credit? 1= cash 2=Kind J3	In whose name was the loan received? J4	Who was responsible for the loan in the household? J5	What was the total amount of loan? J6	What was the main reason for obtaining the loan? J7

RS. **RECENT SHOCKS TO HOUSEHOLD WELFARE**

Over the past five years, was your household severely affected negatively by any of the following events? GO THROUGH ENTIRE LIST	Note down the three most significant shocks you experienced RS1	Did this shock cause a reduction in income, in the assets you have, or both? Rs2	extent and effect of the shock RS3	How long ago did [THIS SHOCK] occur		What did you do in response to this shock to try to regain your former welfare level (LIST UP TO 3 FROM THE LIST BELOW)		
1-Lower crop yields due to drought or floods 2-Crop disease or crop pests 3-Livestock died or were stolen 4-Large fall in sale prices for crops 5-Household business failure 6-Loss of salaried employment or 7-non-payment of salary 8-End of regular assistance, aid, or remittances from outside H H 9-Large rise in price of food 10-Birth in the household 11-Death of HH head 12-Death of working member ofhousehold 13-Illness or accident of household member 14-Death of other family member 15-Break-up of the household 16-Dwelling damaged, destroyed 17-Theft 18-Other				Years Rs4a	Months RS4b	Rs5a	Rs5b	Rs5c
		1= reduction in income 2=reduction in assets 3=both 4=nothing	1-Own HH only 2-Some other HH too 3-All HH in community			0= nothing 1-Spent cash savings 2-Sold assets(tools,.**etc)** 3-Sold farmland 4-Sold animals 5-Sold more crops 6-Worked more(including other household members including ganyu) 7-Started a new business 8-Removed children from school to work 9-Sent children to live with relatives 10-Went elsewhere to find wor for more than a month 11-Borrowed money(relatives,bank ,local money lender) 12-Received help (government,NGO,etc)		

L. **Expenditure in the household**

Which of the following items did you buy or pay for in the last month? L1	**Yes=1 No=0**	**How much did you pay for it?**	**Which of the following items did you buy or pay for in the last month? L1**	**Yes=1 No=0**	**How much did you pay for it?**
Maize (grain and flour)			Cooking oil		
Rice			Tea		
salt			Soft drinks		
soap			Beer		
Sugar			Charcoal		
Cassava tubers and flour			Paraffin or Kerosene		
Sweet potato			Public transport-bus fare,taxi fare		
Groundnuts			Beans		
Vegetables			Clothes		
Meat			Stationary items		
Fish			Books		
Eggs			School fees		
Fruits			Medicines		
Milk			Funeral costs		
Biscuits			bread		

Rodney Witman Lunduka

Rodney Witman Lunduka was born in Blantyre, Malawi, in 1973. He holds a BSc. Degree in Agriculture from the University of Malawi (1997) and a MSc. Degree in Applied Environmental Science from University of London, Imperial College at Wye, UK, (1999).

This thesis consists of an introduction and four independent papers that investigate the customary land tenure systems in Malawi and how the tenure security they provide affect households' decisions on land rental market participation, investments on land and maize production efficiency. The first paper investigates how tenure security affects land rental participation. Evidence that emerging land rental markets in Malawi have redistributed land from land-rich to land-poor households was significant. However, households residing on a woman's village of origin participate less in land rental market than households residing in man's village of origin. The second paper investigates the probability and intensity of investing in trees under secure and insecure land tenure systems. The probability of investing in trees is high in patrilocal and neolocal residence households, but low in matrilocal residence households. Although neolocal residence households are insecure, they increase their tenure security by investment, while matrilocal resident households do not have the ability to change their security. The third paper examines how farmers' resource endowment affects how much they invest in short term inputs of organic manure and inorganic fertilizers. Results show that input use are constrained by the resource endowment of the farmer, mainly livestock, labour and liquidity assets. Therefore, if a household is secure and able to accumulate resources it is able to invest more in short run. The fourth and last paper investigates differences in maize production efficiency in secure and insecure households. The results show that insecure households have lower production efficiency than secure households.

Evidence from the study suggests that the current customary tenure system does not provide enough tenure security to households living in woman's village of origin. Land reforms that do not take into account these insecurities may marginalize these insecure households.

Associate Professor Ragnar Øygard was Rodney's supervisor.

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