Multidimensionality of Land Ownership among Men and Women in Sub-Saharan Africa

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Abstract[1]

Land ownership is multidimensional, spanning various rights and decision-making roles. Although theoretical frameworks exist in categorizing bundles of property rights, in contexts characterized by a mix of formal and customary tenure systems, the lack of individual-level data on specific rights and different forms of ownership has made it difficult to empirically study bundles of land rights and how they vary across population groups, including by gender. Using nationally representative survey data that was collected on individual-level ownership and rights of agricultural land over the period of 2016-2020 in Malawi, Tanzania, and Ethiopia, we use a machine learning clustering algorithm to distinguish types of land ownership categories and break down the bundles of land rights (i.e., rights to bequeath, sell, rent, invest, and use as collateral) and/or decision-making variables that these landowners have. A multiple correspondence analysis (MCA) is used to understand how rights or decision-making variables correlate with each other, while the hierarchical clustering algorithm finds patterns and assigns landowners with similar bundles to the same cluster. The analysis then compares how the bundles of rights that empirically emerge differ from the property rights framework put forth in the theoretical literature. One key result is that rights related to the ability of transfer land is key in differentiating landowner clusters. Using the resulting clusters, our analysis further highlights cross country differences in land ownership status as well as patterns by gender.

JEL Codes: J16

Keywords: Property Rights, Agriculture Land, Sub-Saharan Africa, Gender, Machine Learning, Clustering

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1. Introduction

Land ownership has the potential to enhance individual well-being through multiple channels. This includes improving agricultural productivity; increasing access to liquidity through rent and sale; providing access to credit markets through use as collateral; as well as enhancing the wealth of future generations through bequest. Land is also associated with greater social status in many communities and bargaining power (Kishindo, 2010, Wiig 2013). These channels, however, vary widely by country context where the literature has found a number of correlations and causations of ownership to various socioeconomic measures[2].

To fully understand these channels and the implications of land reforms, examining the definition of ownership itself is needed, including profiles of different types of landowners. Much of the literature analyzing the links between land ownership and welfare tends to focus on a particular definition of ownership: whether individuals are reported as owners (either by themselves, or more commonly, by proxy), land managers, or documented owners.[3] However, in most Sub-Saharan African countries, where there are low levels of documented ownership and high prevalence of customary ownership (Chauveau et al., 2007; Chimhowu, 2019), individuals' reported ownership is expected to entail different sets of rights across localities and population groups. Slavchevska et. al. (2021) showed how different land rights, such as rights to sell, rent, or bequeath, do not necessarily overlap, and should not be used interchangeably. Having certain rights does not mean the owner automatically has the others and benefits of holding certain rights may differ as well. These patterns are often associated with gender differences in economic opportunities. Kilic et al (2021) found, in the context of Malawi, that having long-term rights to bequeath and sell land is significantly linked with investment and cash crop adoption, with especially important effects for women. Additionally, individuals who are joint owners of the same parcel may have very different decision-making roles, such crop timing and choice (Acosta et al. 2020, Twyman et al. 2015).

Land ownership is thus multidimensional—it should be conceptualized as an ownership bundle entailing certain rights (to sell, use as collateral, bequeath, etc) and decision-making power (crop timing, what crops to grow). In the context of land, reported ownership alone does not provide enough information on the type of authority the landowner has. One can find a reported landowner with limited rights versus owners with a full set of rights. A key objective of this paper is to better understand the bundles of ownership that arise in the population, through well-designed, individual-level survey data[4], which can help inform policies linking land ownership with other economic opportunities.

The idea that property ownership contains a bundle of rights has been widely acknowledged in economics (Demsetz, 1967; Alchian and Demsetz, 1973; Schaleger and Ostrom, 1992; and Sikor et al., 2017). Until

[2] Besley (1995), for example, finds a positive relationship between transfer rights and land investing activities such as tree crop planting in Ghana. Similarly, Goldstein and Udry (2008) find that less tenure security decreases the time land is left fallow, which leads to lower productivity. Ali et. al (2014) reported that a land reform in Rwanda improved land access for legally married women where they observed increased investments in land that were mainly driven by female-headed households. Wiig (2013) found that joint titling of land (both husband and wife listed in the land certification) affects women's participation in household decision-making.[2] On the other hand, other papers have also found that land reforms can exacerbate gender bias and disparity. Bhalotra et al. (2019), for example, found that reforms that allocate land to the landless increase the survival rates of boys due to men's ability to inherit the land. Almond et. al (2019) also discusses how land reforms in China contribute to the phenomenon of missing women. For other studies across countries, see also Belsey and Burgess (2000), Banerjee, Gertler, and Ghatak (2002), Deininger, Jin, Adenew, Gebre-Selassie, Nega (2006), and Yoking and Lambrecht (2019).

[3] Documented ownership refers to whether the respondent's name is on a land title.

[4] Survey data on household members' land ownership is often collected by one "most knowledgeable" member of the household. Kilic et al. (2021) discuss how this can lead to significant gender differences in land ownership and rights statistics as opposed to interviewing household members directly.

recently, we did not have the data to study land ownership from a bundle perspective at a national scale, which is particularly relevant in economies with a high dependence on agriculture. This paper makes an important contribution by leverages newly available, nationally represented data on individual landowners from Ethiopia (2018/2019), Tanzania (2018/2019), and Malawi (2016/2017), as part of the Living Standards and Measurement Study-Plus (LSMS+) program. LSMS+ supports national surveys in collecting individual-level, self-reported data on asset ownership and rights, following recent international guidelines.[5] In this paper, we focus on ownership of non-residential land, which in these country contexts is used primarily for agriculture.

A Machine Learning Clustering Algorithm to Understand Land Rights Bundles

Various aspects of land ownership are asked in the LSMS+ survey, which were structured the same (in terms of question order, wording, and implementation) across all countries. On **ownership**, respondents are asked to report on whether they own specific land parcels (reported ownership); whether they would control the proceeds if the land was sold (economic ownership); and/or whether they have a title or certificate to the land with their name (documented ownership). Individual landowners were also asked about several **rights** they may have (specifically, whether they can (1) rent, (2) bequeath, (3) sell, (4) use as collateral, and (5) improve their land). Across these different ownership and rights constructs, respondents are asked whether they have exclusive ownership and rights or hold them jointly with other individuals. Additionally, respondents were asked to identify individuals they need **permission** from before exercising their land rights and the degree of tenure security over the land. Finally, a **decision-making** variable was also asked on whether the respondent have decision-making power over planting time and crop choice.

Given the number of variables related to ownership, one encounters a high dimensionality problem, which requires improved techniques to facilitate a more convenient empirical profiling of landowners on the basis of their rights. In this paper, we use unsupervised machine learning methods that allow one to create aggregate categories of land ownership through clustering. Unsupervised machine learning algorithms are useful for analyzing data without a definite label—the true "land ownership" type or label is unknown to the researcher. We assume different ownership types consist of different bundles of land rights and decision-making variables. Categorizing landowners across multiple dimensions of rights proves to be a difficult task, manually as well as subjectively. We use hierarchical clustering as well as multiple correspondence analysis (MCA) to understand how much certain land rights variables matter in distinguishing between different land ownership categories (Abdi and Williams 2010). Once clusters of different ownership types are identified and patterns of bundles of rights variables emerge, we conduct an additional analysis that examines the profile of landowners within each cluster and across countries.

There is a growing interest in combining machine learning methods with applied and development research[6]. This paper contributes to the literature by suggesting a new way of profiling landowners and their bundles using nationally representative data. To our knowledge, we are the first to implement a clustering exercise on the multidimensionality of land ownership to categorize ownership bundles. We also contribute to the literature by having our analysis span across three Sub-Saharan African countries using nationally representative data in documenting differences in land ownership status as well as patterns of gender differences in ownership. Slavchevska et. al. (2021) does provide gender differences using three types of ownership using six nationally representative country surveys. This paper produces something similar with a wider range of rights and decision-making variables.

[5] The guidelines for UNSD can be accessed at https://unstats.un.org/edge/publications/docs/Guidelines_final.pdf . More information on LSMS+ is available at https://www.worldbank.org/en/programs/lsms/initiatives/lsms-plus .

[6] Storm, Baylis, and Heckelei (2020), Mullainathan and Spiess (2017), and see Bjorkegren and Grissen (2018) for a development policy implementation example.

Our main finding suggests that landowners can be divided into three categories: (1) owners with mostly exclusive transfer rights, (2) owners with mostly joint transfer rights, and (3) owners who claimed to not have transfer rights or only a limited number of them. We define **transfer rights** as encompassing four rights: whether individuals can rent, bequeath, sell, and use land as collateral. Multiple Correspondence Analysis takes as inputs all variables related to ownership in the LSMS+ and reveal that these rights related to transfers emerge as the key variables in distinguishing the bundles. The resulting clusters are quite robust. Similar clusters are generated when a larger or smaller set of ownership variables is used as inputs into the algorithm.

The clusters reveal that owners who have transfer rights tend to also have other decision-making and rights, emphasizing the importance of transfer rights in determining how much is included in the bundle. Documented ownership or even the ability to decide how money is used after a transfer (economic ownership) did not matter much in determining the degree of other types of rights and decision-making in our sample. This finding is consistent with Doss et al. (2014) that found that ownership measured by land titles in Uganda did not properly reflect ownership measures defined using other rights.

Lastly, descriptive statistics of the clusters reveal structural and gender differences in land ownership bundles across countries. Some countries have more "rigid" ownership structures (defined as the variation in bundles within a cluster) than others. For example, the cluster where landowners tend to not have transfer rights in Tanzania consists of 87% of owners where all four transfer rights are not held. The remaining 13% consists of bundles where typically one of the transfer rights is held jointly or exclusively. In Malawi, the landowners-parcel observations in the same cluster consists of about 60% that do not hold any transfer rights. Differences across men and women are also observed across countries. Gender differences within any given cluster are much higher in Tanzania compared to other countries. There is a stark contrast in the gender composition of clusters across matrilineal and patrilineal households in Malawi, although this is not surprising since matrilineal communities allow for land to be passed down through the female line and vice versa for patrilineal communities.

The paper is structured as follows. Section 2 of the paper provides a brief institutional background of each country before we delve into the data description in Section 3. Section 4 describes the use of multiple correspondence analysis and hierarchical clustering in the context of the question. Section 5 discusses the variation within a cluster and cross-country differences. With the resulting landowner clusters, Section 6 analyzes each clusters' overall level of ownership, decision-making, and permission status in detail when it comes to their land. Section 7 discusses further sensitivity analysis and Section 8 concludes.

2. Institutional Background and Country Context

Many countries in Sub-Saharan African face a common struggle with integrating contemporary statutory law with existing norms and customary laws (Berge et al. 2014, Ayano 2018, Dancer 2017). Governments have gone through many iterations of land reforms with policies introduced at the federal level to improve tenure security and equitable access to land. However, land ownership historically has been guided by local customary laws which may assign different set of rights for multiple people even for the same parcel of land. Customary rights are flexible and evolving[7], varying from one local setting to another, which makes them even harder to codify and track (Ayano 2018, Witten 2007). National land reforms with intentions to certify what rights are available to owners may overlook these nuances at the local level and thus may face

[7] For example, originally it was uncommon to rent or sell land in the area since land should have been transferred through lineage but due to demographic pressures, it then became more common and acknowledged by local customs. (Ayano 2018)

some resistance in its implementation. This highlights the importance of understanding how individuals themselves view ownership using representative data.

The contention between the two types of tenure systems is even more relevant when looking at gender. Significant life events such as birth, marriage, divorce, and death have impacts that are intertwined with tenure security of land. A clear example is in the inheritance customs, where the bequest of assets such as land depends on lineage: matrilineal (through the mother) or patrilineal (through the father). This further complicates land allocation which may depend on the number of children being born and their gender. Similarly, customs where women move to the husband's family home after marriage also affects how land rights are divided in her birth home as well as husband's home. Given how these norms and land rights are intertwined, it is difficult for federal law that promotes more gender equality to be adhered. (Dokken 2015; Dancer 2017; Chan et al., 2016)

In this section, we provide a brief overview of laws and customs governing the use of land across countries that provide a more nuanced view of how individuals acquire exercise rights over land and how they relate to gender differences in ownership.

2.1 Ethiopia

Compared to Tanzania and Malawi, the land tenure system in Ethiopia has two distinct characteristics: (1) individuals in Ethiopia do not have the right to sell land, and (2) certification is quite high in Ethiopia especially compared to other Sub-Saharan African countries.

Ethiopia's constitution established that the right to ownership of land belongs "exclusively to the State and the peoples of Ethiopia." The law claiming state ownership of land has its roots from the *derg* regime in 1975 in the "Proclamation to Provide for the Public Ownership of Rural Land." Given this proclamation, individuals have the right to use land allocated to them; however, they do not have the right to sell the land. Following the 1975 proclamation, previous existing ownership was nullified, and the State had the right to redistribute land. Farmers needing land for farming or pastoral as well as private investors (with payments arranged by law) are entitled to free land. Originally, a number of land redistributions were conducted to ensure equality in a number of villages but these become less common by the mid-1990s with the focus shifting to increased tenure security through certification (Witten 2007).

Starting 1996, Ethiopia pursued a land certification program which is one of the most ambitious among Sub-Saharan Countries. Using the LSMS+ land modules, we find that documented ownership in Ethiopia covers close to 80% of landowners (see Section 3) whereas land titling is much more limited in Malawi and Ethiopia. Holden, Deininger, and Ghebru (2011) discuss how the land certification program helped enhance rental land market participation. Women landowners were especially affected by the certification program. Since men tend to be the ones to cultivate land, women have less land tenure security than men in Ethiopia.

Additionally, local governments have a lot of power in determining land tenure laws as long as they are consistent with national law. This has led to variations in land tenure patterns across regions. Some regions, for example, have more restrictions on inheritance rights while other regions restrict users' ability to manage land (Crewett, Bogale, and Korf, 2008). Accounting for this regional variation is important in interpreting land rights for men and women.

2.2 Tanzania

Similar to Ethiopia, all land in Tanzania is owned by the government, although transferring land through sale is allowed. There are three land categories: General land (mostly urban land), Reserve land (used for state purposes), and Village land (Chan, et al, 2016). Village land falls under the jurisdiction of the village and can be used as communal land, reserved land (used for certain functions as defined by law), or individual/household land. The type of land in this paper would be considered village land controlled by the individual or household.

Within the statutory law, the 1999 Village Land Act also recognizes customary land rights through the Customary Right of Occupancy (Kironde 2009, Fairley 2013). These rights allow individuals to use the land and transfer them through sale and bequeath (Slavchevska et al., 2021). Despite land rights recognition either through the statutory law or customary law, registration of land is still quite rare in Tanzania (Kironde 2009). This, however, has not prevented the buying and selling of lands through informal means (Kironde 1995).

Statutory law has emphasized equal rights to land for both men and women. The state prohibits discriminatory acts that deny women land rights under customary law. Spouses also are not allowed to sell land without the consent of the other. In practice, however, discriminatory practices may still occur under customary law, and there are still substantial gender gaps in land ownership and rights (Chan et al., 2016; Slavchevska et al., 2021, Dancer 2017, Hasanbasri et al., 2021). This is consistent with our findings in later sections where we found that the ownership gap across gender in Tanzania is smaller relative to other countries; however, larger gaps in rights and decision-making across gender persists.

2.3 Malawi

Malawi has a history of contentious land reforms. Most private land has historically been held by the Malawian elites since independence, leaving smaller farmers with a restricted amount of land. An estimated 55% of small farm households had less than one hectare of land (USAID, 2010). This has motivated policy changes to address the issue of land equity. Recent reforms and programs have tried to secure more land access to small farm families such as the Community-Based Rural Land Development Programme in 2004.

Similar to the other two countries, tension exist between statutory and customary law. Malawi's 2002 National Land Policy, for example, introduced the concept of equal rights to inheritance for men and women while the status quo relied on lineage-based tenure systems in matrilineal and patrilineal regions (Berge et al. 2014, Tschirhart et al. 2018). Matrilineal and patrilineal norms dictate the land tenure system in Malawi. Northern regions in Malawi are typically patrilineal while the central and southern parts of the country are mostly matrilineal. Berge et al. (2014) discuss how the presence of these informal customs are strong and do create differences in land tenure patterns. In matrilineal regions, land is inherited by the daughter or held by the woman in the case of divorce and vice versa for patrilineal regions. Berge et al. (2014) discuss how land is rarely sold outside the family lineage, creating inequalities in land ownership; land reforms need to take these customs into consideration. Berger et al.'s study further discusses how, despite many examination in the literature of matrilineal and patrilineal systems, their relationship to land-tenure systems is understudied especially for matrilineal systems. Our paper also aims to fill in some of the gaps in the literature on how land rights differ across the two customs in Malawi.

3. LSMS+: Land Rights and Decision-Making Measures in Defining Ownership

3.1 Multidimensionality of Ownership

Three nationally representative, multi-topic household surveys supported by the LSMS+ are used in this paper: the Tanzania National Panel Survey (NPS4 2018/2019), Ethiopia Socioeconomic Survey (ESS4 2018/2019), and Malawi Integrated Household Panel Survey (IHPS 2016/2017). The LSMS+ modules on asset ownership and rights in these surveys are comparable across countries and are administered directly to all household members 18 and older on different asset classes, spanning ownership and rights to residential and non-residential land, as well as respondents' ownership over other assets including financial accounts, and mobile phones.[8] A specific emphasis of the LSMS+ asset modules was on self-reporting and interviewing respondents privately—and hence conducting interviews within the household simultaneously, when possible.[9] The Malawi survey also emphasized a gender match-up between enumerator and respondents to help in accurate reporting of more sensitive information.

This paper focuses on landowners' rights and decision-making over non-residential land parcels. A respondent is defined as the reported landowner if they answer upfront that he/she owns the parcel. A **parcel** is defined as a continuous piece of land which can have more than one parcel. Parcels were first identified and rostered through the household questionnaire and then carried forward to individual interviews. Non-residential land in these contexts is mainly used for agriculture. In Ethiopia, for example, 87% of non-residential parcels have been used in agriculture in the last 12 months[10].

One important feature of the LSMS+ questionnaires is that rights and decision-making questions were asked only to individuals who either report themselves as an owner or have use rights on the land. Malawi is the exception on use-rights, and only asked further questions to reported owners. As a result, individuals who do not have use rights or are not owners were assumed to not have rights or decision-making power on the land, as these questions were not asked to them.

Most individuals who provided answers to rights and decision-making questions were mostly owners instead of users of land. In our sample of interest for Ethiopia (agricultural land in use for the past 12 months), 35% claim to have either use rights or own the land, and 24% claim to be an owner. In Tanzania, these shares are 39% and 31%, respectively. Since the paper aims to analyze rights associated with ownership, we restrict our sample to those who report themselves as landowners. However, we will address robustness issues when including non-owners with use rights for Tanzania and Ethiopia in Section 7.

For each parcel, respondents are asked about different types of ownership (reported, economic, and documented); rights (to sell, bequeath, use as collateral, rent out, and make improvements/invest); as well as decision-making in the case of agricultural parcels.[11] A detailed list of land rights and ownership variables in the LSMS+ surveys, as well as additional decision-making variables, are presented in Table 1. All countries had the same questionnaire structure and implementation, except for Ethiopia where the right to sell was not asked because land is legally owned by the state and is prohibited to be sold. The scope of

[8] Ownership of livestock was also covered in Ethiopia.
[9] The module on land specifically covers all land owned or accessed via use rights and follows 2019 recommendations by the Food and Agricultural Organization (FAO), the World Bank, and UN Habitat. Access guidelines here.
[10] Ethiopia and Malawi looked at all non-residential land used for agriculture. Tanzania was not restricted to agricultural use only due to missing data on current use.
[11] Along with rights/ownership, respondents reported on how each parcel was acquired; identified the individuals from whom the asset was inherited or received as a gift, as applicable; and provided the current hypothetical sales value for each asset (and the construction costs specifically for the dwelling) and limited information on their knowledge of asset transactions in their communities.

rights included in the questionnaire was influenced by Schlager and Ostrom's (1992) theoretical framework which focuses, in the context of natural resources, on issues related to access, withdrawal, management, exclusion and alienation while defining a bundle of rights.

Additionally, the LSMS+ modules further asked landowners to identify whether ownership is joint or exclusive and whether permission is needed to exercise rights. Up to three household members and two non-household members can be listed who share ownership/give permission. Emphasizing that assets can be owned jointly or exclusively acknowledges that there are varying degrees of ownership which has implication on how decisions are made and bargaining power (Doss et al. 2020, Doss et al. 2011). A number of papers have discussed the effects of joint ownership and joint titling of land on welfare measures (Wiig 2013, Newman et al. 2015, Kabumbuli 2016, Agarwal 2003).

Table 1: LSMS+ Survey Questions on Rights and Decision-Making

Rights over land parcels: 1) **Sell:** Are you among the individuals who have the right to sell the land, even if you need permission or consent from someone else? 2) **Bequeath:** Are you among the individuals who have the right to bequeath the land, even if you need permission or consent from someone else? 3) **Collateral:** Are you among the individuals who have the right to use land as collateral, even if you need permission or consent from someone else? 4) **Rent:** Are you among the individuals who have the right to rent out the land, even if you need permission or consent from someone else? 5) **Improvement**: Are you among the individuals who have the right to make improvements/invest in the land, even if you need permission or consent from someone else?
Additional ownership and decision-making variables: 1) **Documented ownership**: Is your name among the names listed as owners on the document for this land? 2) **Economic ownership**: If the parcel were to be sold today, would you be among the individuals that would decide how the money would be used**?** 3) **Parcel decision-making:** Are you among the decision-makers about the parcel, regarding the timing of crop activities, crop choice, and input use?

Notes: In Ethiopia, the question on selling right was not asked. Questions were asked to individuals who report themselves as the owner or have use rights. In Malawi, questions were asked only to owners.

One could argue that these variables can already be categorized into bundles of rights depending on the question of interest. Under the Evidence and Data for Gender Equality initiative, for example, the United Nations has emphasized the concept of *SDG ownership*: having either documented ownership, right to bequest, or right to sell.[12] Under Schlanger and Ostrom's (1992) classification, on the other hand, clarifies

[12] This is related to the Sustainable Development Goals (SDGs); guidelines can be accessed at https://unstats.un.org/edge/publications/docs/Guidelines_final.pdf

rights into three categories: management, alienation, and exclusion. Management rights are related to patterns of use and ability to improve on the land. For example, decision-making and improvement rights over land in the LSMS+ survey can be classified into the management category. Exclusion rights are those related to determining who has access or the ability to transfer land, while alienation rights relate to whether the land can be sold or rented. Economic ownership from the LSMS+ survey does not fit in this standard classification; however, economic ownership is still of interest because it provides a more tangible idea of who would receive the valuation of the land when a land transfer occurs. Documented ownership, on the other hand, might increase the land's ability to be transferred or used as collateral as well as an official recognition that would improve its tenure security. Our methodology will help us analyze whether we empirically see these theoretical bundles and categorization in the data. We can contrast how these bundles compare with what the owners view as enough rights to report themselves as landowners.

3.2 What Does the Data Tell Us About Ownership?

Table 2 presents the share of landowners of non-residential land across the three countries; less than half of individuals in all three countries reported owning non-residential land. Table 2 shows that the proportion of landowners by gender ranges from 6-19% for urban areas and 29-37% for rural areas. The share of men landowners tends to be slightly higher than women. The share of households owning any land is much higher relative to the share of individuals, indicating that within a household, some individuals claim ownership while others do not. Urban areas tend to have less landowners than rural areas, yet in Malawi and Tanzania, the urban share is still sizable making up around 20% of households who own land.

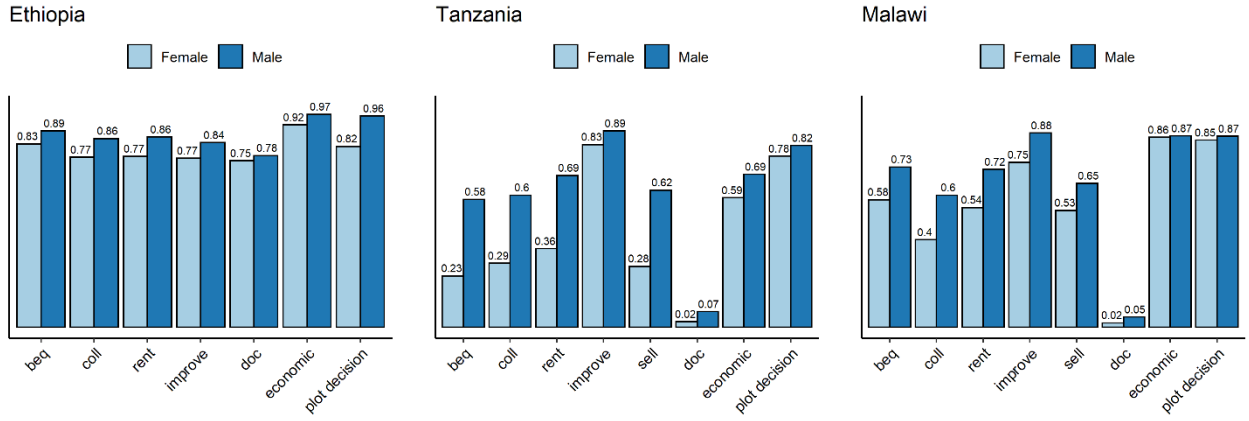
Table 2: Share of Landowners Across Countries

	Ethiopia		**Tanzania**		**Malawi**	
	Urban	Rural	Urban	Rural	Urban	Rural
Share of individual landowners						
Men	0.08*	0.33***	0.19	0.37	0.10***	0.30**
Women	0.06	0.30	0.19	0.33	0.14	0.36
Share of household with any land	0.09	0.44	0.23	0.55	0.19	0.50
# of obs (landowner + non-landowners)	8073	7315	1199	1785	1307	3428
# of obs (households)	3655	3115	502	683	649	1799

Notes: Landowners are individuals who self-report as the owner of the land. The table focuses on non-residential land only. Statistical significance of gender differences is highlighted in red.

Figures 1 and 2 illustrate that despite self-reporting as an owner, respondents often do not have full rights and decision-making power over their land parcel. Figure 1 reports the distribution of rights and decision-making variables among landowners across the three countries. Figure 2 shows the number of rights held per parcel by landowners (an individual can own multiple parcels). In Tanzania, for example, the majority of landowners (53%) do not have the right to bequeath the land, while in Malawi, 52% of landowners do not have the right to use their land as collateral. In terms of documentation, Tanzania and Malawi landowners rarely have a document certifying their ownership. In Ethiopia, as discussed earlier, documentation of ownership is much more common given the country's certification program.

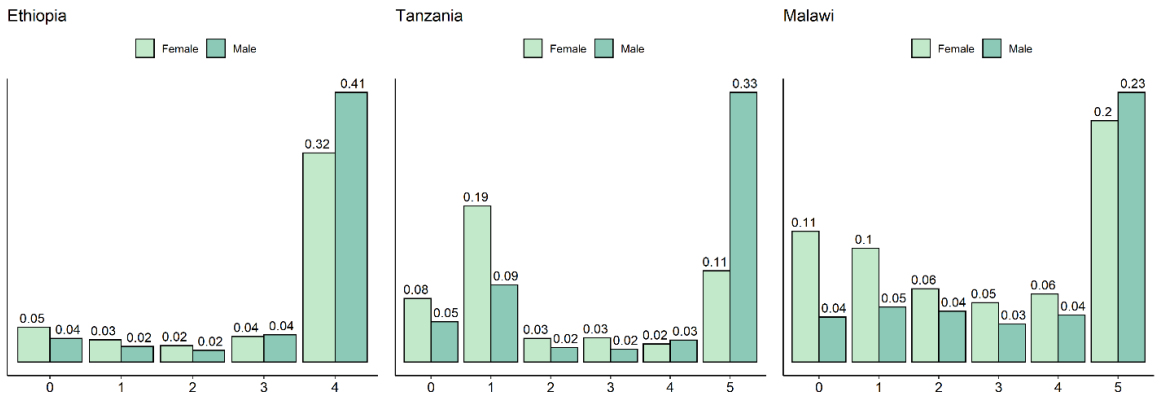
Figure 1: Distribution of Rights, Economic and Documented Ownership, and Parcel Decision-Making among Non-Residential Landowners: per Parcel



Notes: Figure illustrates proportions of landowners who hold specific rights or decision-making role for a piece of land. The unit here is an individual-parcel level observation since a landowner may own multiple parcels and have unique rights associated with the parcel. Landowners are those who self-reported as the owner of the land.

Across countries, less than half of landowners reported having all rights, with the exception of Ethiopia. Figure 2 focuses specifically on rights to bequeath, sell, rent, improve, and use as collateral and reported the numbers a landowner holds. In Ethiopia, most landowners have all four rights (right to sell is not allowed by the state) with a total of 73% of men and women. In Tanzania and Malawi, more than half of landowners do not have all rights to land. Landowners' rights over land in Ethiopia is quite distinct compared to Tanzania and Malawi. Ethiopian landowners who reported having specific land rights and decision-making are quite high, at least 75% and as high as 97% (men economic decision-making) shown in Figure 1. Gender differences among men and women are also small compared to Tanzania.

Figure 2: Share of Landowners Holding 'X' Number of Rights per Parcel



Notes: For Ethiopia, only four rights are available since landowners are not allowed to sell according to state law.

Relative to Ethiopia, gender disparities in rights and decision-making variables are quite high in Malawi and Tanzania. About 58% of men landowners claimed having rights to bequeath land, compared to 23% of

women landowners. Rights to improve land, on the other hand, are held by over 80% of men and women. Economic ownership and parcel decision-making have high proportions and less gender differences compared to other variables. In Malawi, gender differences shown could potentially be higher when separating households based on their lineage: patrilineal (mostly in northern regions) and matrilineal. More landowners are men in patrilineal marriages and vice versa. Thus, within a region, the gender differences will be much higher.

By covering different categories of ownership and rights, the LSMS+ survey modules help shed light on the multidimensionality of rights associated with a concept of ownership. The figures above highlight the difficulty of subjectively choosing which rights one should focus on, especially in Tanzania and Malawi where land variables are not equally held among landowners. Using all the variables for an analysis may not be ideal since there could be a lot of correlation between variables. On the other hand, choosing one variable as a proxy for property rights is also problematic since it is unclear what exactly one is measuring with the proxy. To achieve a more objective categorization, this paper uses a clustering exercise to find which variables differentiate landowners the most with the aim of finding an aggregate categorization of ownership.

4. Methodology

In this section, we discuss the two main methodologies used in this paper: Multiple Correspondence Analysis (MCA) and Hierarchical Clustering with Principal Components (HCPC). We provide some results using the land rights data to provide some intuition.[13]

4.1 Multiple Correspondence Analysis using Land Rights Data

Factor Analysis methods, such as Principal Component Analysis (PCA) and MCA are dimensionality reduction techniques. These methods can also be used in exploratory data analysis to identify important patterns in the data, particularly when there are a large number of correlated variables. MCA is an extension of PCA that is used when all variables are categorical with multiple levels without necessarily an order. The discussion below will focus solely on MCA given the type of data that we used, although PCA is generally more widely known.

Factor analysis methods have a long history of being used in other disciplines (Abdi and Williams 2010) and have recently been used in a number of economic studies to reduce the dimensionality of data. In labor economics, a single measure of skill can be derived using PCA when multiple types of skill variables are available (see Autor et al. (2003); Antonovics and Golan (2012)). In the macro literature, factor analysis is useful since multiple economic measures are highly correlated. Gregory and Head (1999) used dynamic factor analysis to find a single measure of common economic activity among G7 countries. Factor analysis can also be used in modelling asset returns and economic forecasting (for example Ludvigson and Ng (2009)). In the development context, PCA has been used to create a wealth index. The Demographic and Health Survey (DHS) uses PCA on data of household durables to create a single wealth index measure separately for urban and rural households. Most studies that used PCA typically assign the first principal component as the index measure that summarizes the data.

For our purposes, MCA helps in two ways. First, we are able to analyze which variables (based on their variance) distinguish different types of right bundles/profiles. Second, since MCA provides a

[13] For a more theoretical discussion on these methodologies, please refer to Abdi et al. (2007), Husson et al. (2017) and Pages (2015).

transformation of the data from categorical to continuous variables, we can use the continuous variables for the hierarchical clustering method that will categorize individuals into groups with a similar rights profile. Most common clustering methods such as hierarchical clustering and k-means clustering rely on continuous variables instead of categorical.

MCA receives an input of variables and then constructs a number of components (also known as factors or dimensions). These components correspond to the eigenvectors of the variables' correlation matrix and are ordered based on which component contains the most variance to the least.[14] Each component/dimension summarizes *x* % of the total differences in information, this is analogous to each dimension containing *x* % the total variance seen in the original data.

How does MCA calculate variance and measure dissimilarity between observations or different categories in the data? To illustrate, we provide an example using all land associated variables in the LSMS+: sell rights, bequeath rights, improvement rights, collateral right, rent right, documented ownership, parcel decision maker, and economic ownership. Each variable has three possible categories (answers): exclusively owned, jointly owned, or not owned. Let J be the number of variables (sell, rent, collateral, etc.), and K_j is the number of categories within variables J (exclusive, joint, and not hold). An individual can only hold one category for each variable (mutually exclusive). Thus, there are 21 possible categories in total. Table 3 lists some of these categories and illustrates what the data looks like for MCA. To create a measure of distance, we first assign an individual y_{ik} = 1 for each category they belong to and 0 otherwise.

Table 3: Data on rights for MCA

		Rent Right			**Bequeath Right**			**Collateral Right**			**…**
ID	Parcel ID	Exclusive owner	Joint owner	Not owned	Exclusive owner	Joint owner	Not owned	Exclusive owner	Joint owner	Not owned	
1	1	0	1	0	1	0	0	0	1	0	….
1	2	0	1	0	0	0	1	0	1	0	….
2	1	0	1	0	1	0	0	0	1	0	….
3	1	0	1	0	0	1	0	0	1	0	….
…	…	…	…	…	…	…	…	…	…	…	….
…	…	…	…	…	…	…	…	…	…	…	…..

Notes: An observation identifies a landowner for a particular parcel. There are 21 columns corresponding to 21 categories. The table lists 9 of these categories that are associated with three variables (rent, bequeath, and collateral).

One can calculate the differences between two individuals i and j as

$$d^2(i,j) = \sum_k \frac{p_k}{J}\left(x_{ik} - x_{jk}\right)^2$$

[14] In essence, one could think of the process of MCA as analogous to writing a literature review section of a paper. Suppose a researcher has taken fifteen pages of notes summarizing other research papers. Of course, fifteen pages of notes are not ideal for a literature review section. The researcher rearranges the notes, extracting the most important information to be shown in the earlier pages. After the rearrangements, only the two top pages are necessary for the literature review section. The two pages do not retain all the information in the notes, yet they retain enough necessary information that focuses on the major differences in views in the literature. In MCA, the two pages can be thought of as the first two dimensions. More dimensions can be extracted if needed.

such that $x_{ik} = \frac{y_{ik}}{p_k}$ where p_k is the proportion of individuals belonging to category k in variable j. Dividing y_{ik} with p_k allows higher weights to be given to rarer categories. $\frac{p_k}{J}$ is the weight importance of a specific category. Recall that J is the number of variables. If the number of landowners having the exclusive sell ownership category is very low, for example, this category will not matter much in calculating the difference between individuals because of the weight importance. If $d^2(i,j)$ between individual-parcel ID 1 and 3 is zero, this indicates they have the same land variable categories. On the other hand, if two individuals have a large number of categories where they differ and especially in some of the rarer categories, then the measure of distance will exhibit a very high value.

A measure of distance can also be calculated between an individual and an average individual (called the individual at the center of gravity G_I). By summing up all the distances between the individual and G_I, we have calculated the total variance or total inertia.

$$Total\ Inertia\ \left(\frac{N_I}{G_I}\right) = \sum_i p_i\, d^2(i, G_i) = \frac{K}{J} - 1$$

where p_i is the weight of an individual if available, otherwise is constant across individuals.

In our datasets, there are thousands of parcel-individual level observations. Analyzing how different these observations are with each other is not very useful. The total variance, however, can also be expressed in terms of the sum of distances between different categories, called the duality principle. The variance of category k can be written as,

$$Var(k) = \sum_i p_i \left(\frac{y_{ik}}{p_k} - 1\right)^2 = \frac{1}{p_k} - 1$$

We continue the discussion by focusing on the correlation between variables and the principal components (dimensions). The principal components are newly created variables that are a mixture of linear combinations of the original variables. The first dimension is the axis that explains the most variance in the data, followed by the second axis which is orthogonal to the first dimension, and so on. Figure 3 below shows the result of the MCA for Ethiopia using all land ownership variables. The first dimension is the x-axis and explains 28.3% of the total variance while the second dimension is the y-axis and explains 26.2% of the total variance. To understand how landowners differ in terms of their combination of rights and land ownership bundles, we need to understand which variables are contributing the most to the variance in the data.

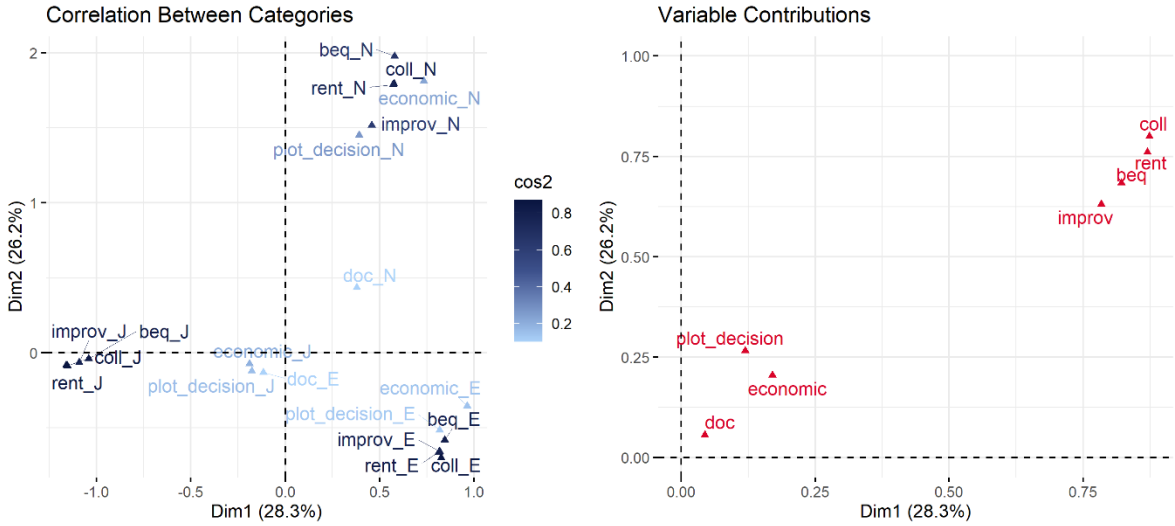
The graph on the left of Figure 3 plots the categories with respect to the first and second dimensions. Categories that are correlated with each other are closer in proximities and categories that are opposite to each other are negatively correlated. The newly created principal components are not always interpretable. In our case, however, there seems to be a clear pattern that characterizes the first and the second dimensions. The second dimension differentiates landowners by whether they own or not own most rights. Joint and exclusive categories lie below 0 in the y-axis. The x-axis then separates joint ownership and exclusive ownership. Figure 3 shows that landowners typically have either mostly joint categories, mostly exclusive categories or not own.

Figure 3 also color coded the categories based on their cosine-squared, a measure indicating the importance of a given dimension for the category. For a particular category, adding up the cosine-squared of every dimension will sum up to 1. The category “bequeath-not hold” for example has a high cosine-squared of

approximately 0.8 for dimension 1 and 2 as shown in the left graph of figure 3. This indicates "bequeath-not hold" is well represented in the first two dimensions but may not in the other dimensions. Categories related to economic ownership, parcel decision-making, and documented ownership show a lower cosine-squared for the first two dimensions.

The graph on the right of Figure 3 reports how much a variable contributes to the variance in each dimension. Rights variables (collateral, rent, bequeath, and improve) are the ones that are contributing the most to both dimensions. Since the two dimensions explain 54.5% of the variation in the data, this shows that the transfer rights variables are key drivers of this variation.

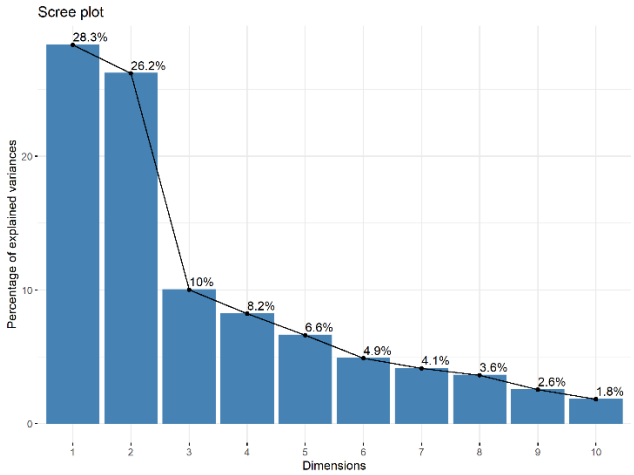
Figure 3: MCA Results for Ethiopia using All Land Ownership Variables



Notes: Sell right is not available for Ethiopia. Categories are attached to the variables: joint owner (J), exclusive owner (E), and not hold (N). The figures only describe the first two dimensions from the MCA.

We have shown that rights variables seem to matter more in distinguishing differences between landowners, or at least it can mostly explain about 54.5% of the total variance. Does parcel decision-making, economic ownership and documented ownership matter at all for explaining the rest of the variance? Upon further investigation, parcel decision-making and economic ownership do have a higher contribution to dimension 3 and 4, while documented ownership seems to mostly contribute to dimension 4 and 5. These later dimensions, however, explain a lesser portion of the total variance as seen in the scree plot in Figure 4 below. Dimension 5, for example, only explains 6.6% of the total variance and two document categories explains about 75% of this variation.

Figure 4: Ethiopia MCA All Land Variables Scree Plot



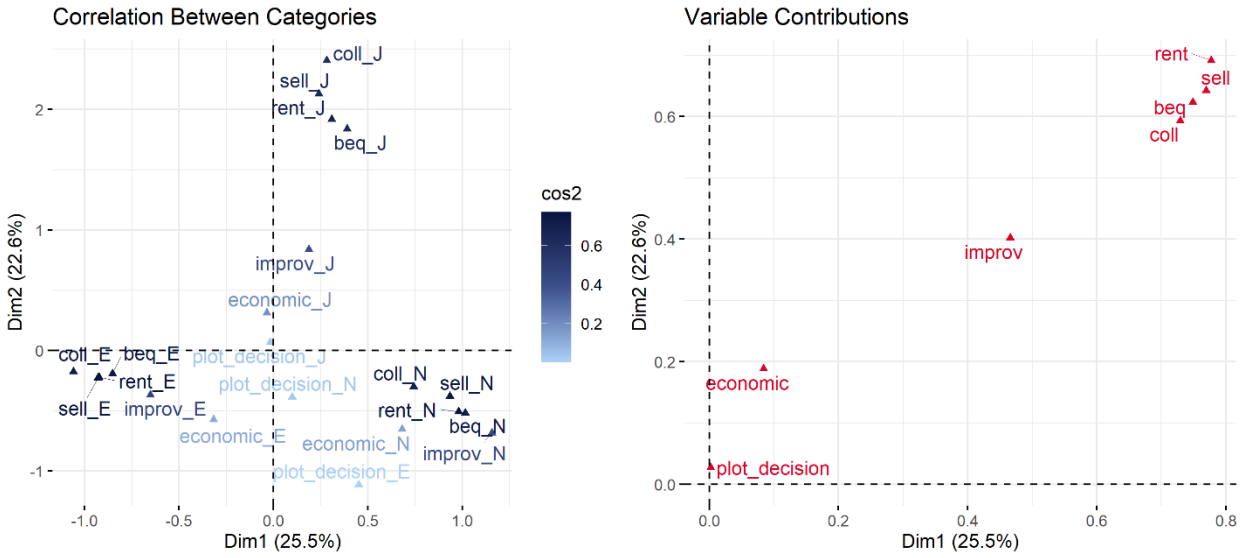
Notes: The scree plot explains the percentage variance explained by each dimension. The MCA conducted uses all land related ownership variables.

The MCA results for Ethiopia highlights a few key findings with respect to land ownership variables. First, there is a key separation between right variables (bequeath, collateral, rent, and improvement) and other types of ownership and decision-making variables (economic ownership, parcel decision-making, and documented ownership). Second, rights variables are highly correlated with each other. In the case of Ethiopia, all contribute approximately the same amount to the first two dimensions of the MCA. Having one of these rights makes you very likely to receive all of these rights jointly or exclusively.

The findings for Ethiopia are similar to findings from the MCA results for Tanzania and Malawi shown in Figure 5 and Figure 6. Documented ownership was not included in the MCA analysis since the number of observations of documented ownership were quite low in both countries.[15] The figures still exhibit the separation of rights and decision-making variables. One exception is for improvement rights. Improvement rights do not contribute as much as the other rights in both Tanzania and Malawi. Furthermore, in Tanzania, the contribution of improvement rights on the two dimensions are similar to contributions of parcel decision making and economic ownership. This suggests that improvement rights in the context of the two countries are treated more similarly to economic ownership or parcel decision-making ownership instead of similar to the other rights variables.

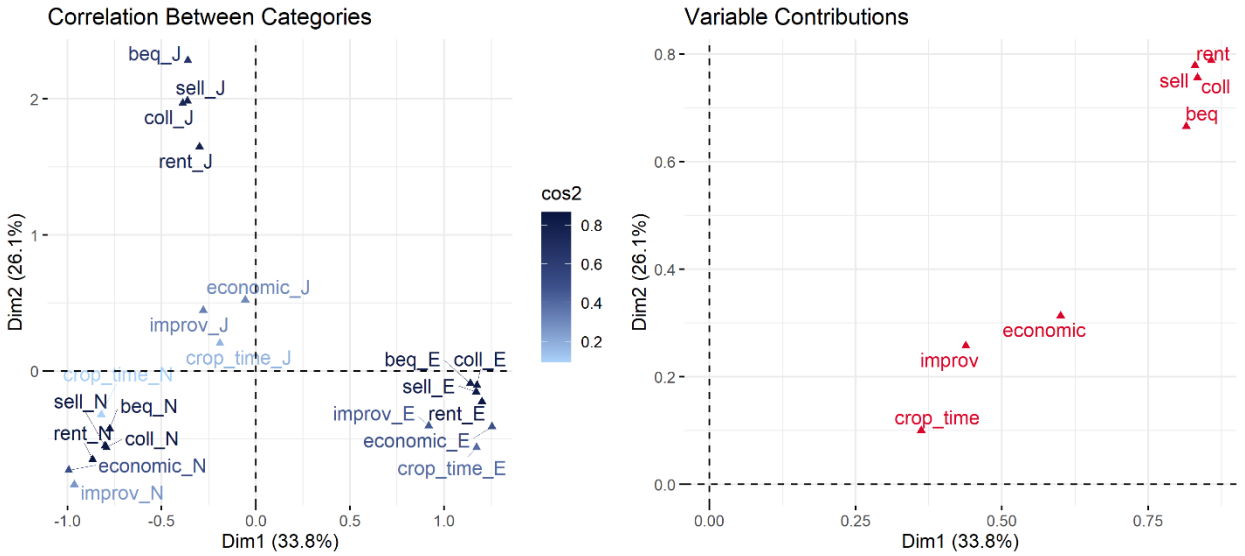
[15] MCA is quite sensitive to very low proportions.

Figure 5: MCA Results for Malawi using All Land Ownership Variables



Notes: Documented ownership was excluded from the analysis for Malawi. Categories are attached to the variables: joint owner (J), exclusive owner (E), and not hold (N). The figures only describe the first two dimensions from the MCA.

Figure 6: MCA Results for Tanzania using All Land Ownership Variables



Notes: Documented ownership was excluded from the analysis for Tanzania. Categories are attached to the variables: joint owner (J), exclusive owner (E), and not hold (N). The figures only describe the first two dimensions from the MCA.

4.2 Brief Review of Hierarchical Clustering

Using the resulting components from MCA, we are able to conduct Hierarchical Clustering on Principal Components (HCPC). Hierarchical clustering algorithm is quite intuitive and relies on grouping together

observations that are the most similar. Our measure of dissimilarity would be the Euclidean distance on the components from the MCA. The dissimilarity between landowner-parcel *i* and landowner-parcel *l* is equal to

$$d^2(i,l) = \sum_m (x_{im} - x_{lm})^2$$

where *m* is a component. Each landowner-parcel observation has value x_{im} for component *m*.

Hierarchical clustering identifies the main groupings by building a tree-like structure. We will use an agglomerative algorithm to build the tree, meaning we start from the roots up. The algorithm starts by treating all observations as a single cluster and they are put at the roots of the tree. First, find the two observations with the least Euclidean distance and connect them together side-by-side. These two then are grouped together in a new cluster. For this new cluster and all the remaining observations, recalculate the Euclidean distance again and find the two most similar groups[16]. Link these two again. The algorithm keeps repeating this step until all observations/clusters are linked. This creates a hierarchical tree. With a large number of observations, this hierarchical tree is hard to draw. We used a sample dataset shown in Table 4 to illustrate what a hierarchical tree would look like.

Table 4: Sample Landowner for HCPC Illustration

	bequeath	**collateral**	**rent**	**improvement**	**parcel decision-making**	**economic ownership**	**documented ownership**
ID 1	E	E	E	E	J	J	N
ID 2	J	J	J	J	J	J	E
ID 3	E	N	N	E	J	J	N
ID 4	E	E	E	N	J	J	E
ID 5	J	J	J	J	N	J	E
ID 6	N	N	N	E	N	J	E
ID 7	J	J	J	J	J	J	N
ID 8	E	E	E	E	J	J	E
ID 9	E	E	E	E	J	J	E
ID 10	E	N	E	N	N	N	E

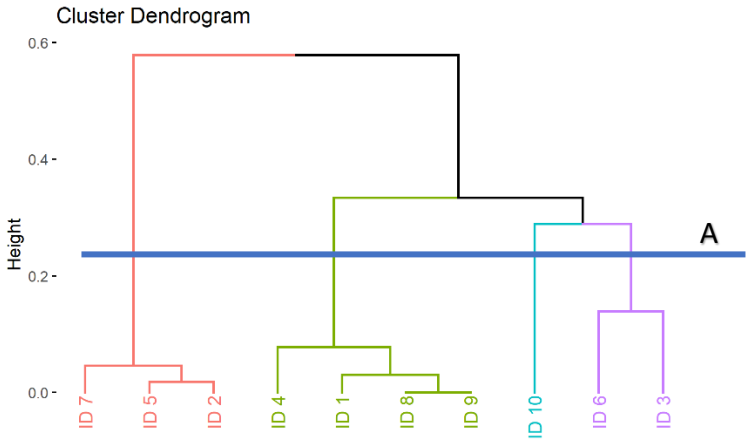
Notes: The table randomly samples 10 individuals from Ethiopia and reports the ownership status on 7 land variables. The types of ownership status are exclusive (E), joint (J), and not hold (N).

The data from Table 4 is then preprocessed into MCA in which the principal components are used for the HCPC algorithm. The resulting hierarchical tree is presented in Figure 7. The height of each tree link indicates how similar two observations/clusters are. Landowner ID 8 and ID 9 have the lowest height which means their Euclidean distance is the smallest relative of all other pairs in the beginning. In Table 2, we do see that ID 8 and ID 9 have exactly the same categories for all land variables. The second closest distance once ID 8 and ID 9 are linked, is between ID 5 and ID 2. Again, we can confirm this in Table 2 that the two

[16] For the previously new created cluster that encompasses two observation, one can use the mean of the two observation and find the Euclidian distance between this mean and the other observations.

landowners are very similar in terms of their categories. It is important to keep in mind that the clustering is done on the MCA principal components and not on the raw data in Table 4 even though the results are intuitive and consistent with the raw data.

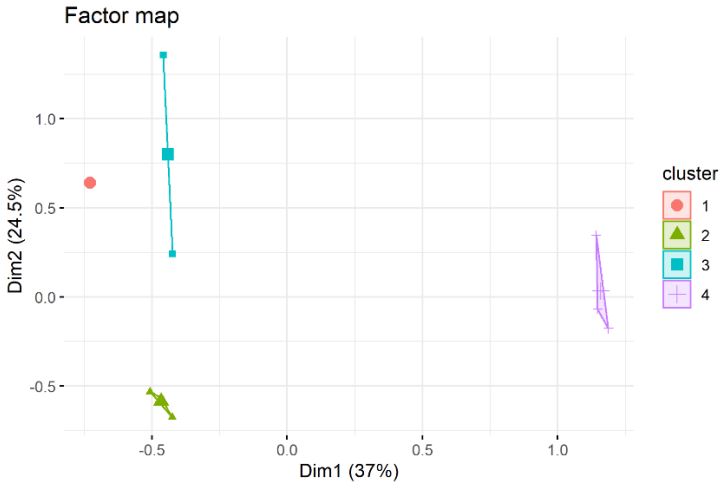
Figure 7: Hierarchical Tree (Dendrogram) Illustration of 10 Landowners



Notes: The figure shows the resulting hierarchical tree (dendrogram) from the sample Ethiopia data of 10 individuals. Line A partitions the data into four clusters.

Once a dendrogram is created, one needs to partition the tree into smaller clusters. The HCPC method chooses the highest quality partition to determine the final clusters. A good quality partition ensures the minimum variance within a cluster (landowners within a cluster are the most similar) and maximizes the variance across clusters (landowners belonging to differing clusters are very different). In the case of Figure 7, the partition was created by line A which resulted in four clusters. The first cluster contains ID 2, 5, and 7. The second cluster contains ID: 1, 4, 8, and 9. Third contains ID 3 and 6, and lastly ID 10 is its own cluster. Once can also view these clusters on the two MCA dimensions as shown in Figure 8.

Figure 8: Clustering Illustration of 10 Landowners and MCA Dimensions



Notes: The figure shows the first and second dimension of the MCA results for the 10 landowners sample and the resulting cluster from the HCPC method.

We further conduct HCPC on our entire landowner sample for the three countries. The results should not be compared with the illustrative example above since the above sample is quite limited and does not properly mirror patterns in our full datasets.

4.3 Variable Choice and Clustering Results

Previous MCA analysis using all land ownership-related variables shows that the transfer rights variables are more important in explaining the variance across landowners relative to other land variables. Because of this observation, we further restrict our specification for hierarchical clustering to use only the five rights variables (bequeath, sell, rent, improve, and use as collateral). Focusing on rights also makes the resulting cluster categories much easier to conceptualize and interpret.

As a robustness check, we compare clustering results using all land-related variables versus only rights variables. The resulting tabulation is shown in Table 5. Both methods produce nearly identical clusters with about less than 3% of individuals assigned to different clusters depending on the methods. This confirms that rights variables are what drives the algorithm in choosing the cluster categories even when other variables are fed into the algorithm. MCA results using only rights variables are consistent with MCA discussed in the previous section and are provided in the appendix.

Table 5: Clustering Results Using Different Variable Inputs (in Percentages)

Ethiopia				
	Cluster w/ All Variables			
Cluster w/ Right Variables	1	2	3	
1	33.95	0.26	0.13	
2	0.32	19.34	0.16	
3	1.26	0.63	43.95	
		Sum of Diagonal		97.24

Tanzania				
	Cluster w/ All Variables			
Cluster w/ Right Variables	1	2	3	
1	46.84	0.00	1.20	
2	0.24	17.69	0.00	
3	0.08	0.08	33.87	
		Sum of Diagonal		98.40

Malawi				
	Cluster w/ All Variables			
Cluster w/ Right Variables	1	2	3	
1	44.64	0.00	0.15	
2	0.00	14.28	0.00	
3	1.24	0.21	39.48	
		Sum of Diagonal		98.40

Notes: The table reports the cluster in which the landowner is assigned to. Those assigned in the diagonal are the proportion of landowners that were grouped to the same people in both clustering algorithms.

We further analyze different combinations of rights variables in creating clusters. Given that the MCA analysis showed that the right to make improvements on land does not show similar patterns as the other rights, one could potentially take out the right to improve from the clustering algorithm. Doing so does not change the resulting cluster categorization much. When comparing clustering results with all variables and the rights categories without improvement rights, we found that 94.17% (Malawi), 97.08% (Ethiopia), and 98.6% (Tanzania) individuals were groups in the same three clusters. This shows that similar clustering can be gained from having the 4 types of rights (collateral, bequeath, rent, and sell). These rights are ones that have to do with the right to transfer land.[17] For the rest of the paper, our preferred specification for hierarchical clustering uses the four rights (without the right to improve).

[17] Interestingly, documented ownership (in Ethiopia) did not show the similar patterns to the right to transfer variables in the MCA, nor did economic ownership, which is having the ability to decide how money is spent once the land is sold/rented. These two variables have to do with land transfers; however, the results indicate that they are separate from the rights to transfer.

In Table 6, we experiment with taking out each right one by one to see how the results change. Again, the clusters created by different combinations of rights are quite robust, mostly achieving more than 90% of individuals being grouped the same way. One exception is Ethiopia, since we only used 2 rights (sell was not available, and improvement was automatically taken out in this exercise) and the algorithm created more than 3 clusters. Fortunately, there were only 3 clusters with the most observations, which is what was counted in Table 4, but this resulted in a lower percentage of matches in Ethiopia. For Ethiopia and Tanzania, taking out collateral right from the algorithm created the least percentage of matches but still fairly large. For Malawi, taking our bequest, sell or collateral provides a similar percentage of matches.

Table 6: Clustering Results Leaving One Right Variable Out (in Percentages)

Clustering w/ 3 rights variables instead of main 4	Sum of diagonal		
	Ethiopia	**Tanzania**	**Malawi**
w/o bequest	89.66	98.64	94.23
w/o sell	Na	96.96	94.02
w/o collateral	**85.42**	**95.44**	94.18
w/o rent	86.16	97.28	96.34

Notes: Ethiopia clustering algorithms were only given two rights variables since right to sell did not exist and improvement was also excluded.

In Table 7, we compare the clustering results with right variables with the categories defined by individual rights. The most similar (high percentage in blue) are consistent with findings in Table 4 which shows collateral for Ethiopia and Malawi seems to matter more than the others relative to other rights. Sell, on the other hand, were more closely aligned to the clustering result for Malawi.

Table 7: Clustering Results Comparing with Individual Right Variables (in Percentages)

Comparing cluster using all right with individual right variable *x*	Sum of diagonal		
	Ethiopia	**Tanzania**	**Malawi**
bequest	92.66	91.27	86.96
sell	Na	**94.64**	**90.82**
collateral	**94.92**	**94.08**	85.41
rent	**94.50**	92.79	88.97
improvement	84.10	57.00	63.40

Notes: The table reports the cluster in which the landowner is assigned to. Those assigned in the diagonal are the proportion of landowners that were grouped to the same people in both clustering algorithms.

Given the results of Table 7, it might seem possible to use one right as a proxy of having all the other rights. The issue with using one right is that there are individuals who only have 1 or 2 rights and not fully all.

Using an aggregate land ownership variable from a clustering algorithm will capture this but using an individual variable as a proxy would not.

In the next section, we use the cluster categories as given and explore differences in clusters across countries and in relation to landowner characteristics. It is worth keeping in mind that the clustering results separates landowner in terms of transfer rights when interpreting results in the next section.

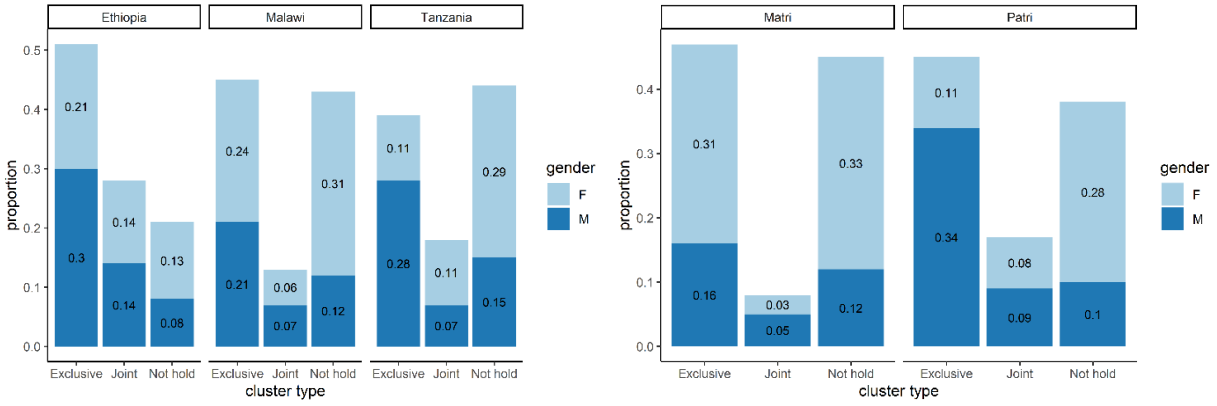
5. Cluster Distribution and Composition across Countries

Although every country has the same clustering categories (joint, exclusive, and no transfer rights), the distribution of landowners into the three clusters differ. In this section, we use the clustering result to illustrate key differences across countries in terms of their distribution of clusters as well as the variation of rights within a cluster. Variation of rights within a cluster refers to whether bundles are mostly the same, i.e., the majority of landowners in cluster A have bundle *x*, otherwise can be thought of as the "rigidity" of the cluster.

5.1 Comparison of Clusters within a Country

The most dominant type of landowner comes from the exclusive cluster, followed by the not hold cluster, and the joint cluster. Figure 9 summarizes the proportion of landowners in each cluster by gender. The exclusive cluster consists of about 40% – 50% of all landowners. It is interesting to note that despite restricting the sample to landowners only, the second largest type of landowners are those not having transfer rights on their land. Ethiopia has the least number of landowners in the "no rights" cluster, 21%. However, the numbers are much larger for Malawi and Tanzania, 42% and 44% respectively. The joint ownership landowners are rarer—13% of landowners in Malawi and as high as 28% in Ethiopia.

Figure 9: Distribution of Landowners by Clusters across Countries



Notes: The figure shows the proportion of reported owners that belong to a cluster type. For each country, the proportions add up to one. Raw sample calculations (not weighted) of landowner observations are reported.

The majority of exclusive rights are held by men, with the exception of Malawi. At a glance, Malawi's cluster distribution for exclusive rights is quite balanced. Country level statistics, however, masks differences between the matrilineal and patrilineal regions. When parsing the Malawi data into matrilineal

and patrilineal type marriages as shown on the right of Figure 9, one observes stark gender differences in the compositions of clusters. Exclusive cluster landowners in matrilineal marriages are more likely to be women (31% versus 16% for men) and vice versa for patrilineal marriages (12% versus 35% for men). In terms of the not hold cluster, the majority in both customs are female. There are more joint landowners in patrilineal marriages than in matrilineal ones. These patterns highlight the fact that even within a specific country context, rights structures still can differ depending on local customs.

Tanzania's distribution of clusters is comparable to Malawi's patrilineal region given that the latter follows similar patrilineal customs. One difference unique to Tanzania is having a larger not hold cluster compared to even the exclusive cluster. Women are more likely to be in the not hold cluster (29% of women compared to 15% of men).

Ethiopia is characterized by a high share of landowners having exclusive or joint rights and has the least gender differences across the three countries. Approximately 78% of landowners belong in the two categories, leaving only a minority who do have transfer rights to land. Ethiopia stands out relative to the other two countries because of this as well as having a smaller gender gap when compared to Tanzania and clusters by Malawi's marriage customs.

5.2 Rigidity of Rights Bundles within a Cluster

Within a cluster, variation of rights bundles is still observed. Table 8 illustrates the rights bundle that are categorized within a cluster. In Malawi, for example, the cluster in the first column contains 61.4% of observations (landowner-parcel level) that do not have the right to bequest, collateral, rent, and sell (symbolized by NNNN). Then the second most bundle type is ENNN (bequeath is exclusively held and no other rights held) with 7.06% of observations having this bundle. Table 8 thus confirms that a clear pattern emerges on how these clusters differ. The landowners in each cluster can be described as: (1) those with mostly exclusive rights, (2) those with mostly joint rights, and (3) those with mostly no rights.

Cluster bundles vary in terms of their rigidity. Variation of rights within a cluster shows how "rigid" the rights structures are. Ethiopia has the least variation in rights bundles. The majority in the "exclusive" cluster (approx. 84%) holds exclusive rights for all four rights while 88% in the "joint" cluster hold all joint rights. When one randomly chooses a parcel-landowner combination from Ethiopia who has a right to bequeath, for example, there is a high probability that this landowner will also have the other two transfer rights. For the "no rights" cluster, only 65% of observations hold no rights at all, showing less rigidity. Nevertheless, 25% of observations in this cluster have bequeath rights either exclusively or jointly despite not having the other two rights.

For Tanzania and Malawi, the "Joint" cluster has more variation of bundles: 52% of observations have all joint transfer rights in Tanzania and 36% in Malawi. The joint cluster does have fewer observations in the two countries compared to the other clusters. In Malawi, especially, those with joint rights tend to also have some exclusive or no rights in their bundles.

Given the variation of right bundles observed in the data, having a machine learning algorithm prevents researcher bias when assigning individuals to a cluster and is more efficient in doing so compared to assigning individuals manually.

Table 8: Bundles of Rights Belonging to a Cluster by Country (Agricultural Land)

Malawi

Type of rights in order: bequest, collateral, improve, rent, sell
Not Hold **(N)**, Jointly Hold **(J)**, Exclusively Hold **(E)**

Cluster 1: Mostly Not Hold		Cluster 2: Mostly Joint		Cluster 3: Mostly Exclusive	
Rights Bundle	%	Rights Bundle	%	Rights Bundle	%
NNNN	61.22	JJJJ	37.96	EEEE	75.67
ENNN	6.72	JNJN	10.7	ENEE	11.12
JNNN	5.09	JNJJ	8.2	EEJE	2.15
NNEN	4.99	EJJJ	5.35	EEEN	1.89
ENNE	4.02	JEEJ	4.43	EENE	1.63
ENEN	3.52	NNJJ	3.95	NEEE	1.58
NNNE	3.33	EEJJ	3.69	EEEJ	1.54
NNJN	2.54	JNNJ	3.52	JEEE	1.17
NNEE	1.78	JJJE	2.65	ENJE	0.98
NNNJ	1.1	JEJJ	2.5	EJEE	0.97
NJNN	1.03	JJEJ	2.3	JNEE	0.54
EENN	0.89	JEJE	2.08	ENEJ	0.33
NEEN	0.8	JNJE	1.9	EEJN	0.22
JNEN	0.78	NJJN	1.79	NEJE	0.11
ENJN	0.76	JJJN	1.74	JEEN	0.1
NENN	0.33	EJJE	1.49		
JNNE	0.32	EJEJ	1.13		
ENNJ	0.24	ENJJ	0.79		
EJNN	0.21	JJNN	0.66		
NENE	0.11	NJJJ	0.59		
NNJE	0.1	JJEN	0.41		
NEJN	0.1	EJJN	0.36		
		JJEE	0.35		
		JNEJ	0.3		
		JJNJ	0.29		
		NJJE	0.29		
		JENJ	0.29		
		NEJJ	0.28		
obs	932	obs	303	obs	914

Tanzania

Type of rights in order: bequest, collateral, improve, rent, sell
Not Hold **(N)**, Jointly Hold **(J)**, Exclusively Hold **(E)**

Cluster 1: Mostly Not Hold		Cluster 2: Mostly Joint		Cluster 3: Mostly Exclusive	
Rights Bundle	%	Rights Bundle	%	Rights Bundle	%
NNNN	87.35	JJJJ	51.35	EEEE	82.21
NNJN	4.28	NJJJ	10.91	EEJE	4.99
NNEN	1.75	NNJJ	7.71	EEEN	3.64
NNNE	1.56	NJJN	6.37	NEEE	3.13
ENNN	1.31	EJJE	6.37	ENEE	2.42
NJNN	1.25	EEJJ	4.12	NNEE	1.61
NENN	0.85	EJJJ	4.11	ENJE	0.44
NNNJ	0.62	JEJJ	3.92	ENEN	0.35
NNEJ	0.32	JEEJ	1.81	EJEE	0.35
ENNE	0.28	JJJN	1.03	NEEN	0.32
JNNN	0.20	JEJE	0.87	EEEJ	0.26
NEJN	0.16	JJEJ	0.56	NENE	0.13
NJEN	0.06	EJJN	0.48	EEJN	0.07
JNEN	0.02	JNJJ	0.20	NJEE	0.07
		NJNJ	0.14	JEEE	0.02
		JJJE	0.06		
obs	612	obs	225	obs	472

Ethiopia

Type of rights in order: bequest, collateral, improve, rent
Not Hold **(N)**, Jointly Hold **(J)**, Exclusively Hold **(E)**

Cluster 1: Mostly Not Hold		Cluster 2: Mostly Joint		Cluster 3: Mostly Exclusive	
Rights Bundle	%	Rights Bundle	%	Rights Bundle	%
NNN	65.42	JJJ	87.93	EEE	84.78
ENN	14.39	JJE	3.16	JEE	4.72
JNN	10.75	JEJ	2.12	EEN	2.96
NNE	6.12	EJJ	2.05	ENE	2.64
NNJ	1.97	JJN	1.90	NEE	1.27
NEN	0.68	NJJ	1.65	EEJ	1.27
NJN	0.67	JNJ	1.19	EJE	1.25
				JEN	0.52
				ENJ	0.23
				JNE	0.17
				EJN	0.11
				NJE	0.05
				NEJ	0.02
obs	746	obs	1,338	obs	1,844

Notes*:* The table reports rights bundle for a parcel-individual observation that is assigned into a cluster.

6. Ownership Bundles, Decision-making, and Permission Structures by Cluster

The previous section has found that transfer rights define landowner categories. Besides transfer rights, however, landowners have other types of rights, decision-making, and even permission structures that provide a fuller picture of one's authority of the land. Policy makers wanting to improve tenure security tend to focus on increasing documentation ownership which was not used in the clustering algorithm due to its low proportion in Malawi and Tanzania. Other variables of interest are economic ownership, parcel decision-making, and the right to improve land. Lastly, the ability to exercise rights with or without permission is also an important part of land ownership. Unfortunately, permission structures are not widely understood in the literature.

Table 8 to Table 10 provide descriptive summaries for each country on these other important ownership variables to further understand what bundles certain clusters have. The descriptive statistics show that transfer rights are more likely to be bundled with other ownership variables and owners are also more likely to have land security. In terms of permission structures, the tables reveal that exclusivity or jointness of transfer rights matter in exercising certain rights and decision-making. Those having exclusive transfer rights look very similar to those having joint transfer rights with respect to other decision-making variables, but their permission structures look different.

6.1 Other Ownership and Decision-making within a Cluster

One key pattern emerges in all three countries. Those having transfer rights (sell, bequeath, use as collateral, or rent), either jointly or exclusively will almost always have roles in parcel decision making, economic ownership, and having the right to improve the land. In Tanzania, for example, women in the joint and exclusive right clusters all reported having the right to improve. In all three countries, the share of joint and exclusive cluster landowners with parcel decisions power, the right to improve, and economic ownership ranges from 89% to 100%.

On the other hand, those not having transfer rights still enjoy these decision-making and management powers but to a lower extent. In some cases, there is a large gap between the cluster without transfer rights, versus the exclusive and joint clusters. Right to improve in Ethiopia, for example, is very low for non-landowners at around 27%. This is despite non-landowners having other rights such as economic ownership and parcel decision-making, 79% and 89% for men while 62% and 82%, respectively.

Some variation across countries does exist in terms of the gap between non-holders of transfer versus holders of transfers. As mentioned previously, for Ethiopia, the right to improve is a key distinction between clusters. In Tanzania, economic ownership instead is where the large gap lies between the clusters. Malawi has its own distinguished pattern. The non-transfer rights holders have the highest share of decision-making, economic ownership, and right to improve that ranges from 70% – 86%, except for the right to improve for women at only 57%.

Another important aspect of ownership is documented ownership. Documentation is more prevalent in Ethiopia than the other two countries. Share of landowner with documented ownership is low in Malawi and Tanzania and thus not really different across clusters. One exception would be the higher proportion of document rights for joint males in Tanzania. This is, however, a very low and likely selected sample. In

Ethiopia, documented ownership share is high for exclusive and joint owners, but it is not universal. Joint cluster does have the highest share of documented ownership.

Documented ownership is of interest because of its possible links with productivity, tenure security, and increased market transactions although the results in the literature have been mixed (for example see Sitko et al. 2014, Jacoby and Minten 2007). Despite having low levels of documentation, most reported landowners, however, do have tenure security in Ethiopia and Tanzania[18]. Estimation of tenure security comes from the question: on a scale from 1 to 5, where 1 is not at all likely and 5 is extremely likely, how likely are you to involuntarily lose ownership or use rights to this parcel in the next 5 years? We coded tenure security as 1 for not at all likely, and some likelihood of losing tenure is coded as 0. For Tanzania, tenure security is very high for women in both joint and exclusive clusters, 90% and 92% respectively. While men in the exclusive cluster also enjoy higher tenure security 87% compared to 73% in the joint cluster. Tenure security itself for Ethiopia does not seem to differ much across clusters, with the exception of women with mostly exclusive rights having a higher tenure security than other clusters that is statistically significant.

6.2 Permission Structure by Cluster and Cross-Country Differences

Knowledge on how permissions affect decision-making is understudied and not well understood in the literature even though permission is a key part in understanding the degree of the landowners' authority in exercising their right. We provide a description on how permission structure differs across clusters, especially in distinguishing joint versus exclusive clusters. The LSMS+ survey asks questions on whether permission is needed to exercise each right. The permission statistics at the bottom of Table 8 through Table 10 are provided for only joint and exclusive clusters since the number of individuals with rights for the not-hold clusters are limited.

There is richness in permission structures across countries. Some countries, relative to others, have a high share of landowners needing permissions. In Ethiopia, joint owners both men and women reported to always need permissions for at least one right, while 75%-84% in the exclusive cluster reported this. In Malawi and Tanzania, exclusive owners need less permissions. Those needing permissions for at least one right ranges from 31% to 33% for the exclusive cluster and 93% to 98% for the joint cluster.

Landowners in the joint cluster differ in permission structure relative to the exclusive cluster, despite being very similar in terms of having rights and decision-making. Table 8 to Table 10 does show that having transfer rights regardless of it being exclusively held or jointly held leads to the acquisition of other decision-making variables and ownerships, making the two clusters quite similar. The permission statistics, however, show how the two clusters are quite different in terms of the landowners authority in exercising the right.

Permissions are not necessarily needed for all rights. In Malawi and Tanzania, only 19% - 22% of exclusive landowners need to do so, while in Ethiopia, the numbers are much higher at 59% - 63%. The numbers are much higher for the joint clusters. Tanzania landowners, however, have the least share of joint owners needing permissions for all rights (32% for males and 51% for females). This is being driven by the gender gap in the right to improve. For other rights, the % of landowners needing permissions are in higher than 90%. The right to improve, however, requires less permission but varies by gender.

[18] Data on tenure security for Malawi was not available.

Table 9: Land Rights, Decision-Making and Permissions Variables by Cluster (Malawi)

	Male			Female		
	Malawi Landowners by Cluster			Malawi Landowners by Cluster		
	(1)	(2)	(3)	(6)	(7)	(8)
	Mostly Not Hold (base)	Mostly Joint Rights	Mostly Exclusive Rights	Mostly Not Hold (base)	Mostly Joint Rights	Mostly Exclusive Rights
Document Owner	0.04	0.06	0.07	0.03	0.02	0.02
	(0.20)	(0.23)	(0.25)	(0.17)	(0.15)	(0.15)
Plot Decision Making	0.78	0.93***	0.92***	0.86	0.90	0.90
	(0.41)	(0.26)	(0.27)	(0.35)	(0.30)	(0.30)
Economic Decision Making if Plot Sold	0.76	0.98***	0.97***	0.85	0.96***	0.96***
	(0.43)	(0.15)	(0.17)	(0.36)	(0.19)	(0.21)
Right to Improve	0.71	0.98***	0.98***	0.57	0.9***	0.98***
	(0.45)	(0.14)	(0.13)	(0.50)	(0.31)	(0.15)
Land Market Knowledge	0.41	0.59**	0.55**	0.28	0.37	0.38***
	(0.49)	(0.50)	(0.50)	(0.45)	(0.49)	(0.49)
Need permission for at least 1 right (see notes on significance)	0.60	0.83***	0.42***	0.63	0.98***	0.44***
	(0.49)	(0.38)	(0.49)	(0.48)	(0.15)	(0.50)
Need permission for some rights (at least 3 out of 5 inc. right to improve)	0.39	0.77***	0.32	0.27	0.88***	0.33
	(0.50)	(0.42)	(0.47)	(0.45)	(0.33)	(0.47)
Need permission for all rights	0.00	0.67***	0.22***	1.00	0.75***	0.22***
	(0.00)	(0.47)	(0.41)	(0.00)	(0.44)	(0.42)
Perc. of rights needing permission	0.53	0.77***	0.32***	0.55	0.87***	0.35***
	(0.47)	(0.38)	(0.42)	(0.46)	(0.24)	(0.43)
Observations	165	90	289	416	76	319

Table 10: Land Rights, Decision-Making and Permissions Variables by Cluster (Tanzania)

	Male			Female		
	Tanzania Landowners by Cluster			Tanzania Landowners by Cluster		
	(1)	(2)	(3)	(6)	(7)	(8)
	Mostly Not Hold (base)	Mostly Joint Rights	Mostly Exclusive Rights	Mostly Not Hold (base)	Mostly Joint Rights	Mostly Exclusive Rights
Document Owner	0.01	0.36**	0.1***	0.01	0.08*	0.06
	(0.10)	(0.48)	(0.30)	(0.12)	(0.28)	(0.25)
Plot Decision Making	0.77	0.95***	0.99***	0.82	0.96**	0.98**
	(0.42)	(0.22)	(0.11)	(0.38)	(0.19)	(0.14)
Economic Decision Making if Plot Sold	0.27	0.89***	1***	0.51	0.95***	0.99***
	(0.45)	(0.32)	(0.03)	(0.50)	(0.21)	(0.09)
Right to Improve	0.68	1***	0.96***	0.73	1***	1***
	(0.47)	(0.00)	(0.20)	(0.44)	(0.00)	(0.00)
Land Market Knowledge	0.57	0.65	0.58	0.31	0.42	0.28
	(0.50)	(0.48)	(0.49)	(0.46)	(0.50)	(0.45)
Tenure Security	0.46	0.73	0.87***	0.72	0.9**	0.92***
	(0.50)	(0.45)	(0.34)	(0.45)	(0.31)	(0.27)
Need permission for at least 1 right (see notes on significance)	0.29	0.95***	0.42*	0.43	0.98***	0.31
	(0.45)	(0.21)	(0.49)	(0.50)	(0.14)	(0.46)
Need permission for some rights (at least 3 out of 5 inc. right to improve)	0.02	0.93***	0.35***	0.00	0.91***	0.24***
	(0.13)	(0.25)	(0.48)	(0.02)	(0.28)	(0.43)
Need permission for all rights	0.00	0.32***	0.19***	0.00	0.51***	0.19***
	(0.00)	(0.47)	(0.39)	(0.00)	(0.50)	(0.39)
Perc. of rights needing permission	0.41	0.82***	0.34	0.55	0.92***	0.26***
	(0.49)	(0.22)	(0.44)	(0.49)	(0.18)	(0.41)
Observations	117	55	223	235	86	88

Table 11: Land Rights, Decision-Making and Permissions Variables by Cluster (Ethiopia)

	Male			Female		
	Ethiopia Landowners by Cluster			Ethiopia Landowners by Cluster		
	(1)	(2)	(3)	(6)	(7)	(8)
	Mostly Not Hold (base)	Mostly Joint Rights	Mostly Exclusive Rights	Mostly Not Hold (base)	Mostly Joint Rights	Mostly Exclusive Rights
Document Owner	0.49	0.85***	0.76***	0.55	0.86***	0.76***
	(0.50)	(0.35)	(0.43)	(0.50)	(0.35)	(0.43)
Plot Decision Making	0.79	1***	0.97***	0.62	0.89***	0.89***
	(0.41)	(0.05)	(0.16)	(0.49)	(0.31)	(0.32)
Economic Decision Making if Plot Sold	0.89	1***	0.98**	0.82	0.98***	0.96***
	(0.31)	(0.00)	(0.14)	(0.38)	(0.13)	(0.19)
Right to Improve	0.27	0.92***	0.91***	0.28	0.89***	0.91***
	(0.44)	(0.27)	(0.29)	(0.45)	(0.31)	(0.28)
Tenure Security	0.57	0.59	0.63	0.55	0.65	0.68*
	(0.50)	(0.49)	(0.48)	(0.50)	(0.48)	(0.47)
Need permission for at least 1 right (see notes on significance)	0.46	1***	0.84***	0.47	1***	0.75***
	(0.50)	(0.01)	(0.37)	(0.50)	(0.00)	(0.43)
Need permission for some rights (at least 3 out of 5 inc. right to improve)	0.14	1***	0.79***	0.12	1***	0.72***
	(0.35)	(0.01)	(0.40)	(0.33)	(0.00)	(0.45)
Need permission for all rights	0.00	0.88***	0.63***	0.00	0.85***	0.59***
	(0.00)	(0.33)	(0.48)	(0.00)	(0.36)	(0.49)
Perc. of rights needing permission	0.86	0.99***	0.78	0.92	1**	0.72***
	(0.31)	(0.06)	(0.38)	(0.23)	(0.03)	(0.43)
Observations	153	286	609	253	283	430

7. Sensitivity Analysis

7.1 Comparing Reported Owners versus Reported Users of Land

The analysis above used a sample of individuals who reported themselves as landowners. One concern is that there are individuals who do not identify themselves as owners yet are users of the land and have certain rights assigned to them as well. The resulting clusters might be incorrect if those identifying as users only have right bundles that contains variations not captured by the original clustering results.

Due to a technical error in survey implementation, rights and decision-making variables were asked to both owners and users of land in Ethiopia and Tanzania. The module was administered through a computer assistant software CAPI which automatically allowed those answering as owner or users to continue to the next question on rights. This was not the case in Malawi, where rights were asked only to those who claim to be owners as specified in the original survey design. This error, however, allows us to investigate whether including the user only group will change the categorization of bundles.

We found that the categorization of bundles is quite robust. Adding individuals who are users only to the sample of owners still lead to three cluster categories based on the rights to transfer. Owners who were thus assigned in the exclusive cluster in the original analysis, for example, will still be assigned to the same cluster after users were added.

Does the clustering result provide any information on how users and owners differ from each other? Table 12 reports the percentage of individuals in each cluster by reporting type (users or owners). In terms of similarities, users were assigned to clusters which included the owners instead of populating their own cluster category. This suggest that transfer rights and distinguishing exclusivity/jointness determine their right bundles similarly to owners. In Ethiopia, 19% of the sample are users who have mostly exclusive transfer rights, which is 58% if users. Thus, research that focuses only on reported ownership would miss out a large portion of individuals who would identify as non-owners but would still hold transfer rights of the land.

Table 12: Percentages of Users and Owners in Each Clusters

Tanzania

	Cluster Category Based on Holding Transfer Rights		
	Mostly Exclusive	Mostly Joint	Mostly Not Holding
Using but not an owner	4.6%	2.2%	16.5%
Report to own land	28.2%	13.9%	34.6%
Total number of obs.	1681		

Notes: Percentages sum to 100%.

Ethiopia

	Cluster Category Based on Holding Transfer Rights		
	Mostly Exclusive	Mostly Joint	Mostly Not Holding
Using but not an owner	19.0%	1.7%	12.3%
Report to own land	29.8%	26.0%	11.2%
Total number of obs.	6189		

Notes: Percentages sum to 100%.

In Tanzania, on the other hand, users tend to not have transfer rights which suggest that there could be other differentiation between users and owners preventing users of gaining transfer rights. A small minority of users reported to have transfer rights (4.6% exclusively and 2.2 jointly).

For both Tanzania and Malawi, users are rarely in the joint cluster in comparison to owners (only 2.2% of users in Tanzania and 1.7% in Ethiopia). One possible explanation could be that users are much less likely to be married, which is the case in Tanzania. In Ethiopia, however, approximately 80% of users are married.

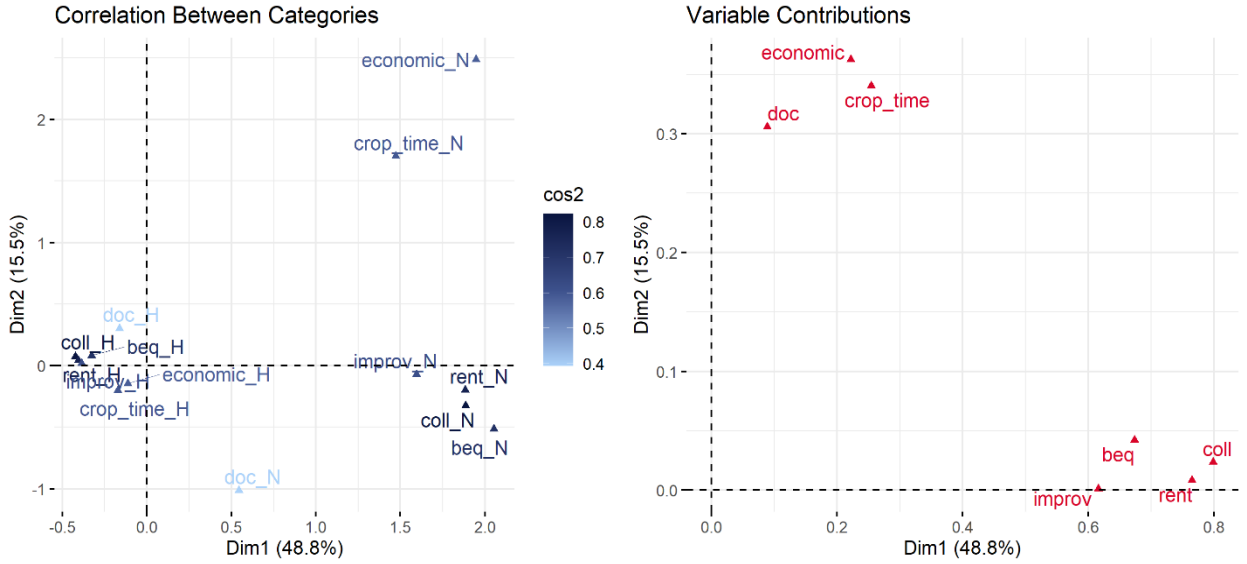
Even though the resulting cluster categories are robust, further work is still needed to investigate the differences between users and owners. One caveat of the analysis is that cluster were created based on the variables available. It is possible that users and owners differ in other right or decision-making which we do not observe in our data. Difference may also be due to subjective definition of what an owner is which could lead to individuals with the same bundle of rights to answer one versus the other. Future cognitive and qualitative studies could further help clarify how individuals respond to the ownership question of land.

7.2 Clustering using a Simpler Specification (Hold versus Not Hold)

The current approach categorizes rights and decision-making variables into exclusively held, jointly held, or not held. One could instead take a simpler approach and categorized them into hold and not hold. We conducted this exercise to see whether the results are sensitive to the chosen categorization.

The simple approach still shows that transfer rights tend to cluster together and explains a large part of the variation in the first dimension. Figure 10 demonstrates the results for Ethiopia. Similarly, Tanzania and Malawi show the same pattern as well, which confirms the importance of transfer rights in categorizing different types of landowners.

Figure 10: MCA Results for Ethiopia Simple Specification



Notes: MCA results using all variables for Ethiopia.

One might wonder, however, whether the simple approach leads to different categorization in landownership bundles. The answer is yes. By construction, the algorithm would not be able to cluster based on jointness/exclusiveness as in the original analysis and instead finds other source of variation based on the data. For example, in Ethiopia, the simple approach resulted in three clusters with the first containing 80% of landowners, second with 14% of landowners, and third with 5.5% of landowners. In comparison, using the exclusive/joint approach leads to 43%, 39%, and 17%. In the simple approach, there are some notable differences between the largest two clusters (80% + 14%= 94%) with the small 5.5% cluster.

For either approach transfer rights are still important. We acknowledge that the cluster results differ, however, we prefer the specification using exclusivity/jointness due to the following reasons. First, the idea of jointness or degrees of bargaining power within a household and how it affects decision-making has been a topic of interest within the family economics and development literature (see for example collective households model in Browning et al. 2013) and more studies have been examining the jointness of asset ownership (Doss et al. 2011, Doss et al. 2020). Thus, the exclusive/jointness approach has extra information in terms of the degree of ownership a person has. Second, the jointness category created more variation in clusters relative to the simple approach. The simple approach made it easy to emphasize one or two variables that distinguishes clusters, which for some countries resulted in smaller cluster. In the end, the

resulting clusters using the joint/exclusive approach were much more consistent across countries than with the simple approach, which made cross-country comparison much easier to do.

The simple approach still provides some interesting findings in terms of what variables in addition to transfer rights would differentiate landowners. We do provide basic descriptions of the cluster results for each country using the simple approach below for comparison.

In Ethiopia, economic ownership and transfer rights distinguishes the cluster category. By inspection, we found that every landowner in the largest two cluster has economic ownership, while the smallest cluster does not (only 5.5%). The difference between the largest (80%) and second largest cluster (14%) lies in the amount of transfer rights that they have which is consistent with our finding that transfer rights are important variable to distinguish clusters. The second largest group have less transfer rights.

For Tanzania, the algorithm created four different cluster. The largest cluster (54.8%) mostly have the transfer rights, while the other landowners with no transfer rights were divided into the other three clusters. 25% of landowners were in a cluster without parcel decision-making, 11% were in a cluster where improvement right was not held, and lastly 8.4% included landowners with both the right to improve and decision-making. Unlike Ethiopia, economic ownership was not used to separate the clusters.

Lastly, for Malawi, three clusters were also created. The first largest (53%) cluster were landowners with transfer rights. The second and third cluster did not have transfer rights but were differentiated by having the right to improve (28.9%) or not (18%).

8) Conclusion

Across agricultural developing-country contexts, individual land ownership can ease access to credit, allow for better consumption smoothing during economic volatility, as well as improve bargaining power within the household. Understanding these channels has been difficult, however, since land ownership can take on very different features across countries (reported versus being able to control proceeds from the sale of land, for example), as well as different rights that landowners may have over their parcels (these include transfer rights, across the rights to bequeath, sell, rent, and/or use as collateral). Whether ownership and rights are owned exclusively or jointly is also important. Using new, direct-respondent survey data from Living Standards and Measurement Study-Plus (LSMS+) supported surveys in Malawi, Tanzania, and Ethiopia, on different dimensions of land ownership, this paper uses a hierarchical clustering algorithm to identify three types of landowners that can be categorized by their degree of transfer rights (bequeath, sell, rent, and collateral). Reported landowners can either (a) not have any of the transfer rights, (b) owned most of them jointly, or (c) owned most of them exclusively (which also correspond to alienation rights as discussed in Schlager and Ostrom, 1992). The reliance of the clustering results on transfer rights variables are quite robust when various combinations of variables were entered into the algorithm.

We found links with these clusters on different roles respondents have over parcels. Exclusive and joint right clusters close to universally will have the right to improve as well as parcel decision making. On the other hand, the landowners with no or limited transfer rights are less likely to have crop-decision making power, economic ownership, and the rights to improve land in comparison to landowners who own transfer rights jointly or exclusively.

This paper thus paints a more nuanced portrait on what ownership bundles look like in three Sub-Saharan countries. We show that machine learning techniques using the right type of data can be useful in summarizing what ownership entails in these countries. Future research can continue to look at how these

bundles might correlate to other socio-economic measures. Acknowledging that ownership comes in a bundle will add richness to our understanding in how ownership is linked to these variables.

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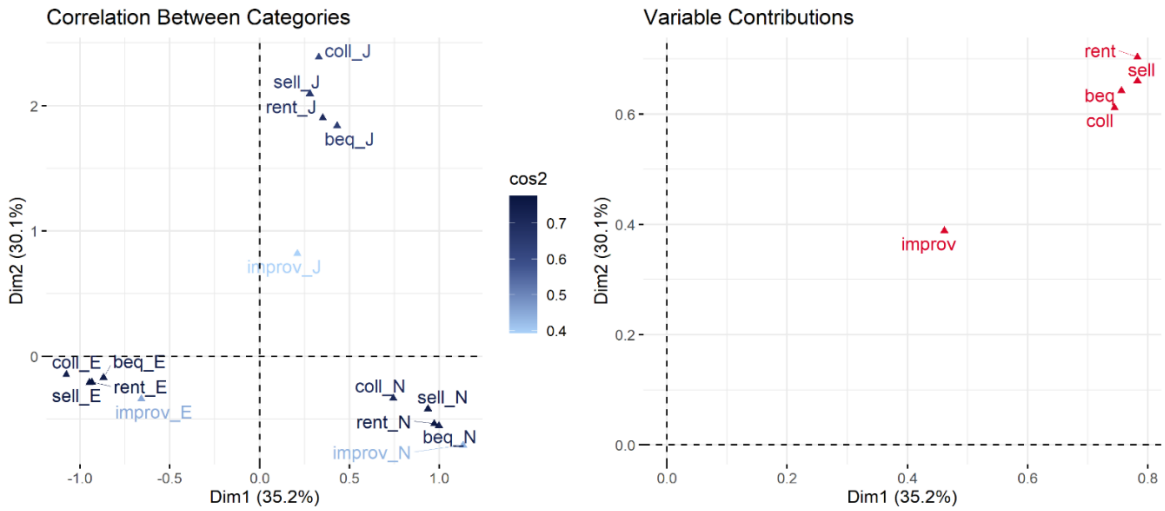
Appendix

A1) Multiple Correspondence Analysis Graphs

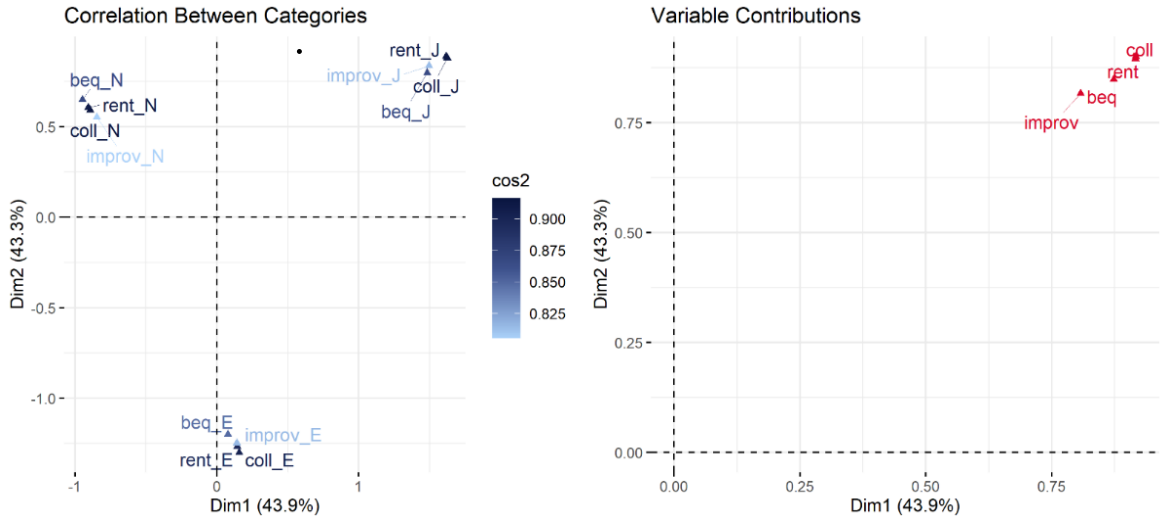
Figure A: MCA Results Using Only Rights Variables

Malawi



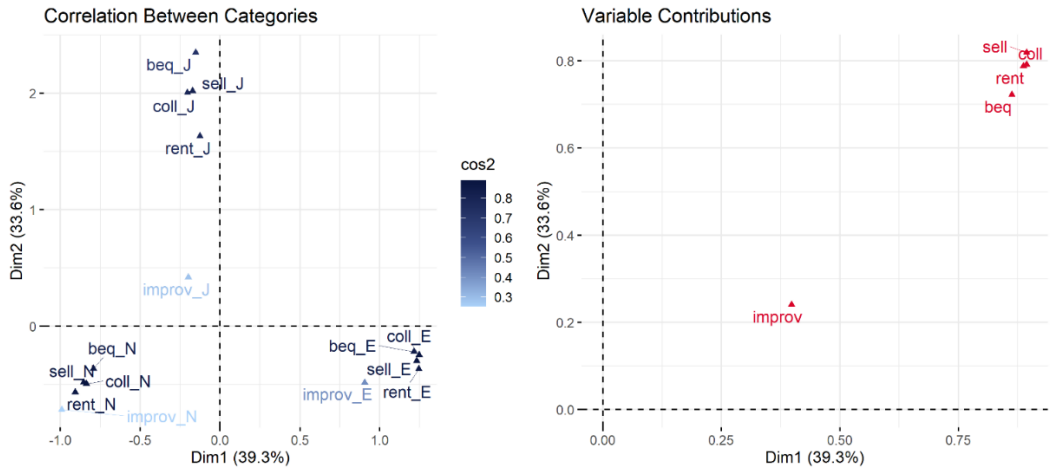
Notes: Documented ownership was excluded from the analysis for Malawi. Categories are attached to the variables: joint owner (J), exclusive owner (E), and not hold (N). The figures only describe the first two dimensions from the MCA.

Ethiopia



Notes: Documented ownership was excluded from the analysis for Tanzania. Categories are attached to the variables: joint owner (J), exclusive owner (E), and not hold (N). The figures only describe the first two dimensions from the MCA.

Tanzania



Notes: Documented ownership was excluded from the analysis for Tanzania. Categories are attached to the variables: joint owner (J), exclusive owner (E), and not hold (N). The figures only describe the first two dimensions from the MCA.

A2) Characteristics of Landowners and Non-Landowners

Table A2-1: Characteristics of Landowners and Non-Landowners in Malawi (Agricultural Land)

	Male					Female				
	Malawi Landowners by Cluster			Non-Landowners		Malawi Landowners by Cluster			Non-Landowners	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Mostly Not Hold (base)	Mostly Joint Rights	Mostly Exclusive Rights	Non-landowners in HH with land	All Non-Landowners	Mostly Not Hold (base)	Mostly Joint Rights	Mostly Exclusive Rights	Non-landowners in HH with land	All Non-Landowners
HH head	0.75	0.87*	0.98***	0.66	0.67	0.17	0.08*	0.24**	0.12	0.21
	(0.43)	(0.33)	(0.14)	(0.47)	(0.47)	(0.37)	(0.28)	(0.43)	(0.33)	(0.41)
Married	0.74	0.90**	0.97***	0.70	0.67	0.81	0.84	0.78	0.70	0.67
	(0.44)	(0.30)	(0.18)	(0.46)	(0.47)	(0.39)	(0.37)	(0.41)	(0.46)	(0.47)
Age group 18 - 24	0.28	0.08***	0.07***	0.30	0.30	0.18	0.14	0.15	0.28	0.29
	(0.45)	(0.28)	(0.26)	(0.46)	(0.46)	(0.39)	(0.35)	(0.36)	(0.45)	(0.45)
Age group 25 - 34	0.18	0.27	0.30***	0.23	0.26	0.28	0.33	0.25	0.24	0.28
	(0.38)	(0.44)	(0.46)	(0.42)	(0.44)	(0.45)	(0.47)	(0.43)	(0.43)	(0.45)
Age group 35 - 44	0.23	0.34	0.23	0.21	0.20	0.21	0.28	0.24	0.21	0.18
	(0.42)	(0.48)	(0.42)	(0.41)	(0.40)	(0.41)	(0.45)	(0.43)	(0.40)	(0.38)
Age group 45 - 54	0.14	0.17	0.18	0.12	0.11	0.13	0.12	0.17	0.11	0.11
	(0.35)	(0.38)	(0.39)	(0.33)	(0.31)	(0.34)	(0.33)	(0.37)	(0.32)	(0.31)
Age group above 55	0.17	0.14	0.21	0.15	0.13	0.19	0.13	0.20	0.16	0.15
	(0.37)	(0.35)	(0.41)	(0.35)	(0.34)	(0.40)	(0.34)	(0.40)	(0.37)	(0.35)
Have attended school	0.91	0.95	0.92	0.92	0.93	0.81	0.84	0.79	0.83	0.85
	(0.29)	(0.21)	(0.27)	(0.28)	(0.25)	(0.39)	(0.36)	(0.41)	(0.37)	(0.35)
Years of school, if attende	7.44	7.27*	6.62	7.19	8.15	5.70	6.35	5.35	6.11	6.94
	(3.88)	(3.78)	(3.61)	(3.80)	(4.04)	(3.49)	(3.44)	(3.15)	(3.84)	(4.13)
Rural	0.86	0.84	0.89	0.87	0.69	0.89	0.81	0.88	0.88	0.74
	(0.35)	(0.37)	(0.31)	(0.34)	(0.46)	(0.31)	(0.39)	(0.32)	(0.33)	(0.44)
Agri activity in last 7 Days	0.52	0.59	0.54	0.46	0.37	0.39	0.64***	0.50**	0.45	0.39
	(0.50)	(0.49)	(0.50)	(0.50)	(0.48)	(0.49)	(0.48)	(0.50)	(0.50)	(0.49)
Hours worked in agri last 7 days if worked	15.48	17.96	18.02	16.06	15.88	11.64	13.58	13.27	13.15	12.45
	(13.11)	(16.47)	(14.45)	(13.92)	(14.40)	(13.78)	(12.30)	(11.45)	(12.59)	(11.75)
Observations	165	90	289	1119	2118	416	76	319	1247	2631

Notes: This table reports descriptive statistics within a cluster as well as samples of non-landowners. Significance-levels were added to compare the base cluster (mostly not hold) with the other two clusters.

Table A2-2: Characteristics of Landowner in Tanzania (Agricultural Land)

	Male						Female					
	Tanzania Landowners by Cluster			Non-Landowners			Tanzania Landowners by Cluster			Non-Landowners		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Mostly Not Hold (base)	Mostly Joint Rights	Mostly Exclusive Rights	Have use rights but not an owner	Non-landowners in HH with land	All Non-Landowners	Mostly Not Hold (base)	Mostly Joint Rights	Mostly Exclusive Rights	Have use rights but not an owner	Non-landowners in HH with land	All Non-Landowners
HH head	0.52	0.85***	0.98***	0.74	0.60	0.64	0.10	0.03***	0.68***	0.24	0.15	0.20
	(0.50)	(0.36)	(0.15)	(0.44)	(0.49)	(0.48)	(0.31)	(0.17)	(0.47)	(0.42)	(0.36)	(0.40)
Married	0.48	0.82***	0.81***	0.24	0.19	0.18	0.67	0.77	0.28***	0.13	0.11	0.10
	(0.50)	(0.39)	(0.40)	(0.43)	(0.40)	(0.38)	(0.47)	(0.42)	(0.45)	(0.34)	(0.31)	(0.30)
Age group 18 - 24	0.30	0.12*	0.00***	0.16	0.27	0.22	0.21	0.11	0.04***	0.16	0.24	0.27
	(0.46)	(0.33)	(0.03)	(0.37)	(0.45)	(0.42)	(0.40)	(0.31)	(0.20)	(0.37)	(0.43)	(0.44)
Age group 25 - 34	0.42	0.39	0.17***	0.29	0.27	0.36	0.19	0.30	0.08	0.20	0.23	0.27
	(0.50)	(0.49)	(0.37)	(0.45)	(0.45)	(0.48)	(0.40)	(0.46)	(0.28)	(0.40)	(0.42)	(0.44)
Age group 35 - 44	0.14	0.10	0.22	0.16	0.13	0.15	0.32	0.11***	0.19	0.23	0.20	0.16
	(0.35)	(0.30)	(0.41)	(0.36)	(0.34)	(0.36)	(0.47)	(0.32)	(0.40)	(0.42)	(0.40)	(0.37)
Age group 45 - 54	0.08	0.19	0.22	0.16	0.13	0.12	0.14	0.25	0.24	0.17	0.14	0.12
	(0.27)	(0.39)	(0.41)	(0.36)	(0.34)	(0.32)	(0.35)	(0.43)	(0.43)	(0.38)	(0.34)	(0.33)
Age group above 55	0.06	0.20	0.40***	0.24	0.19	0.15	0.14	0.23	0.44***	0.24	0.19	0.18
	(0.24)	(0.41)	(0.49)	(0.43)	(0.39)	(0.36)	(0.35)	(0.42)	(0.50)	(0.43)	(0.39)	(0.38)
Have attended school	0.88	0.96	0.85	0.88	0.88	0.90	0.71	0.76	0.71	0.72	0.76	0.80
	(0.33)	(0.19)	(0.36)	(0.32)	(0.32)	(0.30)	(0.45)	(0.43)	(0.46)	(0.45)	(0.43)	(0.40)
Years of school, if attended	7.53	7.09	6.72	6.94	6.95	7.43	6.63	7.65***	6.80	6.96	7.22	7.67
	(2.71)	(2.08)	(2.30)	(2.41)	(2.43)	(2.61)	(1.83)	(1.78)	(1.93)	(1.86)	(2.13)	(2.39)
Rural	0.72	0.85	0.85	0.82	0.83	0.69	0.83	0.80	0.82	0.84	0.83	0.72
	(0.45)	(0.36)	(0.36)	(0.38)	(0.38)	(0.46)	(0.38)	(0.41)	(0.38)	(0.36)	(0.37)	(0.45)
Agri activity in last 7 Days	0.63	0.67	0.63	0.63	0.56	0.43	0.70	0.70	0.63	0.67	0.56	0.43
	(0.49)	(0.47)	(0.48)	(0.48)	(0.50)	(0.50)	(0.46)	(0.46)	(0.49)	(0.47)	(0.50)	(0.50)
Hours worked in agri last 7 days if worked	17.03	14.84	17.87	17.32	17.91	16.60	14.86	14.65	21.29	16.39	15.48	14.57
	(11.76)	(13.96)	(13.27)	(13.11)	(14.35)	(12.81)	(11.11)	(8.18)	(18.31)	(12.44)	(11.27)	(9.24)
Observations	117	55	223	495	647	1407	235	86	88	515	688	1577

Notes: This table reports descriptive statistics within a cluster. Significance-levels were added to compare the base cluster (mostly not hold) with the other two clusters.

Table A2-3: Characteristics of Landowner in Ethiopia (Agricultural Land)

	Male						Female					
	Ethiopia Landowners by Cluster			Non-Landowners			Ethiopia Landowners by Cluster			Non-Landowners		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Mostly Not Hold (base)	Mostly Joint Rights	Mostly Exclusive Rights	Have use rights but not an owner	Non-landowners in HH with land	All Non-Landowners	Mostly Not Hold (base)	Mostly Joint Rights	Mostly Exclusive Rights	Have use rights but not an owner	Non-landowners in HH with land	All Non-Landowners
HH head	0.69	0.92***	0.94***	0.85	0.65	0.66	0.10	0.05	0.31***	0.18	0.12	0.22
	(0.47)	(0.27)	(0.24)	(0.36)	(0.48)	(0.47)	(0.30)	(0.22)	(0.46)	(0.39)	(0.32)	(0.41)
Married	0.69	0.91***	0.90***	0.83	0.65	0.63	0.92	0.93	0.73***	0.81	0.70	0.62
	(0.46)	(0.28)	(0.30)	(0.37)	(0.48)	(0.48)	(0.28)	(0.26)	(0.44)	(0.39)	(0.46)	(0.48)
Age group 18 - 24	0.24	0.08***	0.06***	0.12	0.24	0.25	0.14	0.10	0.08	0.13	0.22	0.25
	(0.43)	(0.27)	(0.24)	(0.33)	(0.43)	(0.43)	(0.34)	(0.30)	(0.28)	(0.33)	(0.41)	(0.44)
Age group 25 - 34	0.29	0.21	0.20	0.23	0.23	0.28	0.42	0.30*	0.29*	0.31	0.30	0.30
	(0.46)	(0.41)	(0.40)	(0.42)	(0.42)	(0.45)	(0.49)	(0.46)	(0.46)	(0.46)	(0.46)	(0.46)
Age group 35 - 44	0.27	0.25	0.29	0.25	0.21	0.20	0.24	0.34	0.25	0.29	0.23	0.21
	(0.45)	(0.43)	(0.45)	(0.43)	(0.41)	(0.40)	(0.43)	(0.47)	(0.43)	(0.45)	(0.42)	(0.41)
Age group 45 - 54	0.12	0.17	0.18	0.17	0.13	0.12	0.12	0.12	0.17	0.14	0.12	0.11
	(0.32)	(0.38)	(0.38)	(0.37)	(0.33)	(0.33)	(0.33)	(0.32)	(0.38)	(0.35)	(0.32)	(0.31)
Age group above 55	0.07	0.29***	0.27***	0.24	0.19	0.16	0.08	0.15	0.21***	0.14	0.14	0.13
	(0.26)	(0.46)	(0.45)	(0.43)	(0.39)	(0.36)	(0.27)	(0.35)	(0.40)	(0.34)	(0.35)	(0.34)
Have attended school	0.60	0.42***	0.46*	0.48	0.49	0.58	0.30	0.17*	0.18*	0.24	0.27	0.39
	(0.49)	(0.49)	(0.50)	(0.50)	(0.50)	(0.49)	(0.46)	(0.38)	(0.39)	(0.42)	(0.44)	(0.49)
Years of school, if attendec	6.03	6.42	6.11	6.44	6.54	7.87	6.11	5.95	6.05	6.05	6.40	7.77
	(3.31)	(3.85)	(3.56)	(3.51)	(3.39)	(3.97)	(3.18)	(3.51)	(3.07)	(3.29)	(3.21)	(3.88)
Rural	0.83	0.94*	0.91	0.91	0.92	0.72	0.87	0.95	0.91	0.91	0.91	0.69
	(0.38)	(0.23)	(0.28)	(0.29)	(0.27)	(0.45)	(0.34)	(0.22)	(0.28)	(0.29)	(0.29)	(0.46)
Agri activity in last 7 Days	0.82	0.91	0.81	0.82	0.76	0.57	0.52	0.60	0.53	0.52	0.48	0.36
	(0.39)	(0.29)	(0.39)	(0.38)	(0.43)	(0.49)	(0.50)	(0.49)	(0.50)	(0.50)	(0.50)	(0.48)
Hours worked in agri last 7 days if worked	33.05	34.30	29.21	30.42	30.53	28.56	20.58	24.52	20.63	21.66	22.12	20.51
	(18.93)	(17.59)	(16.95)	(17.28)	(17.54)	(17.64)	(15.17)	(14.62)	(14.87)	(14.64)	(15.04)	(14.91)
Observations	153	286	609	1603	1557	7235	253	283	430	1502	1518	8153

Notes: This table reports descriptive statistics within a cluster. Significance-levels were added to compare the base cluster (mostly not hold) with the other two clusters.

A3) Individuals Belonging to Multiple Clusters

Since the clustering was done at an individual-parcel level analysis, we need to account for individuals who belong to multiple clusters to continue the analysis at the individual level. Approximately 7% to 8% of individuals across the three countries have multiple parcels which shows different right profiles as shown in Table A3. For Tanzania and Malawi, more than 45% of these individuals have parcels where they mostly have exclusive rights and parcels where they have mostly no rights at all. OLS regression of individual having identified with multiple clusters on household head, female, rural, age and number of parcels revealed that only number of parcels in all countries seems to be correlated with multiple clusters.

Table A3: Individuals in Multiple Clusters

	Tanzania	Malawi	Ethiopia
Individual belonging to multicluster	7.80%	8.10%	7.10%
Multicluster type:			
not hold - joint	21.21%	21.21%	29.20%
not hold - exclusive	45.76%	50.51%	35.77%
joint - exclusive	18.64%	26.26%	31.39%
all three cluster	0.00%	2.02%	3.65%

Notes: The table reports individuals who belong to multiple clusters because they may own multiple parcels with different right bundles.