What's hers isn't mine: Gender-differentiated tenure security, agricultural investments and productivity in sub-Saharan Africa

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Abstract

The present study estimates how land tenure security, measured through gender differentiated inheritance patterns, affects maize productivity, the price of agricultural land, along with soil fertility investments and annual input use in sub-Saharan Africa. We test the relationship between gender differentiated inheritance patterns and the outcomes of interest, using nationally representative data from Malawi that was collected in 2019. Inheritance patterns in the data are either matrilineal where land inheritance and ownership flows through women, or patrilineal where they flow through men. Malawi has a mixture of matrilineal and patrilineal settlement patterns across the country and we employed an exogenous instrumental variable (IV), distance from the plot to the Livingstonia Mission established in the 19th century, to identify the inheritance pattern of a particular plot. Under Malawi's settlement history, communities closer to the mission have a higher propensity to practice patrilineal inheritance in 2019. Our results indicate that male plot managers in matrilineal inheritance systems had significantly lower yields than matrilineal female plot managers and both males and female plot managers in patrilineal inheritance systems. Matrilineal male plot managers were significantly less likely to use soil fertility enhancing practices like soil erosion and water control methods, organic manure, and inter cropping maize with legumes, compared to matrilineal females and patrilineal male plot managers on average. However, matrilineal male plot managers were more likely to use these practices than were patrilineal female plot managers who were the other disadvantaged group in the analysis. These results raise a new dimension in the gender parity debate. Matrilineal plot managers can have the land they farm reclaimed by their wives clan so invest less in the land than their wives do on their plots. This disincentive translates directly into lower maize yields and has implications for sustainable agricultural intensification policies and programming in the region.

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1 Introduction

In most rural economies land is the most important factor of production that determines if households are poor and food insecure. Though sub-Saharan Africa (SSA) has historically be considered a land abundant region, this has clearly changed in recent decades (Place, 2009). Rapid population growth and climate change are increasingly rendering parts of the region unsuitable for agricultural activities (Otsuka and Place, 2015). This has placed even more emphasis on the need to increase food production through agricultural intensification and investment in land and soil fertility (Jayne et al., 2014). As such, the role of land tenure and tenure security has come into focus as it potentially plays an important role in shaping farmers incentives to invest in their land. Economic theory suggests that farm operators who have higher levels of tenure security have greater incentives to invest in the long term fertility and productivity of their land (Besley, 1995). This is because those with secure tenure stand to reap the benefits of those investments over time, compared to those who fear that their tenure claims can be contested and their land expropriated.

While enhancing investment in soil fertility and increasing agricultural productivity are becoming ever more important in SSA, the vast majority of farm land in the region continues to be cultivated under customary tenure arrangements. In customary systems land is overseen by local leaders and households are given customary user rights to it (Berge et al., 2014). These rights can be passed from parents to children but households do not hold formal titles to the land. Though the literature suggests that customary systems have historically provided households with sufficient tenure security (Tripp, 2004), rising land prices, and pressure for land have strained the ability of the customary tenure system to secure land rights for smallholder farm households (Wineman and Jayne, 2018).

One unique feature of land tenure security within SSA's customary tenure systems is the existence of gender differentiated land inheritance practices. Specifically, in areas with matrilineal inheritance practice land is passed to women, so that men can only access land for production through their sisters and mothers or through their wives when they marry (Berge et al., 2014; Kishindo, 2011). Maternal uncles hold overall control over household land, and hence husbands do not fully control the household production process in matrilineal systems (Walther, 2018). This is in complete contrast to other places where patrilineal inheritance practices dictate that land belongs to men, and husbands face limited or no competition with the extended family (Johnson, 2018). Thus it stands to reason that matrilineal practices give men limited control over land, household wealth, production capital, and therefore agriculture output. This would seem to disincentivize the men from investing in the land for both its short and long term value and productivity. However, this issue remains largely under-explored and unresolved to date.

With these considerations in mind the objective of the present study is to establish how land tenure security, which is manifested in gender-differentiated land inheritance practices affect agricultural productivity and the value of agricultural land in Malawi. In order to understand the pathways to these impacts we estimate the extent to which matrilineal practices affect the plot managers incentives to invest in plot fertility through use of longer-term soil fertility enhancing investments such as organic manure and soil erosion control. We also test whether matrilineal inheritance practices affect annual input use on the plot such as application of inorganic fertilizer and the amount of labor allocated to the plot. We compare investment behaviours of men in matrilineal inheritance systems to those of men in patrilineal systems. We also compare men's land investments to women's land investments in both inheritance systems.

Malawi makes for an excellent case study to estimate the impacts of tenure security through settlement practices on land prices, productivity, agricultural investments and input use. The country has a spatial heterogeneity in these settlement practices with primarily patrilineal land inheritance practices existing in the north, mixed inheritance systems between patrilineal and matrilineal inheritance systems existing in the central region, and matrilineal inheritance practices dominating the south. However, given migration patterns in Malawi over the past 50 years it is possible to find intra-community variation in inheritance practices. Further, Malawi passed a series of land reform acts in 2016, that were supposed to make it easier for individuals with customary tenure to obtain formal titles for their land. In theory, this could improve tenure security for men in matrilineal inheritance systems. However, it is not clear if these laws have had any tangible benefits in rural Malawi that would influence our results. We use household and plot level data from the 2019 fifth integrated household survey on agriculture IHS5 that covered the 2018/19 agricultural season. The data-set is nationally representative and interviewed 11,434 households. The unique feature of the IHS5 survey is that it asked respondents about inheritance and settlement practices at both the household and community levels, while earlier versions of the survey only asked about these practices at the community level. Having household-level data on inheritance practices within a community adds more precision to our estimated impacts. The IHS5 also collected detailed plot and household data, including input use and land investments, labor, productivity and a self assessed value of plots by the plot managers. All of this information is essential for our analysis.

In order to identify the impacts of how tenure security through settlement patterns affect the outcomes of interest in our cross-sectional analysis, we exploit an interesting facet of Malawi's historical development, following Kudo (2017). Namely, the distance from the household's community of residence in 2019 to the Livingstonia Christian Mission in the northern part of the country, along lake Malawi, was used as an instrumental variable (IV) to predict the probability of a matrilineal practice in a particular location. This is a relevant IV because prior to colonization, nearly all of the ethnic groups in Malawi practiced matrilineal inheritance. However, in the late nineteenth century the Scottish missionaries established the Livingstonia Mission in northern Malawi. They taught Christianity and Western values including that land inheritance should be patrilineal, moving from fathers to sons (Phiri, 1983). As such, the adoption of Christianity along with patrilineal inheritance practices moved from northern to southern Malawi with the missionaries.

While we would expect a clear positive relationship between matrilineal inheritance and distance to the Livingstonia mission, it is reasonable to assume that the distance itself is exogenous as an IV because the missionaries established the mission on a high plateau overlooking lake Malawi. The key reason for the mission's location was because it was free from malaria (Kudo, 2017). This decision which occurred nearly 150 years ago was unrelated to levels of agricultural productivity, land prices, investments or input use in 2019 when our data were collected. Even if there was some other agro-climatic reason for the mission being established where it was that is still relevant today, we account for this by controlling for agro-ecological zones, and adding temperature and rainfall patterns to our models.

The present article makes two main contributions to the development economics literature. First, by using nationally representative data with a unique identification strategy it provides new insights on the impact of tenure security on agricultural outcomes and investments. Fenske (2011) reviewed the existing literature and found that though there is strong theory to support a positive association between land tenure rights and investment, the empirical literature has been more mixed. Specifically, he concluded that small sample sizes, binary dependent variables, and unobserved heterogeneity have had strong effects on the results. Further, he found that relationship was more robust for certain investments, such as fallow, than others such as land improvement. He also found that using a respondent's perceived level of tenure insecurity has been a poor predictor of investment outcomes in the previous literature. Goldstein and Udry (2008) found that in Ghana individuals who held positions of power in the community had more secure tenure rights. As a result these people invested more in land fertility and obtained higher output on average than those with less power.

Other studies (Goldstein et al., 2018; Ali et al., 2014) that evaluated tenure security have used Randomized Controlled Trials (RCT) or quasi experimental methods. For example, to identify the effects of possible tenure security improvements through land demarcation pilot programs on agricultural outcomes of interest and women's empowerment. Goldstein et al. (2018) evaluated a land mapping and demarcation effort in Benin. They found that the program induced a 23-43 percent increase in long-term investment in treated plots. Women increased the likelihood of fallowing their plots and invested more to secure their other plots that were not demarcated in the program. In another study, Ali et al. (2014) identified the impact of a land demarcation program in Rwanda using a regression discontinuity design with spatial fixed effects. They found that the program induced soil fertility investment and soil conservation measures. This was particularly true for female headed households.

To our knowledge ours is the first study to estimate the impact of land inheritance structures on land productivity, land prices and land investments. Lunduka et al. (2010) estimated how inheritance and tenure systems in Malawi affected an individual's decision to rent-in or rent-out land. They found that households were more likely to rent-in land in patrilineal and less likely to rent-out land in those areas, compared to matrilineal areas. This was likely due to greater tenure of male household heads in the patrilineal areas. We build on Lunduka et al. (2010) by using nationally representative data with an exogenous IV to identify a broader set of outcomes related to soil fertility, input use, productivity and land prices.

The second contribution of this article informs the gender empowerment and land rights literature. We empirically test how different inheritance patterns (matrilineal vs patrilineal) affect both men and women's decisions to invest on their plots. There is some evidence to suggest that cultural tenure systems provide flexibility and protection of women's land rights (Tripp, 2004). However, other authors have found that in areas where women inherit land and have ownership over the land, it does not mean that they actually have control over the land (Peters, 2002). The control resides with male members of their family (often maternal uncles). Thus, under matrilineal inheritance and tenure systems, it may seem that women remain disadvantaged. Our contribution is to test this empirically, comparing productivity and investments across gender and inheritance patterns.

In doing so we contribute to the literature on the gender productivity gap in the developing world. This has been found to be particularly acute in SSA, where women contribute a significant amount of agricultural labor but experience lower land and labor productivity on their plots than do men across a number of contexts (Doss, 2014; Kilic et al., 2015; Palacios-López and López, 2015; Udry, 1996; Hill and Vigneri, 2014). In Malawi specifically, the gender productivity gap for labor has recently been found to be about 25 percent for land and 44 percent for labor (Kilic et al., 2015; Palacios-López and López, 2015). However, these studies did not differentiate the effects of gender from those of gender differentiated inheritance patterns. To our knowledge ours is the first study to do so in this context. Our analysis allows us to disaggregate the extent of the advantages and disadvantages in production and land value that males and female plot managers have in matrilineal and patrilineal systems *vis-à-vis* one another.

Briefly, the results of our study indicated that when we did not specifically differentiate gender of the plot manager from inheritance practices and considered them separately, matrilineally managed plots had significantly lower maize yields and were valued significantly lower than patrilineally managed plots on average. We also found no impact of gender by itself on maize yields and only a 7.8 percent reduction in average land price on female managed plots compared to male managed plots. However, when we disaggregated gender from inheritance we found that average maize yields were 80 percent higher on plots managed by females in matrilineal inheritance systems than they were on plots managed by males in the same inheritance system. Furthermore, yields on plots managed by men in patrilineal inheritance systems were 160 percent higher than they were on plots managed by their male counterparts in matrilineal systems on average, and males in matrilineal systems even had maize yields that were 66 percent lower than they were on plots managed by females in patrilineal systems, who would generally be thought to be the other more disadvantaged of the four groups. In addition, male plot managers in matrillineal systems were significantly less likely to use soil fertility enhancing practices like soil erosion and water control methods, organic manure, and inter cropping maize with legumes, compared to matrilineal females and patrilineal males on average. However, matrilineal males were more likely to use these practices than were patrilineal females. Overall, these results raise the important issue that sustainable agricultural intensification policies and programming in sub-Saharan Africa need to recognise the nuanced gender and inheritance norms and practices in the region.

The remainder of the article is organized as follows. In the next section we present the background for our study setting, before discussing the conceptual framework for the issues addressed in the study. This is followed by the methodology, including empirical specification and identification strategy. Next we discuss the data used in the analysis, followed by results and conclusions.

2 Background

2.1 Land tenure and inheritance in Malawi

As mentioned in the introduction, Malawi is characterized by having both Matrilineal and Patrilineal inheritance practices in the country's traditional tenure system. Matrilineal marriage customs require that bridegrooms move into the natal village of their brides, which is called matrilocal settlement (Berge et al., 2014). In this system, familial wealth including land, is passed through women, such that married men are only able to use land that their wives inherit from their clan (Kishindo, 2011). In cases where a Matrilineal man decides to stay in his natal villages after he marries, for instance because he is a chief, he still does not own land, and must use his sisters' and mothers' land (Peters, 2010). Even in instances where upon marriage, matrilineal couples stay in a neutral location, called neolocal settlement, girls are preferred heirs of land among children born in the family (Zuka, 2019). This is to ensure the land remains within the clan, since matrilineal girls remain in their natal community when they come of age and marry (Zuka, 2019).

Matrilineal customs governing marital dissolution do not favor men. For example, even though Matrilineal husbands contribute to building a family in a foreign village Matrilineal inheritance practices dictate that children and familial wealth belong to women and her clan (Van Donge and Pherani, 1999; Mwale et al., 2020; Walther, 2017). In cases of death of their wives or divorce, Matrilineal men must return to their natal homes *empty-handed* (Kishindo, 2011). Marital dissolution is therefore a favourable outside option for matrilineal women, but not their husbands. This is supported by evidence of high divorce cases, brought on by women in matrilineal inheritance systems (Johnson, 2018). This is further reason why matrilineal men my be reluctant to invest in their land.

Furthermore, although matrilineal land belongs to women, ownership of land should not be confused with control. It is in fact the clan leader, called -*Mwinimbumba* who is a member of the wives extended family that makes most decisions including distribution of user rights for the land. He is consulted when anyone wishes to rent-out or sell land within the clan, and also presides over marriages (Kishindo, 2000, 2011). In addition, the *Mwinimbumba* can demand departure of a husband whom he deems a liability to his clan (Phiri, 1983). Aware of their potential precarious position, matrilineal men could therefore be less inclined to invest in familial land than their patrilineal male counterparts who do not face any of these limitations.

The patrilineal inheritance systems, is essentially the complete opposite of the matrilineal system. In patrilineal systems, only men are heirs to family wealth including land. Thus, patrilineal men face limited or no competition with the extended family, as women in this system move into the natal village of the husband, called patrilocal settlement(Johnson, 2018). In cases of divorce in Patrilineal systems, women are required to return to their natal village, leaving their children and the land they have farmed with their former husband. Therefore, patrilineal men more fully control the household land assets which would be expected to also translate into their production decisions (Walther, 2017). At the same time women in Patrilineal inheritance systems may be less empowered to make productive decisions on the plots that they farm compared to women in Matrilineal inheritance systems. The extent to which this is the case is an empirical question.

2.2 Gender productivity gap in Malawi

There may be a productivity gap stemming from different land inheritance and ownership practices in Malawi, but the country also has a notable productivity gap between men and women. The gender productivity gap highlights the stylized fact that in many parts of SSA, women often obtain significantly lower agricultural yields than do men, even with men in their own households (Doss, 2014; Kilic et al., 2015; Palacios-López and López, 2015; Palacios-Lopez et al., 2017; Udry, 1996; Hill and Vigneri, 2014). Men are the head of household in Malawi as in many other parts of SSA, so they make decisions that affect the household, even in areas with Matrilineal settlement practices Djurfeldt et al. (2018). Specifically for Malawi, Palacios-López and López (2015) used the 2011 LSMS data and found that the gender productivity for labor was 44 percent lower on female managed plots than on male managed plots on average, while gender productivity for land was 24 percent lower on female plots than male plots on average. Furthermore, Kilic et al. (2015) found that land productivity was 25 percent lower on female managed plots in Malawi on average than it was on male managed plots. In addition, they found that 82 percent of the productivity gap was due to differences in observable inputs, for example men more often cultivated high-value crops and male-managed plots received more labor than did female-managed plots on average. Based on this evidence there could be some off-setting effects where the disadvantages of being a man in Matrilineal inheritance patterns are offset by the benefits of being a man in Malawi. To our knowledge no study has considered the gender productivity gap along with land tenure through gender-differentiated inheritance practices. The extent to which each of these factors affect productivity and land values is an important empirical question that we model and estimate in the subsequent sections of this article.

Another important point for this analysis is that men and women also almost always manage separate plots in Malawi. This is the case, even though they often supply labor on each others plots. For example Palacios-López and López (2015) Found that only 1.8 percent of plots in their nationally representative sample of smallholder farmers were managed jointly by men and women. This is the case in both Patrilineal and Matrilineal areas where men cultivate, but do not own the land that they farm. It also likely translates into the decisions they make surrounding their production practices (Walther, 2018). This has implications for productivity and land values in communities with different inheritance practices.

3 Conceptual Framework

This section discusses how we conceptualize the impact of both tenure security materialized through inheritance practices and gender productivity differences between men and women on agricultural land value and productivity. We start by considering the possible investments that men are willing to make in their farms, conditional on the land inheritance practices they face.

As mentioned previously, men are the heads of household in Malawian culture and thus we would expect them to enjoy productivity advantages over women on the plots they manage, such as requiring work on their plots from other family members. Conversely, because matrilineal inheritance customs give men limited control over household land, matrilineal men are presumably less interested in investing in familial land (Walther, 2018). This potential reduced investment could occur through adjusting crop selection, changing fertilizer usage, reducing organic manure application and neglecting erosion control methods. These actions would affect soil fertility in both the short-run and long-run, through degradation of land, leading to lower productivity and value. The case should be opposite for patrilineal men, who are both heads of household and have full control over their familial wealth and agricultural production. Thus we would expect patrilineal males' plots to be more productive and valuable than those cultivated by patrilineal women.

The other related issue of interest is how the incentives to invest in land compare between Matrilineal male plot managers and Matrilineal female plot managers. This makes for an interesting comparison because as discussed above, women inherit land in Matrilineal systems and men do not. As such, it would seem that Matrilineal female plot managers would have more incentives to invest in their plots than would Matrilineal male plot managers. However, this incentive could be offset by the gender productivity advantage that favours Malawian men, keeping all other factors constant. Conversely, in Patrilineal systems we would expect female plot managers to be disadvantaged compared to male plot managers due to both their gender and the local inheritance customs. As such, We model how gender and inheritance affect productivity as follows:

$$Y = f(I(G), G, X) \tag{1}$$

where Y denotes the productivity of a particular plot as a function of the plot manager's inheritance practices of the household, denoted by I, being either Matrilineal or Patrilineal, the plot manager's gender, G, and a vector of other factors denoted by X. In equation 1, gender effects Y directly, through gender differentiated productivity, and through inheritance as men and women have different levels of tenure security and investment incentives depending on the type of inheritance that they practice.

$$Y_{ij} = \beta(I_j(G_{ij})) + \alpha G_{ij} \tag{2}$$

Equation 2 presents the relationship shown in equation 1 in linear form where we show productivity on the plot managed by an individual with gender i, and inheritance practice j. Here β represents the size of the gender differentiated inheritance impact on productivity, while α represents the magnitude of the direct gender differentiated effect on productivity. We hypothesize that the impact of gender and inheritance for the four types of gender-inheritance combination to effect productivity in the following ways. First, in Patrilineal inheritance systems we would expect male managed plots to have a higher level of productivity compared to female managed plots, because of the standard male productivity advantage and the fact that men own land in that system. As such, for Patrilineal men we would expect $\alpha > 0$ and $\beta > 0$, while for patrilineal women we would expect $\alpha < 0$, $\beta < 0$. Though the expectations of the productivity effect in the patrilineal inheritance system are fairly straight forward, the expectations of productivity effects between men and women in matrilineal systems are ambiguous. For example, men are heads of households in matrilineal systems and still may enjoy a gendered productivity advantage from being a man, such as requiring more familial labor to work on male controlled plots. However, women own the land in matrilineal systems so this advantage from being a man could be offset by the land tenure insecurity that the man faces in matrilineal systems. Therefore, for matrilineal men we would expect $\alpha > 0$, $\beta < 0$, while for matrilineal women we would expect $\alpha < 0$, $\beta > 0$. Due to this ambiguity, the extent to which the gender and the inheritance effects outweigh one another for matrilineal men and women is an important empirical question that we estimate directly in the equations that we present in the following section.

4 Methodology

4.1 Empirical specification

This section describes how we estimate the impact of inheritance practices on agricultural productivity and prices of maize plots. Consider the agricultural outcomes on plot i, for individual operator j in region r of Malawi as follows:

$$Y_{ijr} = \beta Matrilineal_{jr} + \alpha Male_{ijr} + \boldsymbol{\lambda}'\boldsymbol{x}_{jr} + \mu_j + \varepsilon_{ijr} \tag{3}$$

Where Y represents the outcomes of interest in this study. These two main outcomes are individual plot manager's self-assessed price of the land he or she farms in Malawi kwacha (MWK) per hectare, and maize yield in kilograms per hectare[1]. We also consider the possible transmission mechanisms for the main outcomes. These include: i) use of erosion control or water harvesting methods on the plot, ii) application of organic manure, iii) application of inorganic fertilizer, iv) number of weeding circles conducted on the plot during the most recent growing season, v) if the manager applied herbicides in the plot during the season and, v) if the plot had maize and legume inter cropped during the season.

The key covariates in equation 3 are Matrilineal and Male. The Matrilineal variable equals 1 if the plot manager is in a matrilineal marriage arrangement, indicating that the land is owned by the female family member and her clan, and 0 if the plot is managed by someone in a patrilineal marriage. The parameter to estimate on the matrilineal variable is denoted by β, and the statistical significance of $\hat{\beta}$ tests whether or not the outcomes of interest in this analysis differ between plots managed under matrilineal customs compared to patrilineal customs. We estimate the variable Matrilineal in two ways. First at the household-level where it equals 1 if the plot is operated by someone in a matrilineal arrangement and zero otherwise. Second, we use the community survey to measure inheritance, so the Matrilineal variable is equal to one if respondents in the community survey say that the majority of households practice matrilineal inheritance and zero otherwise.

Given the land tenure security situation discussed earlier in the article, we hypothesise that matrilineal men may invest less in their land and thus the land would have lower productivity and value compared to those in patrilineal arrangement. However, the opposite may be true for matrilineal women as they are the owners of land in such systems. As such the sign of $\hat{\beta}$ is ambiguous as men's and women's incentives in matrilineal systems may offset one another compared to those in patrilineal systems, where men are expected to have clear advantages over women. Male equals 1 if the plot is managed by a male and zero if managed by a female. the coefficient on $\hat{\alpha}$ tests the extent of the gender differentiated productivity effect.

In equation 3 X are control variables, including i) plot manager's age, ii) whether the plot manager is a permanent resident in their village, iii) whether the plot manager benefited from the government subsidized fertilizer programme (FISP), iv) household size; Plot size, v) soil type, vi) soil quality, vii) quantity of seeds planted on the plot, vii) a dummy for rainy season cultivation, viii) rainfall during the growing season, and ix) agro-ecological zones.

The variables $\mu_j + \varepsilon_{ijr}$ are the error terms for the model, where μ_j is assumed fixed for individual plot managers, while ε_{ijr} is assumed random and idiosyncratic. We explain how we deal with potential endogeneity of inheritance practices in the next section.

To build on the model presented in equation 3 and test whether the results estimated in that equation are driven by men's investment behaviour within matrilineal tenure arrangements, we estimate another set of models that interact the matrilineal and male variables. This is our model of gender decomposition, where we capture the heterogeneity as follows:

$$Y_{ijr} = \beta Matrilineal_{jr} + \alpha Male_{ijr} + \gamma Male_{ijr} \times Matrilineal_{jr} + \boldsymbol{\lambda}'\boldsymbol{x}_{ijr} + \vartheta_j + \varsigma_{ijr} \tag{4}$$

Where Y represents the same outcomes as in equation 3. In equation 4 $Matrilineal$ captures female plot managers of matrilineal customs, $Male$ represents male plot managers of patrilineal customs, while

[1]In this study we focused on maize cultivation because it is the most widely grown crop across all regions of Malawi. Other studies that estimated the gender productivity gap in Malawi used value of production as their measure of productivity (See Kilic et al. (2015)). However, tobacco is the major cash crop in Malawi and using it to calculate value of production will increase productivity estimates in the patrilineal areas in the Central and Northern Region of the country where tobacco is mainly grown. As such, using value of production in this context will make estimates of productivity even higher for patrilineal male managed plots. Therefore, by using maize yield as our productivity measure, our estimates can be considered a lower bound for gender differentiated productivity effects by inheritance patterns.

$Male \times Matrilineal$ are male managers of matrilineal customs, with corresponding parameter γ. The reference category are therefore female managers of patrilineal customs. As such, $\hat{\alpha}$ represents the patrilineal male impact relative to patrilineal females, $\hat{\beta}$ represents the matrilineal female impact relative to patrilineal females, while the impact comparing matrilineal males to patrilineal females is captured by the test of $\hat{\alpha} + \hat{\beta} + \hat{\gamma} = 0$. The difference between matrilineal female and matrilineal males is the test of $\hat{\beta}$ - $\hat{\gamma} = 0$, while the difference between the patrilineal males and matrilineal males is the test of $\hat{\alpha}$ - $\hat{\gamma} = 0$. In addition, X are the same control variables as those in Equation 3, while $\vartheta_j + \varsigma_{ijr}$ is the error component of the model[2].

4.2 Identification

Identifying the impacts of matrilineal customs on land value and agricultural productivity demands adequately accounting for the possibility of non-random self-selection by individuals into matrilineal or patrilineal inheritance customs. For example, it could be possible that more motivated and productive men could move into patrilineal areas because their efforts in labor, input use and soil fertility investments would be more highly rewarded in those communities, through increased tenure security for men. This would cause the coefficient estimate on the matrilineal variable in Equations 3 and 4 to be under-estimated. Thus, we use an instrumental variable (IV) to establish an exogenous spread of matrilineal customs, that is unrelated to individual-level unobservable factors that affect maize productivity among people in our data set.

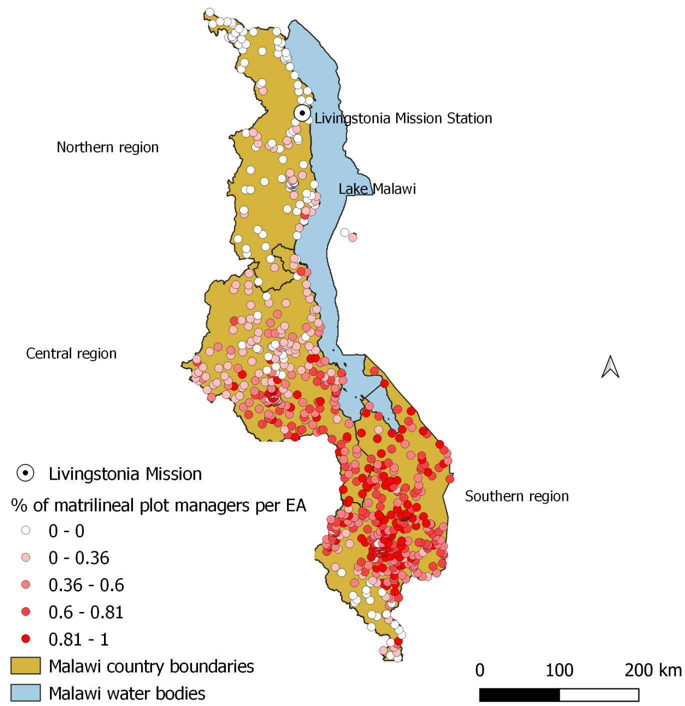
Specifically we use distance from the community where the individual resides to the original Christian missionary settlement in Livingstone located in Northern Malawi. Distance to the Livingstonia mission is likely a strong instrument because it relates to historical settlement patterns in Malawi. Prior to the arrival of Christian missionaries, Matrilineal inheritance was the dominant practice in Malawi (Phiri, 1983). However, nineteenth century missionaries who arrived in Malawi taught of male dominance, (e.g. strengthening men's role as head of households, and inherited land and other assets going to sons). This went against the prevalent matrilineal practices of the time. Given their paternal orientation, missionaries preferred to engage men rather than women in their work (Davison, 1993). Over time the missionaries presence and teachings eroded Malawi's traditional matrilineal practices in their sphere of influence (Kachapila, 2006).

The people who interacted with the missionaries found several other aspects of their work appealing, including lobbying against slavery and the slave trade that was prevalent during the 19th century (Porter, 1985). The missionaries also created schools that provided western education and they established health institutions (Rennick, 2003; Solá-García, 1999). Over time, many of the locals accepted the missionaries teachings and converted to Christianity. However, the extent of the missionaries influence was geographical. The missionaries fully settled in the northern region of Malawi, establishing their central mission station, the *Livingstonia mission* in 1894 (Kudo, 2017). Prior to that, the missionaries unsuccessfully attempted to establish missions in the southern and central parts of the country (Conacher, 2016). For instance they attempted to, but could not settle in the south, because of Tsetse flies, and could not settle in the centre due to high malaria mosquito infestation (Kudo, 2017). Therefore, missionary exposure for the locals and hence teachings that eroded the matrilineal customs were highest in the north, followed by the central and then the south of Malawi. The weakening of matrilineal customs, led to the growth of the patrilineal settlement practices, which took strongest hold in the north, followed by the center and then the south, as shown in figure 1.

Malawian marriage customs have been transferred across generations. The evidence of persistent historical patterns of matrilineal and patrilineal traditions confirms that geography matters for the marriage customs in Malawi (Phiri, 1983). Therefore, we aim to exploit distribution of matrilineal customs that is due to proximity to the Livingstonia mission, and hence exogenous to individual choice of marriage customs. We

[2] Because the instrument that we use to identify effects pf interest does not vary within a community (called an enumeration area in the survey), We do not control for community fixed effects, as they would be co-linear with the IV.

Figure 1: The distribution of matrilineal customs in Malawi



Source: Own calculations from IHPS 5 data.

specifically use distance from the community in which a household resides to the Livingstonia mission as an instrument for the matrilineal customs. This instrument has been used in a recent study based in Malawi by Kudo (2017). The author used information from the demographic health survey of Malawi between 2004 and 2010 along with numerous geographic, historic and climatic controls and found that patrilineal settlements in the 2000's were more likely to be located closer to the Livingstonia mission, while matrilineal settlements were more likely to be located further away from the mission. Furthermore, Kudo (2017) found that Malawian women in the 2000's who lived closer to the Livingstonia mission were less likely to marry early, less likely to enter in polygamous relationships and were more likely to convert to Christianity and to obtain education than were woman who lived further away from the mission.

While we have reason to believe ex ante that distance to the Livingstonia mission is a strong instrument for matrilineal inheritance, its exogeneity would be threatened if missionaries settled in a fertile agricultural land, and hence the mission station directly affects agricultural productivity and land value in contemporary Malawi. If land fertility was unobservable in our model then it would likely bias the IV estimates. Fortunately, we are able to address this issue in our analysis by controlling for agro-ecological zones, and growing season rainfall. We are also able to control for the individual plot manager's assessment of the land's soil quality, soil type and soil fertility, in the model. Ultimately, since the Livingstonia mission was established in the north primarily to escape diseases in the central and southern Malawi, there is no reason to believe that establishing their mission in areas of high agricultural productivity was a primary criteria for site selection.

5 Data

5.1 The Malawi Integrated Household Survey 5

Data used in this study was obtained from the Fifth Malawi Integrated Household Survey IHS-5, conducted by the Malawi National Statistical Office (NSO) in 2019, with technical support from the World Bank. The survey interviewed 11,434 households, across all the 28 districts of Malawi. Information collected included the custom under which individuals (both men and women) were married. Some individuals reported that they married under the matrilineal custom, while others reported that they married under the patrilineal custom. We constructed a binary variable where 1 represented matrilineal, while 0 otherwise. Previous IHS surveys limited to identifying marriage customs at the community level, typically ignoring the intra-community heterogeneity in the customs. Therefore, with the individual treatment variable, the IHS-5 provides a new window of opportunity to test the effects of the marriage customs with less noise.

Agricultural plots on which these individuals managed were also identified. From these plots, they reported the size of the land on which farming is done, the crops cultivated in this land, and the amount of harvest from each crop. They were also asked to report the estimated amount of money that the plot could fetch if it were sold. We classified the sample into male and female plot managers, who either married under Matrilineal or Patrilineal customs. We kept only plots on which maize was cultivated, and calculated maize yields in kilograms per hectare. We used information about the sale value of the plots, that the respondents provided, to calculate the plots prices in Malawi kwacha per hectare. The IHS-5 therefore provided key information that allowed examining the effects of tenure security on agricultural productivity and land prices, on male and female managed plots[3]. The survey also collected many other variables, some of which we used as control variables in our analysis, and are reported in Table 1.

The survey also had a community sub-component. Among the questions asked, informants were required to state the marriage custom practiced by the majority of people in the community. Some community were classified as matrilineal, while others were patrilineal. We constructed a dummy where 1 was matrilineal dominated while 0 otherwise. We used this variable as a robustness to that reported by the individuals, in examining the effects of interest. At the community level, the survey also provided geographical coordinates. These locations allowed us to calculate the distance between the respondents' communities and the Livingstonia Mission Station, which we used as an instrument for affiliating to the matrilineal marriage custom as opposed to the patrilineal marriage customs. Given the coordinates of the mission station, and the coordinates of the respondents from the IHS, we computed geodetic distances, i.e. the length of the shortest curve between the current residence of the respondents and the mission, along the surface of a mathematical model of the earth. By default, the input coordinates were assumed to be based on the WGS 1984 datum (the same used by Google Earth or Map and GPS devices), computing ellipsoidal distances using Vincenty (1975) equations. The final outcome was the distance, from the mission to the respondents, in kilometres.

Because we are interested in married subjects of either the matrilineal or patrilineal customs, our sample automatically excluded unmarried plot managers. Furthermore, limiting to plot managers, by default, excluded all non-farming individuals present in the IHS-5. Our final sample therefore comprised 8788 observations on plots, managed by men and women who married under the matrilineal and patrilineal customs.

[3]For the yields, land price and land area, we Winsorized the top and bottom 3 percent to evade the influence of outliers.

5.2 Variables used

Table 1: Means of plot level attributes by inheritance traditions and gender of the manager

	(1)	(2)	(3)	(4)
	Means			
	Matrilineal		Patrilineal	
	Male	Female	Male	Female
Outcomes				
Maize Productivity (kg/ha)	2,570	3,102	4,160	1,922
Land price (kwacha/ha)	2,420,375	3,359,514	9,618,999	3,387,147
Erosion control	0.461	0.468	0.405	0.315
Applied manure	0.328	0.298	0.256	0.236
Used inorganic fertilizer	0.684	0.662	0.678	0.620
Number of complete weedings	1.958	1.932	1.862	1.921
Applied herbicides	0.054	0.056	0.053	0.033
Inter cropped with legumes	0.233	0.237	0.217	0.208
Covariates				
Male headed household	0.976	0.663	0.990	0.667
Plot manager's age	44.240	39.369	43.084	39.432
Plot manager is a permanent resident	0.631	0.816	0.820	0.671
Household size	5.103	4.957	5.044	5.115
Plot size (ha)	0.315	0.284	0.343	0.309
Sandy (Mchenga) soil	0.234	0.230	0.183	0.199
Between sandy & clay soil	0.512	0.518	0.586	0.537
Clay (Katondo) soil	0.211	0.221	0.189	0.192
Other soil types	0.044	0.030	0.043	0.072
Good soil quality	0.557	0.513	0.571	0.593
Fair soil quality	0.315	0.334	0.317	0.323
Poor soil quality	0.129	0.153	0.113	0.084
Seed quantity (kg)	8.232	7.905	8.300	8.312
Rain season cultivation	0.953	0.966	0.929	0.919
Rainfall (mm)	812	810	865	856
Tropic-warm or semiarid zone	0.504	0.439	0.407	0.403
Tropic-warm or subhumid zone	0.373	0.502	0.288	0.357
Tropic-cool or semiarid zone	0.112	0.048	0.143	0.106
Tropic-cool or subhumid zone	0.011	0.011	0.162	0.134
Plot manager received subsidy (FISP)	0.086	0.149	0.096	0.097
Instrumental Variable				
Distance from Livingstonia mission (km)	485	520	343	381
Observations	2,845	1,411	3,579	905

The table reports means for plot attributes in the sample. Productivity, land price, plot hectares, seed quantity, household size, rainfall, and number of weedings are continuous while the rest of the variables are categorical. The land prices are quoted in Malawi Kwacha (MWK). The average exchange rate at the time of the survey was 1$: 734.2469 MWK. FISP denotes the Malawi Farm Input Subsidy Program.
Source: Own calculations from IHPS 5 data

Table 1 presents the variables used in this analysis. The main outcomes of interest, maize productivity in kilograms per hectare and land price in kwacha per hectare are presented first, followed by the outcomes that represent the intermediate land investments and use of inputs that affect the main outcomes. In 2019, the average male in matrilineal areas had a maize yield of 2,570 kilograms per hectare, which was lower than females in matrilineal areas who had a mean maize yiled of 3,102 kilograms per hectare. Both of these mean yields were lower than males in patrilineal areas who had an average yield of 4,160 kilograms per hectare. But both of the matrilineal yields were higher than females in patrilineal areas who had a mean yield of 1,921 kilograms per hectare. In terms of self-assessed land price reported by plot operators, matrilineal males reported an average land price of MWK 2.4 million per hectare, while matrilineal females reported an average land price of MWK 3.3 million per hectare. This compared to patrilineal males who reported an average sales price of MWK 9.6 million per hectare and an average price per hectare of 3.3 million for patrilineal females.

When looking at differences in Table 1 in intensification practices, it appears that a higher percentage of Matrilineal households engaged in erosion control on their plots than patrilineal households. For example, 46 percent of matrilineal men applied erosion control while 47 percent of matrilineal women did so. This compared to 41 percent of Patrilineal men applying erosion control and 32 percent of patrilineal women who used the practice. Similarly, 33 percent of matrilineal men applied organic manure and 30 percent of matrilineal women did so. This compared to 26 percent of Patrilineal men applying manure and 24 percent of Patrilineal women doing so. In addition, a very similar percentage of matrilineal men applied inorganic fertilizer (68 percent) compared to matrilineal men (67 percent) and matrilineal women (66 percent). Only 62 percent of patrilineal women applied inorganic fertilizer.

The bottom of Table 1 presents the means of the IV used in the analysis: Distance from the households' community to the Livingstonia mission in km. The table very clearly shows that matrilineal households were much further on average from the mission than were patrilineal households. For example, the average matrilineal male's plot was 485 km from the mission and the average matrilineal female's plot was 520 km from the mission. This compared to an average distance from the mission of 343 km and 381 km by patrilineal men and women respectively. These averages lend some *prima facia* evidence to the argument that our IV is strong; the missions distance was clearly further away from households in matrilineal communities than it is from households in patrilineal communities. Subsequent analyses test how this relationship held in a regression context.

6 Results

We begin the results section with table 2 that presents the first stage regression of the relationship between the IV used in the analysis: distance to the Livingstonia mission and the potentially endogeneous explanatory variable in the analysis: if the plot is managed by a person in a matrilineal marriage custom. Column 1 presents the results where distance to the Livingstonia mission and the Male binary variable are not interacted, while column 2 presents the results when they are. The models in both columns were estimated by linear probability model (LPM). The coefficient estimates and their statistical significance in table 3 indicated that the IV was highly significant and was positively associated with the probability of the plot being managed by a person in a matrilineal marriage. In column 1, a 100 kilometer increase in the distance between the the Livingstonia mission and the plot increased the probability that it was managed by someone in a matrilineal marriage by twenty percentage points on average.

Table 3 presents the estimates of the models for how inheritance patterns and gender affect the main outcomes of interest in the study: maize yields in kilograms per hectare and the land prices in MKW per hectare. Columns 1 and 2 present the results of model for maize yield and land price respectively when the Matrilineal and Male variables are not interacted, as in equation 3. Column 3 and 4 present the results

Table 2: The first stage effects of Livingstonia mission on matrilineal customs

	(1)	(2)
	Matrilineal	$Matrilineal \times Male$
Distance to Livingstonia mission	0.002***	0.001***
	(0.000)	(0.000)
Male	-0.080***	0.113***
	(0.015)	(0.019)
Distance to Livingstonia mission × Male		0.001***
		(0.000)
Constant	-9.373***	-7.139***
	(0.841)	(0.754)
Observations	8770	8770

NOTES: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Matrilineal is discreet indicating whether the plot manager married under the matrilineal marriage custom, captured by 1), and 0) if the manager married under the patrilineal custom. Distance to livingstonia mission is continuous in kilometres. Household probability weights and robust standard errors are employed in the analysis. The analysis included all control variables indicated in Table 1, namely: Male household head; Plot manager's age; Whether the plot manager is a permanent resident in their village; Whether the plot manager benefited from the government subsidized ferlilizer programme (FISP); Household size; Plot size; Soil type; Soil quality; Quantity of seeds planted on the plot; Rain season cultivation; Rainfall; and Agro-ecological zones.
Source: Own calculations from IHPS 5 data

of these models when the variables are interacted, as in equation which allows us to differentiate gender impacts from inheritance impacts 4. Results from column 1 indicated that plots farmed in matrilineal inheritance systems had a 99 percent lower maize yields on average than those in patrilineal systems, with p-value<0.01. Similarly, in column 2 results indicated that plots farmed by operators in matrilineal systems were assessed to be 58 percent lower in price than plots operated in patrilineal systems. This lower price was likely related directly to lower maize yields as seen in column 1.

The results in columns 3 and 4 of table 3 expand the analysis from column 2 by showing the decomposition of whether the differences in maize yields and land prices between matrilineal and patrilineal inheritance systems were driven by males or females. Here the variable Matrilineal equals 1 if the household practiced matrilineal inheritance and equal to 0 if it practiced patrilineal inheritance. In column 3 we see that matrilineal female plot managers did not have different yields on average than did patrilineal female plot managers. However, yields were 58 percent higher for plots managed by patrilineal males than they were for plots managed by patrilineal females on average with p-value<0.01. In addition, according to the F-test at the bottom of the table, yields were 65 percent lower on plots managed by matrilineal males than they were on plots managed by patrilineal females, p-value<0.01. The other F-tests at the bottom of table 3 indicated that i) matrilineal female plot managers had significantly higher yields than did matrilineal male plot managers, with the effect statistically significant at the 5 percent level, and ii) patrilineal male plot managers had significantly higher maize yields on average than did their male counterparts in matrilineal systems, with p-value statistically significant at 1 percent level. Thus, in the case of maize yields it appears that the lower yields in matrilineal systems were associated with male plot managers. In the case of land price in column 4, coefficient estimates indicated that matrilineal female plot managers assessed their land to be worth 48 percent less per hectare than patrilineal female plot managers did on average with p-value<0.01. Additionally, matrilineal male plot managers assessed their land to be worth 60 percent less than patrilineal female plot managers did on average with p-value<0.01. None of the other relationships between land prices and gender-differentiated inheritance were statistically significant in column 4.

Table 3: Estimates of the effects of individual's customs on log productivity and log land prices

	(1)	(2)	(3)	(4)
	Un-interacted treatment		Interacted treatment	
	Productivity	Land price	Productivity	Land price
Matrilineal	-0.989***	-0.568***	-0.217	-0.478***
	(0.112)	(0.106)	(0.172)	(0.162)
Male	-0.011	-0.078*	0.585***	-0.007
	(0.055)	(0.042)	(0.125)	(0.121)
Matrilineal× Male			-1.021***	-0.119
			(0.212)	(0.196)
Constant	0.250	0.600	-0.121	0.561
	(2.059)	(1.774)	(2.071)	(1.770)
Observations	8770	7752	8770	7752
First stage statistic	872.516	773.596	371.209	336.637
$Matri - Matri \times Male = 0$			0.804**	-0.359
$Male - Matri \times Male = 0$			1.606***	0.112
$Matri + Male + Matri \times Male = 0$			-0.653***	-0.604***

NOTES: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Productivity is continuous indicating maize yields in kilogram per hectare. Land price is continuous indicating the Malawi Kwacha value per hectare of the plot. Matrilineal is discreet indicating whether the plot manager married under the matrilineal marriage custom, captured by 1), and 0) if the manager married under the patrilineal custom. Household probability weights and robust standard errors are employed in the analysis. The analysis included all control variables indicated in Table 1, namely: Male household head; Plot manager's age; Whether the plot manager is a permanent resident in their village; Whether the plot manager benefited from the government subsidized ferlilizer programme (FISP); Household size; Plot size; Soil type; Soil quality; Quantity of seeds planted on the plot; Rain season cultivation; Rainfall; and Agro-ecological zones.
Source: Own calculations from IHPS 5 data

Table 4 presents the results of the same model estimated in equation 3 and 4, but the difference was that the measurement of inheritance practices was measured from data in the community survey. Here the Matrilineal variable equals 1 if the respondents in community survey said that most of the households in the community practiced matrilineal inheritance and equal to 0 if they said that most households in the village practiced patrilineal inheritance. This measure of inheritance was less precise compared to the household-level measure of inheritance used to estimate the results in table 3, because the present analysis did not allow for within-village variation in inheritance. Regardless, the results of table 4 were very similar to those in table 3. Results from column 1 indicated that plots farmed in matrilineal inheritance systems had an 83 percent lower maize yields on average than those in patrilineal systems, with p-value<0.01. Similarly, in column 2 results indicated that plots farmed by operators in matrilineal systems were assessed to be 49 percent lower in price on average compared to plots operated in patrilineal systems. As in the previous table, this lower land value was likely related directly to lower maize yields.

In column 3 of table 4, matrilineal female plot managers had a 43 percent lower yield on average than patrilineal female plot managers, with p-value<0.01. However, maize yields were 41 percent higher for patrilineal male plot managers than they were for patrilineal female plot managers on average, with p-value<0.01. In addition, average yields were 52 percent lower on plots managed by matrilineal male plot managers than they were on plots managed by patrilineal female plot managers, p-value<0.01. The f-tests at the bottom of table 4 indicated that patrilineal male plot managers had significantly higher maize yields on average than did their male counterparts in matrilineal inheritance systems, with p-value statistically significant at 1 percent level. Thus, the results in table 4 supported the result in table 3 that in the case of

Table 4: Estimates of the effects of community's customs on log productivity and log land prices

	(1)	(2)	(3)	(4)
	Un-interacted treatment		Interacted treatment	
	Productivity	Land price	Productivity	Land price
Community Matrilineal	-0.833***	-0.487***	-0.428**	-0.628***
	(0.095)	(0.088)	(0.174)	(0.160)
Male	0.085	-0.028	0.414***	-0.144
	(0.054)	(0.040)	(0.121)	(0.114)
Community matrilineal× Male			-0.504***	0.175
			(0.179)	(0.162)
Constant	2.315	2.138	1.748	2.347
	(2.227)	(1.888)	(2.244)	(1.901)
Observations	8703	7691	8703	7691
Reference group means	1323	1014380	1323	1014380
First stage statistic	1321.068	1134.775	485.118	482.775
$Matri - Matri \times Male = 0$			0.075	-0.803***
$Male - Matri \times Male = 0$			0.917***	-0.320
$Matri + Male + Matri \times Male = 0$			-0.518***	-0.597***

NOTES: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Productivity is continuous indicating maize yields in kilogram per hectare. Land price is continuous indicating the Malawi Kwacha value per hectare of the plot. Matrilineal is discreet indicating whether majority of people in the plot manager's cluster married under the matrilineal marriage custom, captured by 1), and 0) if the majority married under the patrilineal custom. Household probability weights and robust standard errors are employed in the analsyis. The analysis included all control variables indicated in Table 1, namely: Male household head; Plot manager's age; Whether the plot manager is a permanent resident in their village; Whether the plot manager benefited from the government subsidized ferlilizer programme (FISP); Household size; Plot size; Soil type; Soil quality; Quantity of seeds planted on the plot; Rain season cultivation; Rainfall; and Agro-ecological zones.
Source: Own calculations from IHPS 5 data

maize yields it appears that the lower yields in matrilineal systems were clearly associated with the male plot managers. In the case of land price in column 4, coefficient estimates indicated that matrilineal female plot managers assessed their land to be worth 63 percent less per hectare than patrilineal female plot managers on average with p-value<0.01. The f-test at the bottom of column 4 revealed that matrilineal male plot managers assessed their land to be worth significantly more than matrilineal female plot managers, with result significant at 1 percent level. Furthermore, matrilineal male plot managers felt that their land was worth 60 percent less on average than did patrilineal female plot managers. None of the other coefficients that tested the relationship between inheritance and gender were statistically different from one another regarding their impacts on land prices in column 4.

Table 5: Estimates of the effects of individual's customs on land investment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Un-interacted treatment						Interacted treatment					
	Strategy	Manure	Fertilizer	Weeding	Herbicides	Intercrop	Strategy	Manure	Fertilizer	Weeding	Herbicides	Inter crop
Matrilineal	0.285***	0.099***	-0.018	0.181*	0.032**	0.134***	0.287***	0.118**	0.156***	-0.131	0.080***	0.136**
	(0.041)	(0.038)	(0.036)	(0.098)	(0.015)	(0.035)	(0.065)	(0.055)	(0.060)	(0.141)	(0.025)	(0.057)
Male	0.051***	0.043***	0.025	0.013	0.013*	-0.003	0.053	0.058	0.159***	-0.228*	0.049***	-0.001
	(0.017)	(0.015)	(0.016)	(0.037)	(0.006)	(0.014)	(0.049)	(0.041)	(0.044)	(0.136)	(0.017)	(0.043)
Matrilineal×male							-0.003	-0.025	-0.230***	0.409	-0.063**	-0.003
							(0.078)	(0.067)	(0.070)	(0.255)	(0.030)	(0.068)
Constant	4.499***	1.452**	-2.702***	2.409**	1.386***	-0.619	4.498***	1.443**	-2.786***	2.571***	1.363***	-0.620
	(0.657)	(0.578)	(0.664)	(1.005)	(0.332)	(0.577)	(0.655)	(0.575)	(0.664)	(0.969)	(0.333)	(0.576)
Observations	8770	8770	8770	8506	8770	8770	8770	8770	8770	8506	8770	8770
Reference group means	0.342	0.236	0.658	1.874	0.058	0.287	0.342	0.236	0.658	1.874	0.058	0.287
First stage statistic	872.516	872.516	872.516	853.911	872.516	872.516	371.209	371.209	371.209	371.546	371.209	371.209
$Matri - Matri \times Male = 0$							0.290**	0.142	0.387***	-0.540	0.142***	0.139
$Male - Matri \times Male = 0$							0.056	0.082	0.390***	-0.637	0.112**	0.002
$Matri + Male + Matri \times Male = 0$							0.336***	0.151***	0.085*	0.050	0.066***	0.131***

NOTES: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Strategy is binary indicating whether the plot manager adopted an erosion control or water harvesting method in their plot. Manure is discreet indicating whether organic manure was applied in the plot. Fertilizer is discreet indicating whether inorganic fertilizer was applied. Weeding is continuous indicating number of weeding sessions undertaken on the plot. Inter crop is discreet indicating whether maize and legumes were cultivated on the plot at the same time. Matrilineal is discreet indicating whether the plot manager married under the matrilineal marriage custom, captured by 1), and 0) if the manager married under the patrilineal custom. Household probability weights and robust standard errors are employed in the analysis. The analysis included all control variables indicated in Table 1, namely: Male household head; Plot manager's age; Whether the plot manager is a permanent resident in their village; Whether the plot manager benefited from the government subsidized fertilizer programme (FISP); Household size; Plot size; Soil type; Soil quality; Quantity of seeds planted on the plot; Rain season cultivation; Rainfall; and Agro-ecological zones.

Source: Own calculations from IHPS 5 data

Table 5 presents the results for how inheritance practices and gender affect the measures of input use and soil investments at the plot-level. Here Matrilineal is measured at the household level as in table 3. Results from columns 1-6 are when the Matrilineal and Male variables are not interacted. On average people in matrilineal systems invested more in soil fertility than do people in patrilineal systems. Also, males invested more in soil investment than did females. For example, people in matrilineal inheritance systems were 29 percentage points more likely to use erosion control or water harvesting on their plot on average than people in patrilineal inheritance systems, with p-value<0.01. They were also 10 percentage points more likely to use organic manure which enhances soil fertility over time on average than people in patrilineal inheritance systems, with p-value<0.01. Matrilineal plot managers also conducted 0.18 more weedings on their plot on average than did patrilineal plot managers, with significance at the 10 percent level. These people were also three percentage points more likely to apply herbicides with p-value<0.05, and were 13 percentage points more likely on average to inter crop legumes with maize which can increase soil fertility compared to patrilineal plot managers, with p-value<0.01. In addition, male plot managers were five percentage points more likely to use erosion control or water harvesting on their plot, and they were 4.4 percentage points more likely to use animal manure than female plot managers on average, with both p-values<0.01.

Columns 7-12 of table 5 show the results when the Matrilineal and Male variables were interacted with each other, thus allowing us to differentiate the gender from the inheritance effects on input use and soil investments. The results suggested that matrilineal female plot managers were 29 percentage points more likely than patrilineal female plot managers to invest in erosion control or water harvesting, with p-value<0.05 and they were 29 percentage points more likely than matrilineal male plot managers to make either of these investment, with p-values<0.05. Matrilineal female plot managers were also 12 percentage points more likely to apply organic manure on average than were patrilineal female plot managers, with p-value<0.05. They were also 16 percentage points more likely to apply inorganic fertilizer than were patrilineal female plot managers on average and they were 39 percentage points more likely to apply fertilizer than were matrilineal male plot managers on average, with both p-values <0.01. Patrilineal male plot managers were 16 percentage points more likely to apply inorganic fertilizer than were patrilineal female plot managers, on average, and they were 38 percentage points more likely to apply fertilizer than were matrilineal male plot managers on average, with both p-values<0.01. Patrilineal male plot managers conducted 0.23 fewer weedings of their plots than did patrilineal female plot managers, with p-value <0.09. Fewer weedings might suggest on the surface that patrilineal males managed their plots less intensively. However it seems that this result was affected by the use of herbicides, which could be a partial substitute for weeding. For example, matrilineal female plot managers were eight percentage points more likely to apply herbicide than were patrilineal female plot managers, with p-value<0.01, while patrilineal male plot managers were five percentage points more likely to apply herbicides than were patrilineal female plot managers, with p-value<0.01. Conversely, matrilineal male plot managers were six percentage points less likely to apply herbicides than matrilineal female plot managers, with p-value<0.01. Matrilineal male plot managers were 14 percentage points less likely to apply herbicides than were matrilineal female plot managers, with p-value<0.01, and matrilineal male plot managers were 11 percentage points less likely to apply herbicides than were patrilineal male plot managers, with p-value<0.05. Matrilineal female plot managers were also 14 percentage points more likely to inter crop legumes with maize on average than were patrilineal female plot managers, with p-values<0.01. Results at the bottom of the table that compared matrilineal male plot managers with patrilineal female plot managers, indicated that matrilineal male plot managers were significantly more likely to use intensive inputs and soil fertility management practices on average. For example, matrilineal male plot managers were 34 percentage points more likely to adopt erosion control or water harvesting practices, 15 percentage points more likely to use manure, seven percentage points more likely to use herbicide and 13 percent more likely to have inter cropped maize with legumes than were patrilineal female plot managers on average, all with p-values<0.01. While this may suggest that matrilineal male plot managers had better access to inputs than did patrilineal female plot managers, the fact that they did so while still obtaining lower yields than patrilineal female plot managers according to results in the previous tables could mean that patrilineal male plot managers may have been forced to work harder to get less output than females in patrilineal inheritance systems due to poor underlying levels of soil fertility on their plots.

Table 6: Estimates of the effects of community's customs on land investment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Un-interacted treatment						Interacted treatment					
	Strategy	Manure	Fertilizer	Weeding	Herbicides	Intercrop	Strategy	Manure	Fertilizer	Weeding	Herbicides	Inter crop
Community Matrilineal	0.235***	0.080**	-0.020	0.153*	0.027**	0.109***	0.313***	0.123**	0.111*	-0.064	0.085***	0.159***
	(0.034)	(0.032)	(0.030)	(0.084)	(0.013)	(0.030)	(0.064)	(0.056)	(0.058)	(0.123)	(0.024)	(0.056)
Male	0.022	0.037**	0.025*	-0.003	0.010	-0.012	0.086*	0.072*	0.132***	-0.180	0.057***	0.029
	(0.016)	(0.015)	(0.015)	(0.031)	(0.006)	(0.014)	(0.047)	(0.040)	(0.041)	(0.120)	(0.015)	(0.041)
Community matrilineal× Male							-0.098	-0.054	-0.164***	0.271	-0.072***	-0.062
							(0.066)	(0.056)	(0.058)	(0.193)	(0.025)	(0.057)
Constant	4.011***	1.265**	-2.466***	2.019*	1.388***	-0.831	3.901***	1.204*	-2.651***	2.326**	1.306***	-0.901
	(0.692)	(0.616)	(0.696)	(1.117)	(0.341)	(0.613)	(0.699)	(0.620)	(0.701)	(1.015)	(0.348)	(0.617)
Observations	8703	8703	8703	8439	8703	8703	8703	8703	8703	8439	8703	8703
Reference group means	0.341	0.237	0.656	1.873	0.059	0.289	0.341	0.237	0.656	1.873	0.059	0.289
First stage statistic	1321.068	1321.068	1321.068	1280.040	1321.068	1321.068	485.118	485.118	485.118	518.132	485.118	485.118
$Matri - Matri \times Male = 0$							0.411***	0.177*	0.276**	-0.334	0.157***	0.221**
$Male - Matri \times Male = 0$							0.184*	0.125	0.296***	-0.450	0.129***	0.091
$Matri + Male + Matri \times Male = 0$							0.302***	0.141***	0.079*	0.027	0.070***	0.125***

NOTES: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Strategy is discreet indicating whether the plot manager adopted an erosion control or water harvesting method in their plot. Manure is discreet indicating whether organic manure was applied in the plot. Fertilizer is discreet indicating whether inorganic fertilizer was applied. Weeding is continuous indicating number of weeding sessions undertaken on the plot. Inter crop is discreet indicating whether maize and legumes were cultivated on the plot at the same time. Matrilineal is discreet indicating whether the plot manager is in a community where the majority married under the matrilineal marriage custom, captured by 1), and 0) if the manager in in a predominantly patrilineal community. Household probability weights and robust standard errors are employed in the analysis. The analysis included all control variables indicated in Table 1, namely: Male household head; Plot manager's age; Whether the plot manager is a permanent resident in their village; Whether the plot manager benefited from the government subsidized fertilizer programme (FISP); Household size; Plot size; Soil type; Soil quality; Quantity of seeds planted on the plot; Rain season cultivation; Rainfall; and Agro-ecological zones.

Source: Own calculations from IHPS 5 data

Table 6 presents the results as in Table 5, except that here the predominant inheritance practice in the community where the plot is located and the individual resides is used to determine matrilineal or patrilineal inheritance practices, instead of individual inheritance. These results were very similar to the estimates in Table 5. In columns 1-6 of Table 6 we see that people in matrilineal communities were significantly more likely to employ intensive management practices than were people in patrilineal communities. For example, plots in matrilineal communities were 24 percentage points more likely to have erosion control or water harvesting method, with p-value<0.01. They were also 8 percentage points more likely to apply organic manure, with p-value<0.0.1, and received 0.15 more weedings on average, with p-value<0.10. Plots in matrilineal communities also were about three percentage points more likely to receive herbicide application on average, with p-value<0.05, and they were 11 percentage points more likely to be inter cropped with maize and legumes, with p-value<0.01. Also, Table 6 indicated that male managed plots were four percentage points more likely to apply organic manure than were female managed plots, regardless of inheritance practices, with p-value<0.05. This could be because men tend to have greater access to animals than women in Malawi and thus can use the manure on their plots.

Columns 7-12 of Table 6 show the results when the Matrilineal Community and Male variables were interacted with each other. Results were also consistent with the results in Table 5, and showed that female plot managers in matrilineal communities were significantly more likely to engage in applying intensive management practices on their plots than were female plot managers in patrilineal communities. It is also true that male plot managers in patrilineal communities were also significantly more likely to apply these practices on their plots than were female plot managers in patrilineal communities. Conversely, patrilineal female plot managers were 17 percentage points more likely to apply inorganic fertilizer on average, and were seven percentage points more likely to apply herbicides on average than were matrilineal male plot managers, both with p-value<0.01. Matrilineal female plot managers were also significantly more likely to apply many of these inputs on average compared to matrilineal male plot managers, including erosion and water controls, organic manure use, applying fertilizer, applying herbicides and inter-cropping maize with legumes. Patrilineal male plot managers were also significantly more likely to adopt erosion and water control methods, inorganic fertilizer, and herbicide than were matrilineal male plot managers on average. However, matrilineal male plot managers were significantly more likely than patrilineal female plot managers to apply erosion control or water harvesting, manure, herbicides and inter crop maize with legumes on average, with p-values <0.01.

7 Conclusions

This study used nationally representative data from Malawi and a unique identification strategy to estimate how land tenure security, measured through gender differentiated inheritance patters, affected maize productivity, the price of agricultural land, along with soil fertility investments and annual input use among smallholder farm households. Despite the fact that Malawi passed a set of Land Acts in 2016 making it easier for smallholder farmers to obtain legal title for their land, 98 percent of the the plots owned by smallholders in the country were held without title in 2019. This meant that the traditional customary tenure structures, that comprise village leaders and the community as a whole, were responsible for recognizing people's tenure claim. We defined inheritance patters as being either matrilineal where land inheritance and ownership flows through women, or patrilineal where it flows through men. In patrilineal systems men have ultimate control over land. Conversely, in matrilineal systems during marriage the wife and her family have ultimate control of land. This may discourage males in matrilineal systems from investing in their land compared to i) women in matrilineal systems, ii) men in patrilineal systems, and even compared to iii) women in patrilineal systems who are often highly disadvantaged relative to men.

Our results indicated most of the impacts on productivity, land prices and input use and soil investments were influenced to a greater extent by the impact of inheritance patterns for men and women in matrilineal and patrilineal systems rather then through gender productivity differences between men and women alone. Specifically, male managed plots in matrilineal inheritance systems had significantly lower yields and had land with lower prices than plots managed by females in matrilineal inheritance systems, and both male and female managed plots in patrilineal inheritance systems. This is consistent with our additional findings that matrilineal male plot managers were significantly less likely to use soil fertility enhancing practices like soil erosion and water control methods, organic manure, and inter cropping maize with legumes compared to matrilineal female plot managers and patrilineal male plot managers on average. Matrilineal male plot managers were also less likely to invest in annual inputs like inorganic fertilizer and herbicides than were matrilineal female and patrilineal male plot managers., but were more likely to make those investments and use those inputs then were patrilineal female plot managers. These findings suggest that male managers in matrilineal inheritance systems were less likely than their counterparts (with the exception of patrilineal female plot managers) to invest in their plots' productivity due to their lack of tenure security and control they experience in these systems, since their land can be reclaimed by their wives clan. This disincentive translates directly into lower maize yields and lower priced land. Such outcomes have implications for sustainable agricultural intensification policies and programming in the region.

Our findings add insights to two important strands of the development economics literature. First, the literature on tenure security and investment has generally found that secure tenure leads to greater agricultural investment (Fenske, 2011; Goldstein et al., 2018; Ali et al., 2014). Our results support this as women in matrilineal inheritance systems and men in patrilineal systems are the most secure in their tenure. We found that they invested the most in their land and subsequently have the highest yields. However, by separating gender of the plot operator within these inheritance systems, we provided new evidence on this issue. We demonstrated that in this context men in matrilineal systems were less secure and thus invested less in their land and obtained lower yields than women in matrilineal inheritance systems and men in patrilineal inheritance systems. Interestingly, we found that matrilineal male plot managers invested relatively more in their land than did patrilineal female plot managers (the other disadvantaged inheritance group) but still obtained lower yields. This finding could indicate that matrilineal male plot managers had to work harder to get less output than females in patrilineal inheritance systems due to poor underlying levels of soil fertility on their plots.

These findings fit into the second contribution of the article, namely the gender-differentiated productivity gap (Doss, 2014; Kilic et al., 2015; Palacios-López and López, 2015; Udry, 1996; Hill and Vigneri, 2014). When we simply estimated gender as men vs. women and measure its effect on the outcomes of interest in the study without considering inheritance patters, we found that there was no significant difference in yields between men and women, and that men considered their plots more valuable. We also found that men applied more erosion control and water harvesting methods along with more organic manure than did women. This is consistent with previous literature on the topic (Doss, 2014; Kilic et al., 2015; Palacios-López and López, 2015; Udry, 1996; Hill and Vigneri, 2014). However, when we interacted gender with inheritance patterns, we found that the gendered differences were related to patrilineal male plot managers, who likely have the strongest tenure and best access to inputs compared to other groups. The fact that we found men who farmed in matrilineal systems to have the lowest yields of the for gender-inheritance groups, and invested less in their land than all groups except patrilineal female plot managers raises a new dimension in the gender parity debate. It highlights the need to understand the nuances of the local contexts when considering what factors affect agricultural intensification. It also highlights the fact that measuring productivity at the household level is too course. Researchers should focus on estimating productivity at the plot-level.

The results of our study raise two important policy recommendations. First, extension and other training programs that seek to sustainably increase soil fertility and raise agricultural productivity may be ineffective or even counter-productive if they do not understand these intra-household relationships. And even more so if they ignore how differences in land tenure security, even within a household, can affect incentives to invest in plots. For example, sustainable intensification programs that target men rather than women in matrilineal inheritance areas may have limited impact due to tenure security among matrilineal men. Finally, the Land Act of 2016 in Malawi that made it easier for smallholders to title their land could theoretically benefit matrilineal men, and change their motivations to invest more in their land with increased security. However, the question remains whether a wife and her extended family in matrilineal inheritance systems would value a newly acquired title by a husband in that system. If it does not change the family's views on ownership and control, the Land Act will have little practical importance. Understanding how the Land Acts have changed perceived and real tenure security across matrilineal and patrilineal inheritance systems should be a topic of future research.

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