Factors affecting differences in livestock asset ownership between male and female-headed households in northern Ethiopia

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Abstract

Empirical studies that analyze the gender gap in livestock ownership are scarce. This paper investigates gender differences in livestock holding using five waves of survey data (1998-2010) from Northern Ethiopia. By employing decomposition analysis, we find that female-headed households (FHHs) own significantly fewer livestock compared to male-headed households (MHHs). Differences in observed characteristics and returns to characteristics account for 29 and 51 percent of the gender difference, respectively. Lower endowment of land area, male labor and children (aged 6 to 14) in FHHs are the observed factors causing the disparity. Gender difference is more pronounced in the ownership of large animals than in the ownership of small animals. Findings are relevant for gender-sensitive public interventions that aim to promote livestock accumulation.

Keywords: Ethiopia; female-headed household; livestock; accumulation; gender

JEL codes: I21, I32, J16

1. Introduction

In this paper, we examine differences in livestock ownership between female- and male-headed households using data collected in Northern Ethiopia. Asset measures have received recent attention in defining chronic poverty (Carter and Barrett, 2006). A growing body of literature shows that building assets is one of the pathways through which rural households move out of poverty (Carter and Barrett, 2006; Meinzen-Dick *et al*., 2011). Among the portfolio of assets at the disposal of households, livestock is an important source of agricultural wealth in rural livelihoods (FAO, 2011a). Livestock can produce nutritious food; serve as a source of traction power; provide manure that can enhance land productivity; serve as a buffer stock to smooth consumption; build social capital; and serve as a store of wealth (Rosenzweig and Wolpin, 1993; Njuki and Miller, 2012). Further, livestock and livestock products can be sold for income. In Ethiopia, where livestock represents 90 percent of the value of assets in the country (Campenhout and Dercon, 2012), livestock ownership reflects agricultural capacity, ability to gain credit and the wealth status of rural households. In addition, livestock offers important livelihood options in the endeavor to achieve livelihood security. Oxen ownership is also important for participation in the land rental market (Holden *et al*., 2008). Female-headed households' (FHHs') ownership of such an important asset is essential for food security, child nutrition, education and women's wellbeing (Meinzen-Dick *et al*., 2011; Njuki and Miller, 2012). However, FHHs are often more constrained in terms of access to assets (including livestock), labor, credit and extension services (Kassie *et al*., 2014), which has implications for FHHs' livestock accumulation strategy and hence poverty.

We aim to answer two research questions: What factors contribute to the gender gap in livestock asset ownership? And does the gender gap depend on whether households accumulate large or small livestock? Data are derived from a household panel survey administered five rounds over the period 1998-2010 in Northern Ethiopia, Tigray region. We employ the Blinder-Oaxaca decomposition technique, a method that decomposes causes of gender differences into differences in observed characteristics and coefficients.

Empirical studies that analyze the gender gap in livestock ownership in a dynamic set up are scarce in the literature. Previous studies with this focus (Muyanga *et al*., 2011; Tegebu *et al*., 2012) have examined the gender difference using pooled regression with a binary variable for gender, measuring only the intercept effect and not the slope coefficients. Others (Dillon and Quiñones, 2011) have analyzed women's and men's asset ownership separately but have not disentangled and classified factors causing the difference into observed and unobserved attributes. This paper contributes to the literature by identifying specific covariates affecting livestock ownership within female-and male-headed households (FHHs and MHHs). Furthermore, it disentangles specific factors causing differences in livestock ownership and categorizing them into observed and unobserved factors, which is important input for making interventions more gender sensitive.

Results show that, on average, FHHs own 0.41 TLU fewer livestock than MHHs. This figure is equivalent to 26 percent of FHHs' level of TLU in the initial survey year (1998). According to our decomposition analysis, 29 percent of the gender difference in livestock ownership is explained by differences in the observed characteristics between the two groups. On the other hand, differences in coefficients account for 51 percent of the difference. Whereas the difference in the observed characteristics indicates that FHHs are poorer in some characteristics, the difference in coefficients shows that a difference in livestock ownership would exist even if FHHs and MHHs had the same characteristics. The observed factors contributing to the gender difference in the accumulation behavior are differences in land area, the size of the male labor force and the number of children between the ages of 6 and 14. Gender difference in livestock ownership due to unexplained factors is mainly attributed to the period in the aftermath of the Ethio-Eritrean war (2001). The war may have caused FHHs to be vulnerable and hence sell their livestock to the army. Further disaggregation of livestock into large animals and small ruminants shows that the difference is more pronounced for large animals. Results inform livestock interventions about the factors affecting livestock accumulation behavior of FHHs versus MHHs.

2. Data

We use five waves of survey data from the highlands of the Tigray region in Ethiopia. Data collection started in 1998 and continued up to 2010 with a two- to four-year gap in between (2001, 2003 and 2006). The survey was initially carried out for a stratified random sample of 400 households in 16 villages. Sample households are representative of population density, market access, agro-climatic conditions and access to irrigation projects in the highlands of the region (Hagos and Holden, 2002). [3] The same households were followed in the subsequent years. The survey covered information on household characteristics, asset ownership (land, livestock and physical assets), agricultural production, non-farm income sources and consumption expenditure. After cleaning the data and identifying the same households across survey years, 1505 household-year observations (301 households for each year) remain.

Agriculture in the highlands of Tigray region is mainly characterized by a mixed crop-livestock farming system (Hagos and Holden, 2002). In such a setting, livestock serves as an input to crop production and as a form of savings (Campenhout and Dercon, 2012). In Tigray region, livestock is vital to agricultural practices, and two-thirds of the households in the region own at least one ox (Hagos and Holden, 2002). As in other parts of Ethiopia, a pair of oxen is used for cultivating land, making oxen an important and at the same time lumpy and indivisible asset for households. The main constraint of livestock production in Tigray is the lack of feed and water. As a result, farmers spend a large portion of their day taking their livestock to water sources (Hagos and Holden, 2002).

Our data show that the percentage of FHHs has increased since the initial survey year. [4] Table 1 presents the proportion of FHHs across the survey years. Overall, approximately 27 percent and 73 percent of the households are female-headed and male-headed, respectively. Across the survey years, there have been switches in the gender of the household head. The last three columns of Table 1 summarize the proportion of households that have experienced switches in the gender of the head. In total, 9 percent showed changes in the gender of the head, with a larger percentage changing from MHH to FHH. This switching behavior is likely due to death, divorce or migration of the household head and the Ethio-Eritrean War. [5] FHHs may change to MHHs when either the female head remarries or the female head's son becomes old enough to form his own family and takes over as the head of the household.

Table 2 presents descriptive statistics pertaining to the household characteristics and asset endowments for FHHs and MHHs during the initial (1998) and final (2010) survey years. It can be observed that MHHs are better endowed in many dimensions than FHHs in both years. On average, FHHs have a smaller number of adult male members, children and total household members. In terms of asset endowment, FHHs have a smaller farm size, lower livestock holding (measured in tropical livestock units-TLU) and fewer oxen. [6] In 2010, MHHs appeared to be older and better educated than FHHs. The data show that the gender difference in livestock endowment was higher in 2010 than in 1998, with FHHs having lower livestock holding.

Figures 1 and 2 depict the livestock holding for FHHs and MHHs. The figures clearly show that the distribution of TLU is shifted rightward for MHHs at all points compared to FHHs in both 1998 and 2010. Figure 3 illustrates the disaggregated average livestock holding for each survey year. The figure reveals that gender differences in terms of total livestock ownership—with a greater value for MHHs—existed in all years.

To visualize the changes in livestock asset ownership, we plot a bivariate graph for stocks of livestock at the beginning (1998) and ending (2010) survey years. In this case, we use the subsample of households without a switch in the gender of the household head across years. [7] Figure 4 illustrates the same information with a separate representation for the livestock holding for MHHs and FHHs. It is clearly shown that MHHs have larger stocks of animals than FHHs, especially in 2010. A greater proportion of MHHs (65%) than of FHHs (59%) showed improvements in livestock ownership between the two years. This pattern is shown in Figure 4.

Intra-household asset endowment has important implications for the asset accumulation pattern within MHHs and FHHs. Women in MHHs face different challenges in terms of asset accumulation compared to women in FHHs. Our data do not allow us to make comparisons of asset ownership of male and female members within the two household categories because they do not capture intra-household information. When submitted to an intra-household analysis, it is possible that our empirical results on the causes of differences in livestock ownership may produce different outcomes.

In general, the unconditional descriptive statistics and figures suggest that there is a significant difference in livestock accumulation between MHHs and FHHs. An econometric analysis is thus performed to examine differences.

3. Method

We use the Blinder-Oaxaca decomposition method proposed by Blinder (1973) and Oaxaca (1973) to examine the mean livestock holding differences between MHHs and FHHs. The method allows for gender differences attributed to differences in household characteristics on the one hand and differences in coefficients on the other (Jann, 2008) to be disentangled. We model livestock ownership for MHHs and FHHs separately in equations (1) and (2), respectively.

$$A_{it}^{M} = \beta x_{it}^{M} + v_{i}^{M} + \varepsilon_{it}^{M} \quad (1)$$

$$A_{it}^{F} = \beta x_{it}^{F} + v_{i}^{F} + \varepsilon_{it}^{F} \quad (2)$$

A_{it} represents livestock ownership (TLU) for household i and survey year t. Superscripts M and F refer to MHHs and FHHs, respectively. x_{it} denotes a vector of explanatory variables (age and education of head; adult labor and land endowment; number of children between the age of 6 and 14; dummy for off-farm employment; and year dummy variables). We run two regressions for MHHs and FHHs. The short regression is Model A. Model B adds a dummy variable for the switch in gender of the head [8] and allows us to control for a potential effect of the change in headship on livestock ownership over time. v_i represents time-invariant unobserved heterogeneity, and ε_i is an error term with an expected value of zero.

We employ a fixed effects method in the decomposition analysis by applying a within transformation of the variables. This transformation is carried out by subtracting the time average from each variable. Equations (3) and (4) represent transformed versions of equations (1) and (2).

$$\tilde{A}_{it}^{M} = \beta \tilde{x}_{it}^{M} + \tilde{\varepsilon}_{it}^{M} \quad (3)$$

$$\tilde{A}_{it}^{F} = \beta \tilde{x}_{it}^{F} + \tilde{\varepsilon}_{it}^{F} \quad (4)$$

where the symbol ~ on the variables denotes that the variables are within transformed. Because the regression also controls for time fixed effects, the modeling approach is two-way fixed effects. In equations (3) and (4), the individual effect (v_i) is wiped out because we use a fixed effects estimator. Equation (5) represents the mean outcome difference in livestock holding between FHHs and MHHs, which is equivalent to the difference in the linear prediction at the gender-specific means of the regressors. E (·) denotes the expected value of the respective variables.

$$E(\tilde{A}_i^M) - E(\tilde{A}_i^F) = \{E(\tilde{x}_i^M) - E(\tilde{x}_i^F)\}'\beta^F + E(\tilde{x}_i^F)'(\beta^M - \beta^F) + \{E(\tilde{x}_i^M) - E(\tilde{x}_i^F)\}'(\beta^M - \beta^F) \quad (5)$$

Alternatively, equation (5) can be written as follows:

$$E(\tilde{A}_i^M) - E(\tilde{A}_i^F) = \Delta\tilde{x}\beta^F + \Delta\beta\tilde{x}^F + \Delta x\Delta\beta \quad (6)$$

In equation (6), subscript *i* is suppressed for convenience. The first term on the right-hand side is referred to as the endowment effect. It measures the average differences in livestock ownership between FHHs and MHHs caused by differences in observed characteristics ($\Delta\tilde{x}$), which is also considered the explained part of the difference. The second term, which is referred to as the coefficient effect, is equivalent to the gender difference in livestock ownership due to coefficient difference ($\Delta\beta$). This term accounts for the unexplained part of the difference and is usually considered the discrimination effect (Blinder, 1973; Jann, 2008). The term is considered a discrimination effect because differences would exist even if FHHs had the same characteristics (endowment) as MHHs (Blinder, 1973; Oaxaca, 1973). However, it is possible that the coefficient effect also includes differences in unobserved variables (Jann, 2008). The model used in this paper controls for relevant confounding factors and uses a fixed effects model to address time-invariant unobserved heterogeneity. Therefore, we believe that the effect of the unobserved factors is minimal, although it is possible that systematic differences between FHHs and MHHs exist. The third term in equation (6) represents the interaction between the endowment and the coefficient effect.

A test for attrition bias shows that the inverse mills ratio generated from an attrition probit model is not statistically significant in the fixed effects estimations of MHHs and FHHs. [9] To examine whether variables in the models for FHHs and MHHs are significantly different, we carry out a chi squared test. Results show that some of the variables are significantly different, which validates the use of the Oaxaca decomposition approach. In the decomposition analysis, we report robust standard errors, clustered by household identity.

One of the limitations of the decomposition approach is its application in a dynamic set-up. The approach looks at an average effect when measuring gender difference in asset ownership, which makes it difficult to disentangle policy effects of government interventions such as the Productive Safety Net Program and the land certification program that has been found to have had substantial impacts in the region (Holden *et al*., 2008; Holden *et al*., 2011). This policy effect is beyond the scope of the paper but may be studied in future research.

4. Results

Table 3 summarizes the fixed effects estimates of the models for MHHs and FHHs. We report two regressions, Model A and Model B, for the two groups. Model B in the MHHs' regression adds an indicator variable equal to one if the headship switched from female to male. Analogously, the switch variable in Model B for FHHs refers to a shift from male to female headship. The coefficient estimates and the level of significance in Model A and Model B are consistent for both groups. [10]

Results show that factors determining livestock ownership differ between MHHs and FHHs. Parameter estimates show disparities in terms of magnitude and level of significance. The age of the household head in MHHs has a positive effect on livestock ownership but at a decreasing rate. Beyond a certain threshold, livestock ownership becomes lower as the male household head becomes older, a reflected in the squared term for the age of the household head. This trend likely occurs because the prospect of accumulating livestock, as with other investments, becomes lower as one ages. The age of the household head does not, however, affect the livestock holding of FHHs. One explanation could be that aging among female heads does not provide a prospect for accumulating livestock, which may be related to the lack of social and political capital in FHHs because such capital potentially develops as one ages and enables households to receive benefits from extension services and other interventions. Such constraints limit FHHs' ability to gain benefits from interventions and hence affect their livestock accumulation.

Educated male household heads own larger stocks of animals, whereas education does not appear to affect FHHs. In both MHHs and FHHs, larger land area and greater numbers of female and male adult members have a positive influence on livestock ownership. The higher the number of children between ages 6 and 14 in FHHs, the larger the stock of animals owned becomes, ceteris paribus.

In the FHHs' regression, findings show that households that switched from male- to female-headed households have more livestock compared to those that were consistently headed by females across the survey years (see Model B). A possible explanation could be that FHHs that have recently been headed by males are better endowed with livestock than those headed by females across all years. In the MHHs' regression, the switch variable is statistically insignificant. In terms of the year-fixed effects, MHHs owned higher stocks of animals in 2001 and lower stocks of animals in 2006 compared to those in 1998. In 2003, both MHHs and FHHs had a lower livestock endowment than in base year (1998). This finding may be explained by the fact that 2003 was a severe drought year.

Following up on the fixed effects results, Table 4 presents the mean predicted difference in TLU for MHHs and FHHs using the Blinder-Oaxaca decomposition technique. The table reports the average gender difference and decomposes the causes of the difference into endowments, coefficients and interaction. Findings reveal that MHHs own significantly higher TLU than FHHs do. This result is similar to the findings reported by Muyanga *et al*. (2011) and Tegebu *et al*. (2012) for rural households in Kenya and Ethiopia, respectively. The gender difference in livestock ownership is equivalent to 0.41 TLU, and the average predicted values for MHHs and FHHs are 0.14 and -0.27, respectively. Apparently, the average livestock owned by FHHs has deteriorated relative to the time average, whereas it has improved among MHHs. Table 4 also shows that differences in the observed characteristics constitute 29 percent of the difference (endowment effect) and the difference in returns to characteristics make up 51 percent of the difference (coefficient effect).

The question now becomes, what are the factors causing the gender difference in forming livestock assets? In Table 5, we report the details of the decomposition analysis, which summarizes the specific effects of the predictors under the endowment and coefficient components. [11] Results show that differences in the endowment of adult male labor contribute to the lower livestock ownership among FHHs, which is likely related to the fact that male labor endowment is vital for agricultural activities that require physical strength. Plowing, which typically involves a pair of oxen in the study area and elsewhere in the country, is carried out solely by the male labor force. In addition to the need for physical strength in plowing activity, there is a cultural norm against women plowing using oxen (Bezabih *et al*., 2012). Hence, the shortage of male labor force in FHHs could hinder these households from acquiring more livestock over time.

Children contribute to the labor requirement in livestock farming by herding animals (Tegebu *et al*., 2012). Findings indicate that differences in the endowment of children between the ages of 6 and 14 is another cause for the gender difference in livestock ownership. This trend is likely observed because FHHs are smaller and hence less able to provide the labor required to maintain animals and take livestock to public grazing land, in which case children may be asked to accompany the animals.[12]

Inequality in owned land area also contributes to the gender difference in building livestock assets (see Table 5). In the study area, land ownership is biased towards MHHs (Dokken, 2015). [13] Furthermore, FHHs are in a weak position in terms of land management and tenure security (Holden *et al*., 2011). One reason could be that husbands are the ones who are in charge of managing the land. Women traditionally change their dwelling place to their husband’s home village upon marriage, which reduces the chance of owning land in their own home village. This tradition eventually renders the wife either landless or the owner of a small portion of the land upon divorce or death of the household head (Holden *et al*., 2011; Dokken, 2015).

Land area can affect livestock ownership through its effect on availing of animal feed from the land and the wealth effect. Ownership of larger land area reflects the wealth of the household and hence the household’s ability to invest in productive assets, which constitutes the wealth effect. A small portion of land area can only generate a small amount of fodder, which is a major constraint in the study area. The availability of crop residues for FHHs might, however, depend on the households' land rental participation. According to Holden *et al*. (2008), FHHs are more likely to rent out their land. Hence, tenants may potentially obtain much of the fodder depending on the agreement made. [14] As a result, we expect that the wealth effect matters more in affecting the difference in livestock ownership. Findings show that more land-poor FHHs are less able to build a large stock of animals.

The coefficient effect, which has an overall significance at the 5 percent level (see Table 4), reveals that FHHs would own less livestock even if their characteristics were the same as those of MHHs. An examination of the specific variables shown in Table 5 (third column) reveals that the year dummy for 2001 is statistically significant in the model. This finding implies that this period contributed to the significantly lower stock of animals in FHHs. One possible explanation could be that this period represented the aftermath of the Ethio-Eritrean War. A common way to treat the army was to provide livestock for slaughtering, and the source of livestock was likely the area closest to the war zone,Tigray region. This practice may have affected the livestock accumulation behavior in the study area. Moreover, FHHs may have been likely to sell livestock to the military for three reasons. One, FHHs are more vulnerable than MHHs. Two, male labor is scarce in these households due to the war, thereby discouraging livestock accumulation and encouraging livestock sale. Three, the market value of livestock during that period may have risen, tempting FHHs to sell livestock because of their relative vulnerability. In this model, the only statistically significant variable is the year 2001. Hence, the coefficient effect may not necessarily reflect the existence of discrimination in livestock accumulation but rather the relative vulnerability of female-headed households.

Tables 6 shows the fixed effects results for TLU equivalent of large and small animals. [15] In these estimations, we report the Model B version of the regressions, i.e., with a variable controlling for a switch in the gender of the household head. The major results of the regression for large animals are similar to those yielded by the model for all animals, except for a slight difference in magnitude. The estimation results for small animals are, however, different from the regression results for all animals and large animals. This discrepancy implies that factors determining the ownership of large animals are different from those determining the ownership of small animals.

Table 7 summarizes mean gender differences in the ownership of large and small animals. The table shows that, for both large and small animals, FHHs own a significantly lower stock of animals. The difference in the ownership of small animals is lower compared to the ownership of large animals, which implies that large animals such as oxen have a lower productive value for FHHs, who are constrained by male labor force and land area. Results in Table 7 also show that the estimates and level of significance for large animals are very similar to the values for all animals in Table 4. On the other hand, results for small animals show a much lower magnitude compared to all animals and exhibit differences in levels of significance.

Tables 8 and 9 show the factors explaining the gender difference in the accumulation of large and small animals, respectively. Endowment of male labor and farm size both contribute to the endowment effect in the ownership of large and small animals. Differences in number of children, however, affects only the ownership of large animals. A plausible explanation is that the requirement of child labor—to look after small animals—is minimal and does not influence gender differences in the ownership of small animals. In general, there appears to be a gender inequality in livestock ownership.

5. Conclusions

Using panel data from Northern Ethiopia, we examined gender differences in livestock ownership. By applying the Blinder-Oaxaca decomposition technique, this study investigated the potential causes of the difference between female-headed households (FHHs) and male-headed households (MHHs). Descriptive analysis showed that FHHs are less well-off than MHHs in terms of labor, land and non-land asset endowments. Empirical analysis revealed that FHHs own significantly lower livestock assets than MHHs do. The differences in the observed characteristics as well as in the returns to characteristics contributed to the gender disparity in livestock ownership. We find that lower endowment of male labor, children (age 6-14) and land area are the factors affecting a lower level of livestock accumulation in FHHs. Decomposition analysis also showed that FHHs would still own fewer animals even if they had the same characteristics as MHHs. This difference, which is attributed to unexplained factors, is mainly affected by the period encompassing the aftermath of the Ethio-Eritrean War (2001). Indeed, there may have been a need to sell livestock to feed the army during that period, which was more likely to affect FHHs because of their relative vulnerability. Findings also show that the gender difference is more pronounced in the ownership of large animals than in that of small animals.

The policy implications of our results are as follows. First, our results show that the smaller area of land owned by FHHs is one of the reasons contributing to the gender-differentiated livestock holding. Therefore, ensuring that land allocation is not biased against wives upon divorce or the death of the household head not only improves the tenure security of FHHs but also encourages them to build their livestock assets. In a similar vein, land certificates for FHHs play an important role in increasing the probability of keeping land upon divorce or death of the husband (Ghebru and Holden, 2013). Second, the provision of technology solutions would loosen the labor constraint in FHHs and ease the burden of raising animals. One such approach is making feeding practices less time and labor intensive, i.e., by availing of fodder and water close to where the households are located. In this manner, labor-constrained FHHs would require less labor to feed their livestock and hence be encouraged to build their livestock assets. Third, policy interventions that encourage livestock accumulation should consider the fact that FHHs are less endowed with important complementary assets, land and labor. Fourth, findings indicate that the gender difference in livestock ownership is much lower with respect to small ruminants than to large animals. An important policy implication is that interventions must create the means for FHHs to invest in large animals. Taking into account the difference in the gender gap for small and large animal ownership can therefore be the means to promote pro-poor and gender-sensitive livestock development policies in Ethiopia and in areas with a similar context and constraints.

Notes

[1] Superscripts M and F are subsumed in defining each variable.

[2] Dokken (2015) finds that FHHs own smaller land area than MHHs. The author attributes the difference to disparities in the observed characteristics of female-and male-headed households as well as gender bias in the allocation of land.

[3] The survey did not include the lowland pastoral areas of the region (Hagos and Holden, 2002).

[4] FHHs can be classified as *de facto* (husband is away from home) or *de jure* (divorced, widowed, single or separated) (Kassie et al., 2014). Although this definition has important implications in asset accumulation, our data do not allow us to distinguish between these groups.

[5] The Ethio-Eritrean War occurred between May 1998 and June 2000 (http://en.wikipedia.org/wiki/Eritrean%E2%80%93Ethiopian_War).

[6] Table A1 in the appendix contains the weights for TLU.

[7] The sample size in this case is 995 observations (199 households in each year). One observation from each year is removed in Figures 3 and 4 because it biased the graphical illustrations, and we remained with 990 observations.

[8] The switch in the gender of the household head represents a change from male to female (female to male) in the FHH (MHH) regressions. The variable takes a value of zero for households consistently headed by a male (female) and one for households that experienced a switch from female to male (male to female) within the MHH (FHH) regressions.

[9] Results can be obtained upon request.

[10] To test the non-linearity of the model, we log-transformed TLU and found that the results are similar to the reported regression output. Furthermore, we attempted to include squared terms for the continuous explanatory variables and found that they are statistically insignificant, except for the squared term for the age of the household head, which is included in all regressions. Non-linearity was also tested by (a) making TLU per farm size the dependent variable instead of TLU and (b) estimating TLU as a function of labor endowments per farm size. The results were inferior to those yielded by our estimated model in terms of the overall fit of the model (very low R-squared). Hence, we report outputs without transformation.

[11] We use Model B when reporting the details of the decomposition analysis.

[12] Number of children might be endogenous in the livestock accumulation decision. Excluding the variable does not, however, alter the main results, and we opt to retain it in the models.

[13] The author employed the 2006 data from the panel survey used in this study.

[14] Because this study considers total land area owned (owner-operated and rented-out land) instead of operational land holding, differences due to farm size take total endowment into account.

[15] Large animals include oxen, cows, heifers, bulls, calves, horses, mules, donkeys and camels. Small animals include sheep, goats and chickens.

Table 1. Percentages of female-headed households (FHHs) and male-headed households (MHHs) in the survey years

Year	FHHs	MHHs	Any switch between sex	Female to male	Male to female
1998	23.3 (70)	76.7 (231)			
2001	23.9 (72)	76.1 (229)	15.3 (46)	7.3 (22)	8.0 (24)
2003	27.2 (82)	72.8 (219)	6.6 (20)	1.7 (5)	5.0 (15)
2006	29.6 (89)	70.4 (212)	8.3 (25)	3.0 (9)	5.3 (16)
2010	28.6 (86)	71.4 (215)	15.0 (45)	8.0 (24)	7.0 (21)
All years	26.5 (399)	73.5 (1106)	9.0 (136)	4.0 (60)	5.1 (76)

Note: 1. Number of households in parentheses

2. In columns 4 to 6, values represent changes from the previous survey year

Table 2. Descriptive statistics of major household characteristics for male and female-headed households

	All Years			1998			2010		
	FHHs	MHHs	T-test	FHHs	MHHs	T-test	FHHs	MHHs	T-test
Age of household head	51.0	54.7	-4.28	47.8	49.9	-0.95	54.5	58.0	-2.01
Education of household head(1=literate, 0=illiterate)	0.08	0.33	-10.1	0.03	0.03	0.12	0.08	0.38	-5.31
Number of adult females	1.19	1.42	-4.74	1.10	1.22	-1.33	1.29	1.47	-1.45
Number of adult males	0.72	1.63	-15.0	0.54	1.48	-7.45	0.73	1.68	-6.40
Number of children (>=6 and <=14 years)	1.26	2.41	-12.8	0.97	2.45	-7.02	1.31	2.17	-4.07
Household size	3.56	5.92	-19.1	2.80	5.37	-9.38	3.59	5.73	-7.62
Land area (Tsimdi) [1]	3.35	4.91	-7.28	3.03	4.72	-2.48	3.64	4.54	-2.20
Off-farm employment (0/1)	0.55	0.47	2.46	0.46	0.40	0.81	0.48	0.44	0.62
TLU (all livestock)	1.49	3.58	-11.7	1.60	2.65	-2.98	1.47	3.50	-6.41
TLU (without oxen)	1.04	2.43	-9.15	1.00	1.54	-1.87	0.99	2.13	-4.79
TLU (large animals)	1.38	3.36	-11.5	1.51	2.50	-3.01	1.35	3.19	-6.28
TLU (small ruminants)	0.11	0.22	-4.70	0.09	0.14	-1.16	0.12	0.32	-3.54
Number of oxen owned	0.41	1.05	-12.9	0.54	1.01	-4.02	0.44	1.25	-7.30
Number of observation	399	1106		70	231		86	215	

Note: Large animals include oxen, cows, heifers, bulls, calves, horses, mules, donkeys and camels. Small ruminants include sheep, goats and chickens.

[1] 1 Tsimdi=0.25 hectare

Table 3. Fixed effects regression of TLU-Male and female-headed households

	MHHs		FHHs	
	Model A	Model B	Model A	Model B
Age of household head [1]	1.58	1.58	-0.42	-0.64
	(0.49)***	(0.49)***	(0.57)	(0.57)
Age of household head squared [1]	-0.12	-0.12	0.05	0.08
	(0.04)***	(0.04)***	(0.05)	(0.05)
Education of head	0.87	0.87	-0.19	-0.07
	(0.22)***	(0.22)***	(0.38)	(0.38)
Number of adult females	0.22	0.22	0.49	0.50
	(0.11)**	(0.11)**	(0.16)***	(0.16)***
Number of adult males	0.25	0.25	0.43	0.46
	(0.10)***	(0.10)**	(0.15)***	(0.15)***
Land area (Tsimdi) [2]	0.06	0.06	0.13	0.13
	(0.03)**	(0.03)**	(0.04)***	(0.04)***
Off-farm employment (0/1)	-0.01	-0.01	0.20	0.17
	(0.17)	(0.17)	(0.21)	(0.21)
Number of children	0.08	0.08	0.31	0.33
	(0.09)	(0.09)	(0.12)***	(0.12)***
2001	1.57	1.56	0.12	-0.08
	(0.16)***	(0.16)***	(0.21)	(0.22)
2003	-0.45	-0.46	-0.31	-0.42
	(0.16)***	(0.16)***	(0.19)	(0.19)**
2006	-0.52	-0.53	-0.30	-0.40
	(0.16)***	(0.16)***	(0.18)	(0.19)**
2010	-0.18	-0.20	-0.16	-0.28
	(0.16)	(0.17)	(0.19)	(0.20)
Switch between sex [3]		0.18		0.61
		(0.31)		(0.24)**
Observations	1106	1106	399	399
R-squared	0.16	0.16	0.15	0.16

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

[1] Age of the household head is divided by 10 years, i.e., one unit is 10 years.

[2] 1 Tsimdi=0.25 hectare

[3] Switch between sexes represents change in sex of household head from male to female in the case of FHHs' regressions and from female to male in the case of MHHs' regressions.

Table 4. Decomposition of mean difference in TLU

		Model A	Model B
Differential	Prediction- MHHs	0.14	0.14
		(0.04)***	(0.04)***
	Prediction- FHHs	-0.26	-0.27
		(0.07)***	(0.06)***
	Difference	0.40	0.41
		(0.08)***	(0.08)***
Decomposition	*Difference due to:*		
	Endowments	0.18	0.12
		(0.06)***	(0.05)**
	Coefficients	0.18	0.21
		(0.08)**	(0.09)**
	Interaction	0.04	0.08
		(0.06)	(0.08)
	Observations	1505	1505
	No. of households	301	301

Robust standard errors clustered by household ID in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5. Detailed decomposition of causes of difference in TLU

	Differences due to:		
	Endowments	Coefficients	Interaction
Age of household head	-0.04	-0.10	0.14
	(0.05)	(0.08)	(0.11)
Age of household head squared	0.05	0.10	-0.13
	(0.06)	(0.08)	(0.11)
Education of head	-0.00	-0.04	0.06
	(0.03)	(0.03)	(0.04)
Number of adult females	0.00	0.00	-0.00
	(0.01)	(0.01)	(0.01)
Number of adult males	0.10	0.03	-0.05
	(0.04)***	(0.03)	(0.04)
Land area (Tsimdi)[1]	0.03	0.01	-0.02
	(0.02)**	(0.01)	(0.02)
Off-farm employment (0/1)	0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)
Number of children	0.04	0.02	-0.03
	(0.02)**	(0.01)	(0.02)
Switch between sex	-0.08	-0.08	0.06
	(0.04)**	(0.07)	(0.05)
2001	-0.00	0.30	0.04
	(0.01)	(0.05)***	(0.02)**
2003	0.00	-0.01	0.00
	(0.00)	(0.04)	(0.00)
2006	0.01	-0.03	0.00
	(0.01)*	(0.04)	(0.01)
2010	0.01	0.02	-0.00
	(0.01)	(0.04)	(0.00)
Total	0.12	0.21	0.08
	(0.05)**	(0.09)**	(0.08)
Number of observation	1505	1505	1505
Number of households	301	301	301

Robust standard errors clustered by household ID in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Results are based on Model B.
[1]1 Tsimdi=0.25 hectare

Table 6. Fixed effects regression of TLU equivalent of large and small animals-Male and female-headed households

	Large animals		Small animals	
	MHHs	FHHs	MHHs	FHHs
Age of household head [1]	1.33	-0.61	0.25	-0.03
	(0.47)***	(0.54)	(0.08)***	(0.08)
Age of household head squared [1]	-0.10	0.08	-0.02	0.00
	(0.04)**	(0.05)	(0.01)***	(0.01)
Education of head	0.84	-0.07	0.03	0.00
	(0.21)***	(0.36)	(0.04)	(0.05)
Number of adult females	0.22	0.46	0.00	0.03
	(0.11)**	(0.15)***	(0.02)	(0.02)
Number of adult males	0.25	0.44	-0.00	0.03
	(0.09)***	(0.15)***	(0.02)	(0.02)
Land area (Tsimdi) [2]	0.06	0.12	-0.00	0.01
	(0.02)***	(0.04)***	(0.00)	(0.01)*
Off farm employment (0/1)	-0.05	0.18	0.03	-0.01
	(0.16)	(0.20)	(0.03)	(0.03)
Number of children	0.07	0.30	0.01	0.02
	(0.08)	(0.11)***	(0.01)	(0.02)
Switch between sex	0.17	0.63	0.02	-0.02
	(0.30)	(0.23)***	(0.05)	(0.03)
2001	1.67	-0.01	-0.11	-0.07
	(0.16)***	(0.21)	(0.03)***	(0.03)**
2003	-0.54	-0.39	0.07	-0.03
	(0.15)***	(0.19)**	(0.03)***	(0.03)
2006	-0.54	-0.48	0.02	0.08
	(0.15)***	(0.18)***	(0.03)	(0.03)***
2010	-0.29	-0.30	0.09	0.02
	(0.16)*	(0.19)	(0.03)***	(0.03)
Observations	1106	399	1106	399
R-squared	0.18	0.16	0.05	0.07

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

[1] Age of the household head is divided by 10 years, i.e., one unit is 10 years.

[2] 1 Tsimdi=0.25 hectare

Table 7. Decomposition of mean difference in TLU equivalent of large and small animals

		Large animals	Small animals
Differential	Prediction- MHHs	0.13	0.01
		(0.04)***	(0.00)***
	Prediction- FHHs	-0.26	-0.01
		(0.06)***	(0.01)*
	Difference	0.39	0.02
		(0.08)***	(0.01)***
Decomposition	*Difference due to:*		
	Endowments	0.11	0.01
		(0.05)**	(0.01)*
	Coefficients	0.18	0.03
		(0.09)**	(0.01)**
	Interaction	0.09	-0.01
		(0.07)	(0.01)
	Observations	1505	1505
	No. of households	301	301

Robust standard errors clustered by household ID in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 8. Detailed decomposition of causes of difference in TLU equivalent of large animals

	Differences due to:		
	Endowments	Coefficients	Interaction
Age of household head	-0.04	-0.09	0.12
	(0.05)	(0.07)	(0.10)
Age of household head squared	0.05	0.08	-0.11
	(0.06)	(0.07)	(0.10)
Education of head	-0.00	-0.04	0.06
	(0.03)	(0.03)	(0.04)
Number of adult females	0.00	0.00	-0.00
	(0.01)	(0.01)	(0.01)
Number of adult males	0.09	0.03	-0.04
	(0.04)**	(0.03)	(0.04)
Land area (Tsimdi)[1]	0.03	0.01	-0.01
	(0.02)*	(0.01)	(0.02)
Off-farm employment (0/1)	0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)
Number of children	0.04	0.02	-0.03
	(0.02)**	(0.01)	(0.02)
Switch between sex	-0.09	-0.09	0.06
	(0.04)**	(0.07)	(0.05)
2001	-0.00	0.30	0.04
	(0.01)	(0.05)***	(0.02)**
2003	0.00	-0.03	0.00
	(0.00)	(0.04)	(0.00)
2006	0.01	-0.01	0.00
	(0.01)**	(0.04)	(0.01)
2010	0.01	0.00	-0.00
	(0.01)	(0.04)	(0.00)
Total	0.11	0.18	0.09
	(0.05)**	(0.09)**	(0.07)
Number of observation	1505	1505	1505
Number of households	301	301	301

Robust standard errors clustered by household ID in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
[1] 1 Tsimdi=0.25 hectare

Table 9. Detailed decomposition of causes of difference in TLU equivalent of small animals

	Differences due to:		
	Endowments	Coefficients	Interaction
Age of household head	-0.00	-0.01	0.02
	(0.00)	(0.01)	(0.01)
Age of household head squared	0.00	0.01	-0.02
	(0.00)	(0.01)	(0.01)
Education of head	0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)
Number of adult females	0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)
Number of adult males	0.01	0.00	-0.01
	(0.00)*	(0.00)	(0.00)
Land area (Tsimdi)[1]	0.00	0.00	-0.00
	(0.00)*	(0.00)	(0.00)
Off-farm employment (0/1)	-0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)
Number of children	0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)
Switch between sex	0.00	0.01	-0.00
	(0.00)	(0.01)	(0.01)
2001	-0.00	-0.01	-0.00
	(0.00)*	(0.01)	(0.00)
2003	0.00	0.02	-0.00
	(0.00)	(0.01)***	(0.00)
2006	-0.00	-0.01	0.00
	(0.00)	(0.01)	(0.00)
2010	-0.00	0.02	-0.00
	(0.00)	(0.01)*	(0.00)
Total	0.01	0.03	-0.01
	(0.01)*	(0.01)**	(0.01)
Number of observation	1505	1505	1505
Number of households	301	301	301

Robust standard errors clustered by household ID in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
[1]1 Tsimdi=0.25 hectare

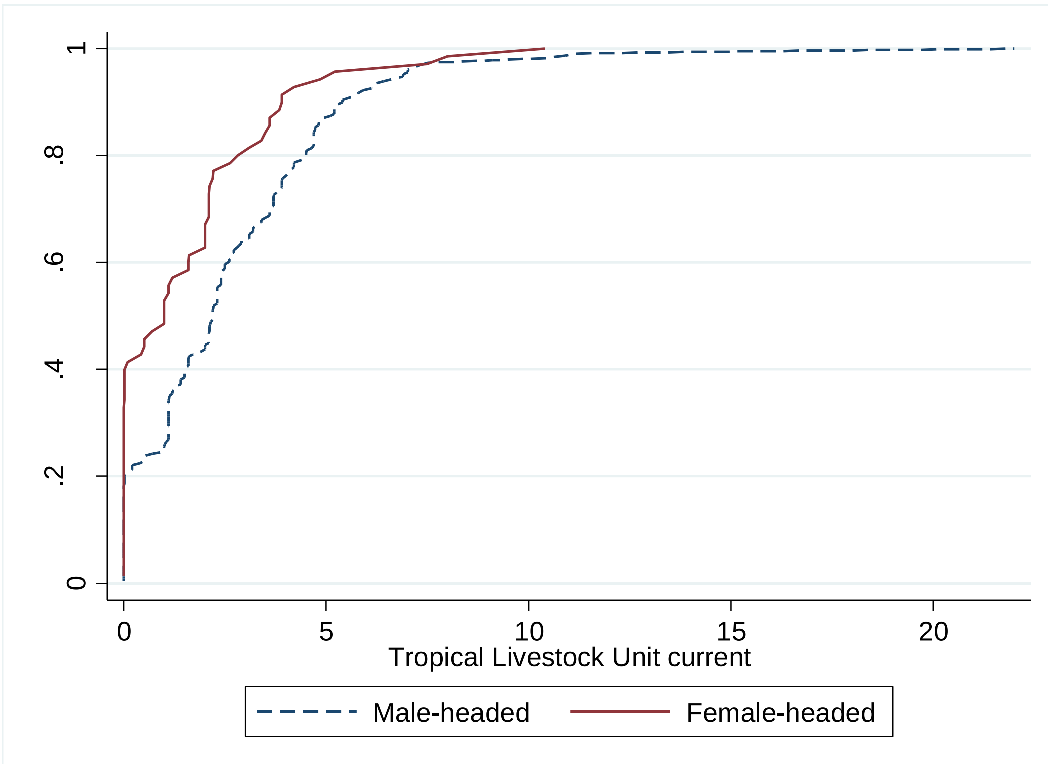

Figure 1. Cumulative density function of TLU for male- and female-headed households-1998

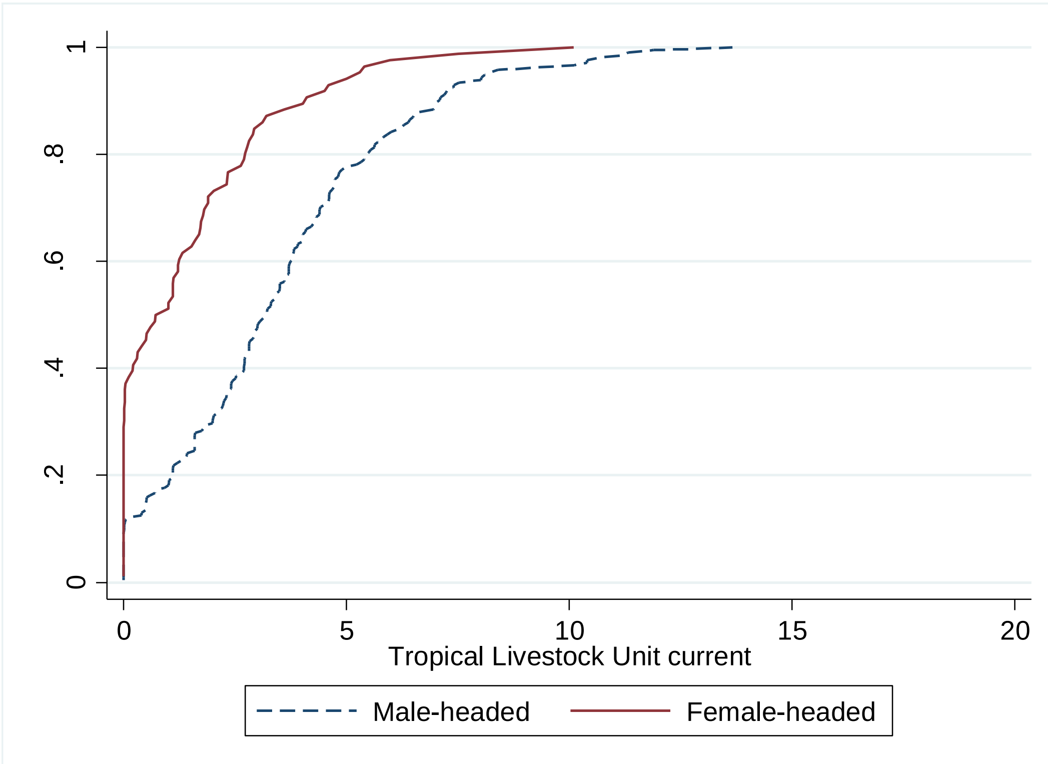

Figure 2. Cumulative density function of TLU for male- and female-headed households- 2010

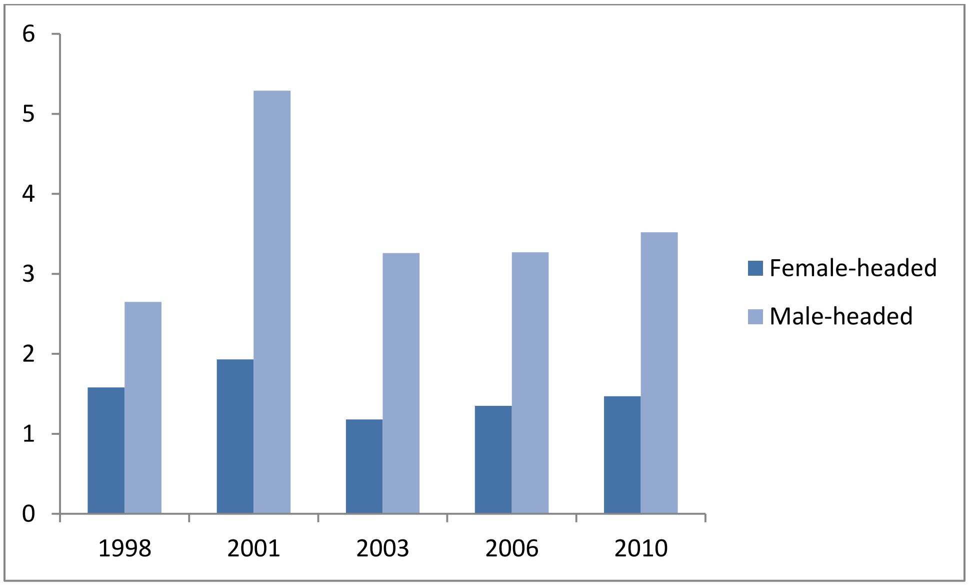

Figure 3. Tropical Livestock Units for female- and male-headed households across survey years

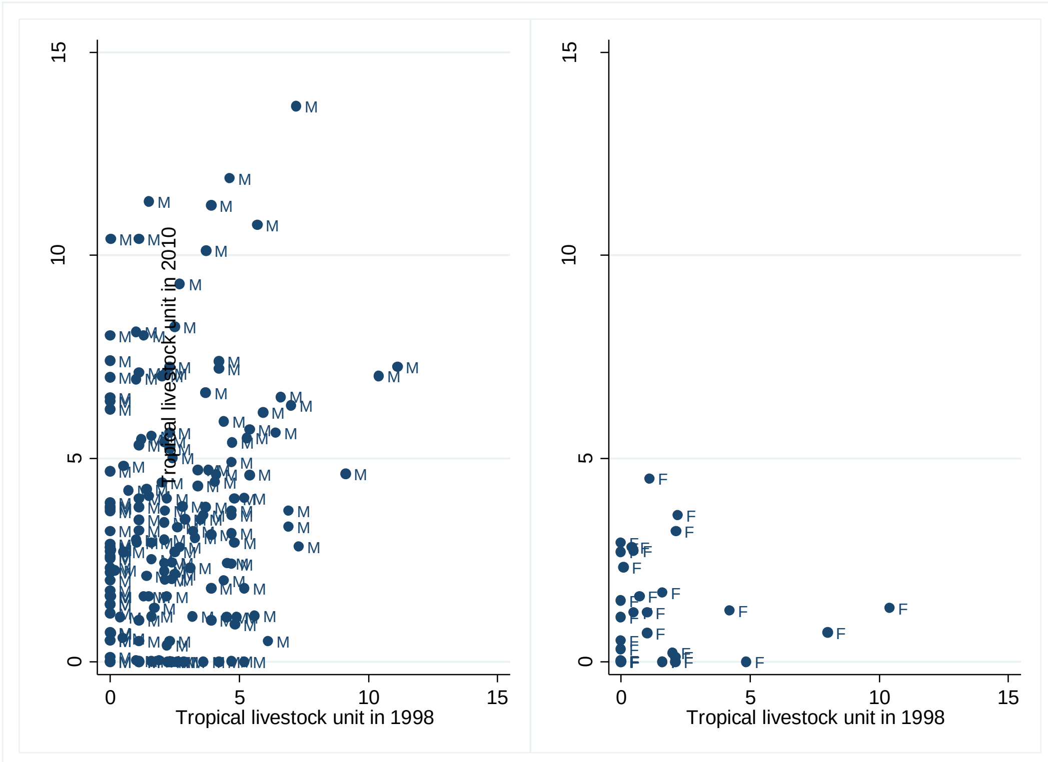

Figure 4. Beginning and ending stocks of tropical livestock units for male- and female-headed households

References

Bezabih, M., Holden, S., and Mannberg. A. (2012). The Role of Land Certification in Reducing Gender Gaps in Productivity in Rural Ethipia. Working Paper 01/12. Center for Land Tenure Studies. Norwegian University of Life Sciences.

Blinder, A. S. (1973). Wage discimination: Reduced form and structural estimates. *Journal of Human Resources* 8: 436–455.

Campenhout, B.V. and Dercon, S. (2012). Nonlinear Dynamics of Livestock Assets Evidence from Ethiopia. IFPRI Discussion Paper 01215. International Food Policy Research Institute, Washington D.C.

Carter, M. R. and Barrett, C. B. (2006). "The Economics of Poverty Traps and Persistent Poverty: An Asset-Based Approach." *Journal of Development Studies* 42 (2): 178–199.

Dillon, A. and Quiñones, E. (2011). Asset Dynamics in Northern Nigeria. Discussion Paper 1049. International Food Policy Research Institute. Washington, DC.

Dokken, T. (2015). Allocation of land tenure rights in Tigray: How large is the gender bias. *Land Economics* 91(1):106-125.

FAO (2011). Gender differences in assets. ESA Working Paper No. 11-12. Agricultural Development Economics Division. Food and Agriculture Organization of the United Nations. Rome.

Ghebru, H. and Holden, S. (2013). Welfare Impacts of Land Certification in Tigray, Ethiopia In Holden, S., Otsuka, K. andDeininger, K. [ed.]. Land Tenure Reform in Asia and Africa: Assessing Impacts on Poverty and Natural Resource Management. Palgrave Macmillan. United Kingdom.

Hagos, F. and Holden, S. (2002). Incentives for Conservation in Tigray, Ethiopia: Findings from a Household Survey. Unpublished paper.

Holden, S., Otsuka, K. and Place, F. M. (2008). Understanding Land Markets: Questions and Hypotheses. In: S. Holden, K. Otsuka and F.M. Place (eds) *The Emergence of Land Markets in Africa: Impacts on Poverty, Equity and Efficiency.* Washington D.C, USA: Resources For The Future, pp. 18-54.

Holden, S. Deininger, K., and Ghebru, H. (2011). Tenure Insecurity, Gender, Low-cost Land Certification, and Land Rental Market Participation. *Journal of Development Studies.* 47: 31-47.

Jann, B. (2008). The Blinder-Oaxaca decomposition for linear regression models. *The Stata Journal*. 8(4): 453-79.

Kassie, M., Ndiritu, S.W., and Stage, J. (2014). What determines gender inequality in household food security in Kenya? Application of exogenous switching treatment regression. *World Development, 56: 153-71*.

Meinzen-Dick,R., Johnson, N., Quisumbing, A., Njuki, J., Bhrman, J., Rubin, D., Peterman, A., and Waithanji, E. (2011). Gender, Assets, and Agricultural Development Programs. Working Paper No. 99. CGIAR System wide Program on Collective Action and Property Rights (CAPRi). International Food Policy Research Institute, Washington D.C.

Muyanga, M., Jayne, T.S., and Bruke, W. J. (2011). Pathways Into and Out of Poverty: A Study of Rural Household Wealth Dynamics in Kenya. Paper presented at the Special IARIW-SSA Conference on Measuring National Income, Wealth, Poverty, and Inequality in African Countries; 28 September-1 October, Cape Town, South Africa.

Njuki, J. and Miller, B. (2012). Livestock and Gender. Achieving poverty alleviation and food security through livestock policies that benefit women. Global Alliance for Livestock Veterinary Medicines, London. URL: http://www.galvmed.org/wp-content/uploads/2013/07/Abstract-paper-2-NjukiMiller-Final-18June13.pdf

Njuki, J. and Sangina, P.C. (eds.) (2013). *Women, Livestock Ownership and Markets. Bridging the gender gap in Eastern and Southern Africa*. New York: Routledge Taylorand Francis Group.

Oaxaca, R. (1973). Male–female wage differentials in urban labor markets. *International Economic Review* 14: 693–709.

Quisumbing, A.R. (2011). Do Men and Women Accumulate Assets in Different Ways? Evidence from Rural Bangladesh. IFPRI Discussion Paper 01096. International Food Policy Research Institute, Washington D.C.

Rosenzweig, M. R. and Wolpin, K. I. (1993). Credit Market Constraints, Consumption Smoothing, and the Accumulation of Durable Production Assets in Low-Income Countries: Investments in Bullocks in India. *Journal of Political Economy*, 101(2): 223-244.

Tegebu, F.N., Mathijs, E., Deckers, J., Haile, M., Nyssen, J., and Tollens, E. (2012). Rural livestock asset portfolio in northern Ethipia: a microeconomic analysis of choice and accumulation. *Tropical Animal Health and Production* 44(1): 133-44.

Appendix

Table A1. Tropical Livestock Unit (TLU) weight

Livestock type	TLU weight
Camel	1.2
Ox	1.1
Milk cow	1
Cow	1
Horse	0.8
Heifer	0.7
Bull	0.7
Mule	0.7
Donkey	0.5
Calve	0.2
Sheep	0.1
Goat	0.1
Chicken	0.005